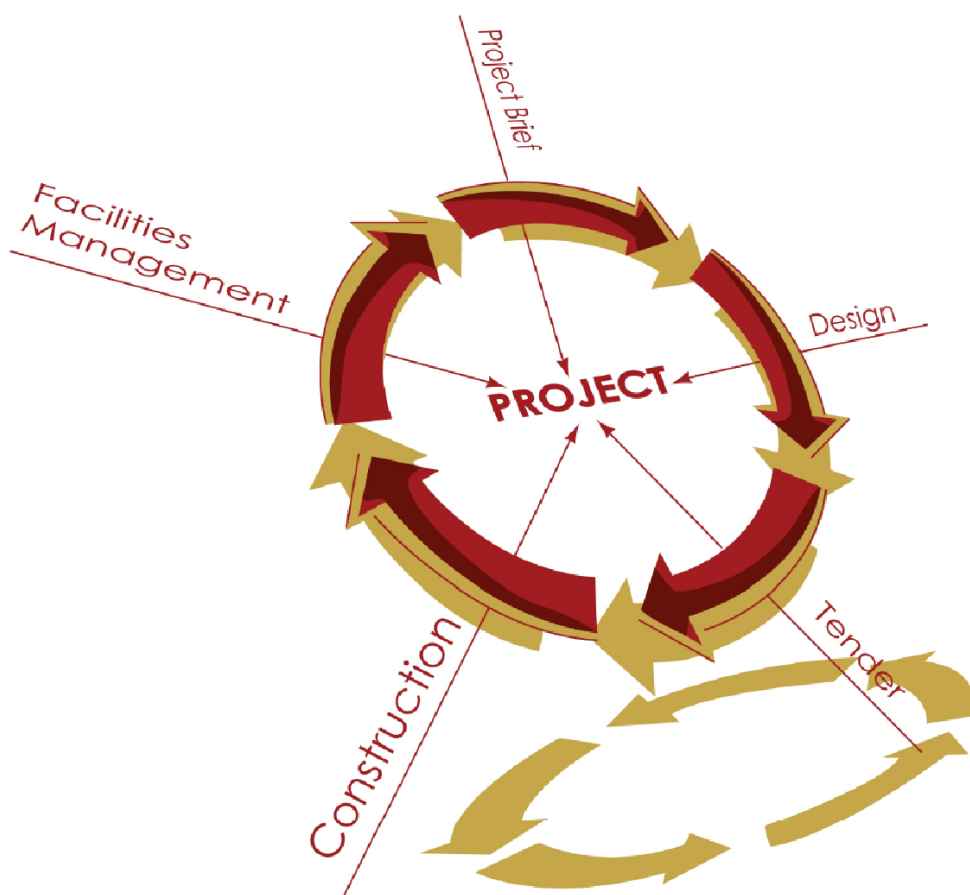


# Malaysian Construction Research Journal

INTERNATIONAL CONFERENCE ON INNOVATION AND MANAGEMENT (ICIM) 2016



# **MALAYSIAN CONSTRUCTION RESEARCH JOURNAL (MCRJ)**

**SPECIAL ISSUE Vol.1 | No. 1 | 2017**

**INTERNATIONAL CONFERENCE ON INNOVATION  
AND MANAGEMENT (ICIM) 2016**

The Malaysian Construction Research Journal is indexed in

**Scopus Elsevier**

eISSN No.: 2590 – 4140

Construction Research Institute of Malaysia (CREAM)  
MAKMAL KERJA RAYA MALAYSIA  
1<sup>st</sup> Floor, Block E, Lot 8, Jalan Chan Sow Lin,  
55200, Kuala Lumpur  
Malaysia

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## INTRODUCTION

Welcome to the Special Issue of the Malaysian Construction Research Journal (MCRJ) in conjunction with the 13<sup>th</sup> International Conference on Innovation and Management (ICIM) 2016. The International Conference on Innovation and Management (ICIM) 2016 was co-hosted by Malaysia-Japan International Institute of Technology (MJIIT), Universiti Teknologi Malaysia and Yamaguchi University, Japan on 28-30<sup>th</sup> November 2016 at Universiti Teknologi Malaysia, Kuala Lumpur.

To promote the research on innovation management and to establish an international annual academic conference for facilitating researchers and expertise in applied research on Innovation and Technology Management, top universities in this field from 6 countries have been organizing this international conference from 2004. The universities are Universiti Teknologi Malaysia (Malaysia), Yamaguchi University (Japan), Tilburg University (The Netherlands), Pontificia Universidade Catolica de Sao Paulo (Brazil), University of Vaasa (Finland) and Wuhan University of Technology (China).

The theme of this year's conference is "*Global Collaboration for Sustainable Innovation*".

The conference theme was divided into 2 major areas: Innovation in Construction Management and Innovation Management (general track). This Special Issue of Malaysian Construction Research Journal for International Conference on Innovation and Management 2016 comprises 19 recommended and selected papers by the conference committee from the papers submitted and presented at the ICIM2016 from both areas based on its merits and implication.

The ICIM is proven to be a high-profile event for leading international scholars in the area of management and innovation and has become a premier conference among researchers, academician and practitioners. This conference is of special significance to the academics and the professionals. The aim of ICIM 2016 was to provide opportunity for researchers to present their findings on innovation and management as well as to create opportunity for the exchange and synthesis of new knowledge on innovation and technology management and Intellectual property. This conference had also provided opportunities to interact with researchers from around the world and provided the platform to share the contemporary research trends and experiences towards sustainable innovation.

This conference was the platform to share the contemporary research trends and experiences in regional common issues as well as to explore research work on Innovation in Construction Management and Intellectual Property from Japan and other countries. Participants from various disciplines contributed to this conference and more than 90 papers were presented from 12 countries. ICIM 2016 was privileged to have Mr Atsuyuki Asano from Ministry of Education, Culture, Sports, Science and Technology, Japan, Mr Toshiaki Terauchi from East Japan Railway Company, Japan, and, Ms Saya Miwa and Mr Charry Chu from Clarivate Analytics Japan as the Keynote speakers. Besides, Dr Mohammad Ali Tareq (UTM), Prof Tim de Leeuw (Tilburg University), Prof Ying Ma (Wuhan University of Technology), Prof Arnoldo de Hoyos (PUC-Sao Paulo University), Prof Josu Takala (University of Vaasa) and Prof Yoshiyuki Matsuura (Yamaguchi University) also shared their views and findings on the trend of Innovation in respective research areas.

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# Editorial

## Welcome from the Editors

Welcome to the Special Issue in Malaysian Construction Research Journal (MCRJ) for International Conference on Innovation and Management (ICIM) 2016. We would like to express our sincere gratitude to our reviewers, contributing authors and readers.

The Special Issue in MCRJ for ICIM 2016 features twenty (19) interesting papers covering two (2) main themes: six (6) papers in Innovation in Construction Management theme and fourteen (13) in Innovation Management theme. It is hoped that the readers will find informative articles from this special edition in MCRJ.

In this issue, under the Innovation in Construction Management theme:

**Takayuki Isaka et al.**, addressed a revising method and algorithm to make precise bidding decisions using past contract data. Using the past contract data including detailed contents related with purchasing, hiring, constructing and insurance, the initial subjective assumptions of the value estimation is refined by updating the estimation model of the value of the infrastructure project based on Bayesian probability.

In the paper by **Hiroshi Nakanishi and Shinobu Komai**, man-hour formula in the Agile method is derived taking into account the man-hour decrease in the system function requirement definition and the man-hour increase in the software making. Comparing the man-hours in between the Waterfall method and the Agile method for IT system development, it is made clear that the Agile method is advantageous when man-hour decrease in the requirement definition is greater than the man-hour increase in the software development.

**Muhammad Tahir Muhammad et al.**, conducted a mixed method of enquiry which consisted of semi-structured interview and questionnaire to achieve the strategies that will be used to improve cost and time control in the industry through the use of Building Information Model (BIM).

**Kamal Sabri Kamaruddin and Hiroshi Nakanishi** aim to clarify the Kaizen activity named Junshi as a continuous improvement activity and analyse the technical and management aspects of lean small group activity by adopting the eight steps of Business Practices problem-solving. Through the research, it is clear that most adoptions to imitate lean management fail because techniques are taken up in pieces with little apprehension of why or what organisational approach is needed to maintain kaizen or continuous improvement.

**S.M. Zobaidul Kabir and Fazle Rabbi** assessed the environmental and social performance of Lever Brothers Bangladesh Limited (LBBL) and identified the areas of improvement. This research shows that there are some limitations in its operational management regarding environmental management. The company needs a change in response to its various stakeholders in order to achieve its business sustainability from environmental perspective. Finally, this paper recommends for some effective tools and strategies to overcome the limitations. It is expected that LBBL will be able to attract more consumers by their green products and contribute in the sustainable development with these tools.



A literature review was carried out by **Suzila Mohd et al.**, to explore on adaptation of BIM in the project design stage and types of maturity model in construction field. Apart from that, several semi-structured interviews were conducted with project design team to explore potential improvements to increase BIM implementation in project design stage. Both data from the literature review and the semi-structured interviews are important and contributed to the development of '*BIM Implementation Model for Project Design Team*'.

In Innovation Management theme:

**Rosmaini Tasmin and Muhammad Shafiq** examines the influence of the business strategies on organisational innovation. For this purpose, they used a quantitative research design and collected data from 250 employees of SMEs in Malaysia through a self-administrated questionnaire. The results indicated that the defender and prospector business strategies are not linked with open innovation while reactor business strategy is not linked with closed innovation.

**Assad Ullah et al.**, explores the relationship between military spending and stock market capitalization in Pakistan. using the methodology of ARDL bounds testing to co-integration over the period 1990-2012. The study concludes that military expenditure is a vital determinant of stock market capitalization in Pakistan. A steady reduction in military spending is required for the enhancement of stock market performance.

Through questionnaire survey by **Muazu Hasan Muazu and Najafi Auwalu Ibrahim** collected a sample of 370 respondents were selected using convenient sampling technique. With the use of multiple regression analysis, the results of the study showed that training quality, trainers competence and training facilities have significant effect on capacity building effectiveness in Kano state enterprise development training institutes. The study thus recommended that the training institutes should standardise the admission process, curricula and improve on post training support activities.

**Humaira Parvin and Fazle Rabbi** addressed the factor that affecting female migration in Bangladesh such as socio-cultural practices, religion, education, government policy and challenges during migration process. They believed that it is necessary to raise this issue for the economic development and gender empowerment aspects of Bangladesh. Concerted efforts of various government and non-government organisations can change the scenario for the international female migrants of Bangladesh.

Through literature review and content analysis on those literatures, **Lim Teck Loon et al.**, identify critical success factors (CSFs) for Enterprise Resources Planning (ERP) implementation based on research articles published between years 2005-2016. The constant comparative methodology and TRIZ perception mapping technique was then used to narrow down the search for the "most critical CSFs". The research findings also showed TRIZ perception mapping could help to improve the quality of the research output on CSFs studies.

**Mohd Yusri Mohd Yusof and Hiroshi Nakanishi** investigate the problem-solving process between selected automotive first-tier suppliers and its carmaker to determine the differentiation between problem solving process managed by automotive manufacturer and

the A3 Methodology problem solving process practiced by Japanese manufacturing practitioner.

This article by **Rosmaini Tasmin et al.**, gives an overview of the potential hazards during normal activity and relevant safety impact to personnel, asset and environment. The study applied Risk Assessment approach to measure potential hazard levels and survey on 157 employees of 4 floating oil storage facilities were analysed with methodological tools of ANOVA One Way, T-Test and Pearson Correlation to evince linkage between potential hazard and safety impact.

**Liew Chee Leong and Mohammad Ali Tareq** describe a process that may be adopted in overcoming maintenance competency deficiencies within an organisation in an engineering sector such as aircraft maintenance, repair and overhaul facility.

**Tsuyoshi Koga et al.**, propose an improving method of estimation accuracy of product development value. The value of product development is calculated using influence diagram and reverse-profit diagram based on discovery driven planning (DDP) method. Classical DDP method uses a subjective hypothesis as an input data. In product development lifecycle, huge data including positive and negative is obtained in research stage, design stage, and mass-production stage.

**Kenji Miyake and Ken Kaminishi** have made the hypothesis verification for the focus strategy with the case study of Minimal Fab, which is a new concept of the National Institute of Advanced Industrial Science and Technology (AIST) in Japan, when Small to Medium Enterprises (SME) and start-up companies enter into the semiconductor manufacturing industry. They have used the framework of the business ecosystem as the verification method.

**Hartini Mohamed and Akbariah Mohd Mahdzir** conducted a program evaluation of an entrepreneurial education in public and private higher education institution in Malaysia. This study aims to evaluate the issues and challenges in the implementation of entrepreneurship education practices by Higher Education Institution (HEI) in Malaysia. They adopt qualitative approach utilizing case study method. The collection techniques included semi-structure interview, document analysis and observation.

**Yan Watequlis Syaifuddin et al.**, discussed about the data communication model between computers (servers) teacher with student computer (client) in supporting streaming feature of learning video data and teacher's live video, as well as in supporting the chatting features between teachers and students. The Use of LAMPP stack, Node.js, NPM and VLC on the server side, the use of RTSP as the protocol to send video/audio data from the server to the client and the VLC plugin embedded in the client browser, have been able to collabourate optimally to make audio/video streaming system.

**Alireza Fili and Ahmad Rahman Songip** emphasize in their paper the global effect in relation to aspect of management and innovation technology in oil tanker vessel safety, ways to improve safety management, reduce casualty and marine pollution, and review some potential innovations and ideas to achieve the optimal maritime safety for oil tanker vessels.

## THEME 1:

# INNOVATION IN CONSTRUCTION MANAGEMENT

# REVISING METHOD OF BIDDING DECISION IN INTERNATIONAL INFRASTRUCTURE PROJECT CONSIDERING PAST CONTRACT DATA

**Takayuki Isaka<sup>1</sup>, Wataru Yoneda<sup>1</sup>, Tsuyoshi Koga<sup>1</sup>, Ken Kaminishi<sup>2</sup>**

<sup>1</sup>Department of Mechanical Engineering, Yamaguchi University, 2-16-2, Tokiwadai, Ube City, Yamaguchi Prefecture, 755-8611 Japan

<sup>2</sup>Graduate School of Innovation and Technology Management, Yamaguchi University, 2-16-2, Tokiwadai, Ube City, Yamaguchi Prefecture, 755-8611 Japan

## Abstract

This paper addresses a revising method and algorithm to make precise bidding decisions using past contract data. Using the past contract data including detailed contents related with purchasing, hiring, constructing and insurance, the initial subjective assumptions of the value estimation is refined by updating the estimation model of the value of the infrastructure project based on Bayesian probability. The proposed method includes two stages; (1) qualitative stage with not enough information, and (2) quantitative stage with past actual contract data. The past contract data is used mainly in the quantitative stage to evaluate whether the project is worth to bid by estimating the overall value and profitability of the project. An application result of the proposed method to the subway construction project is shown in this paper. The result of profit-loss simulation indicated that the overall project profit shifts, and sensitivity analysis show that the element which has highest impact is changed, by importing data and updating average and variance of the element.

**Keywords:** *Infrastructure Project, bidding decision, big data, Bayesian probability*

## INTRODUCTION

### Risk Evaluation in Infrastructure Construction Project

Today, a construction project of the international infrastructure, such as subway, high-speed train and airport is becoming massive because of the growth of the population.

#### Exporting infrastructure package by Japanese Company



Taiwan High Speed Rail



International Airport in Kuala Lumpur



Metro in India



MRT Purple Line in Bangkok

**Figure 1.** Exporting infrastructure package and problem definition

Companies in developed country have certain technologies and specialties in this field because they have some experiences of construction projects in the past. Then, such companies try to contribute to the massive infrastructure construction project, although there are communicational difficulties between the client, such as government, and the contractor, such as a company who is engaged to carry out the sub part of the project. The client and the contractor have competing interests because the client wants to minimize costs and to reduce the construction time. On the other hand, the contractor needs sufficient time to develop and abundant budget to complete all tasks and make profit. These interests always conflict each other. Figure 1 show four examples of the international infrastructure construction projects that involved Japanese firms in the implementation of the project.

The risks inside the massive infrastructure construction project are sometime unclear and not predictable. The bidder wants to grasp the risks inside the construction project in advance, because in most cases the amount of the budget is limited but the cost of measures for risks could be huge. These are the main reason why the contractor is afraid to participate in a bid for the infrastructure construction project. Thus, a precise risk evaluation method is highly desired for contractee.

## **Background of this Research Field and Related Methods**

This research focused on a combined qualitative and quantitative method to evaluate the value of the infrastructure construction project. At the initial stage when it is require to judge whether the project is worth to bid or not, the qualitative screening method is better than the quantitative scoring method because the number of potential projects which are under severe consideration is not so may compared with the total number of the bidding possibilities. On the other hand, once a bid is realized to be considered severely, then the precise scoring method is more suitable than the screening method because the quantification of risks and precise overall value by participating in the bid is needed for accurate decision makings by the company.

Such risk evaluation method in massive construction project is addressed from many points of view today (Ohtsu et al., 2002). A Failure Modes and Effects Analysis (FMEA) method is a screening method of product system failure from the initial stage of the development (Yamasaki 2017) (Wada 1996). In order to evaluate the total value of the development project, a Discovery-Driven Planning (DDP) method is well known and recognized as the effective methodology (McGrath et al. 2009) (Fukuzawa and Ogawa2009). This research tries to combine the FMEA method as the screening method, with the DDP method as the scoring method. Authors already proposed the basic idea of combining scoring and screening (Isaka et al., 2015) and an integrated method of risk evaluation inspired from the FMEA method and DDP method (Isaka et al., 2016). The proposed method includes a system model to evaluate the value of the project by the influence diagram and the reverse profit diagram based on the DDP, and simulates the probabilistic value based on the Monte Carlo method (Mooney, 1997) (Hukushima and Nemoto, 1996). Then, the value simulation result is visualized by the Tornado Chart (Eschenbach, 1992) to explain the result of the impact analysis of element change.

## **Focus Point of this Research and Purpose**

In the risk evaluation process, this research assumed that the past data from old contracts can be effectively used to revise the subjective hypothesis in the value model. There are few companies for which the project is totally the first time to implement. Many companies have some experiences in similar fields or related fields of constructing infrastructure. This research focused on the utilization of such datum from old contracts. With today's improving technologies about IOT (Internet of things), companies are becoming to be able to access on many different kinds of fragmental data including qualitative and quantitative. The idea in this paper is that using these data may improve the accuracy of the scoring of the project value. Then, this paper addresses to propose a method how to improve the preciseness of the value estimation using the past fragmental data.

## **FLOW CHART OF THE PROPOSING BIDDING ASSIST METHOD**

### **Qualitative Checklist Method**

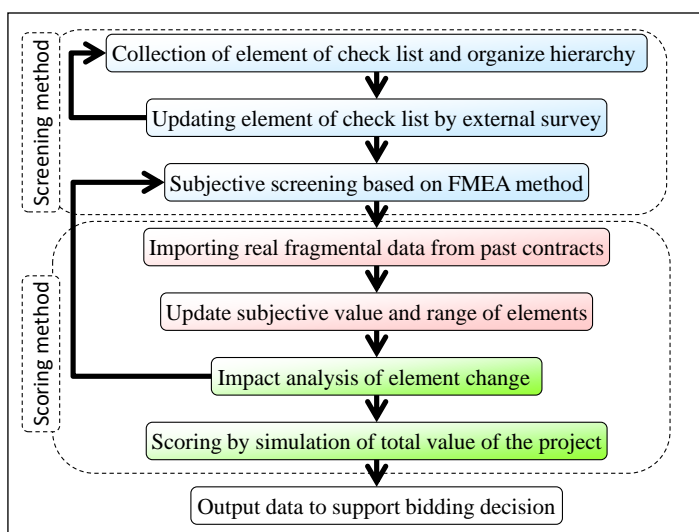
Figure 2 shows the overall process of the proposing bidding assist method for the bidding decision-makings. The first step is to collect the risk elements belonging in the construction project. In many cases, experts in the field may have this kind of knowledge through their experience. The interviewing method is an effective method to help this process. Secondly, the knowledge extracted from such experts is interpolated by the external survey.

The Five Force Analysis provides a point of view of competitor, supplier, customer, and substitutes. The Engineering Chain Analysis provides a point of view of supply chain from materials to component, system, and operation and maintenance stage. PEST analysis provides a point of view about political aspect, environmental aspect, sociological aspect, and technical aspect. From all these points of view, new elements of checklist are added to first extracted elements by interviewing experts.

### **Quantitative Scoring Method**

After screening by the qualitative checklist method, some bid could be selected for further severe consideration. The selected bid is evaluated by the scoring method and the overall value of the project is estimated. On calculation of the value of the project, the desired value and range of each variable is estimated subjectively. A fragmental data from the past contracts is imported to the value model. Based on the imported real data, the subjective value and range of each element is updated. Based on the updated precise model, the impact analysis of the design change is studied using the tornado chart. Considering some statistics variables, the Monte Carlo simulation is carried out which shows the average and the deviation of the total value of the project.

The tornado chart indicates whether the screening process is appropriate or not. Using the result of the impact analysis of the element change, the proposing method can feedback to the screening method, especially the risk assessment stage based on the FMEA method. By collaborating with the qualitative method, the qualitative evaluation result can be also revised.



**Figure 2.** Revising method of bidding decision based on fragmental data

## UPDATING ALGORITHM BASED ON FRAGMENTAL REAL DATA

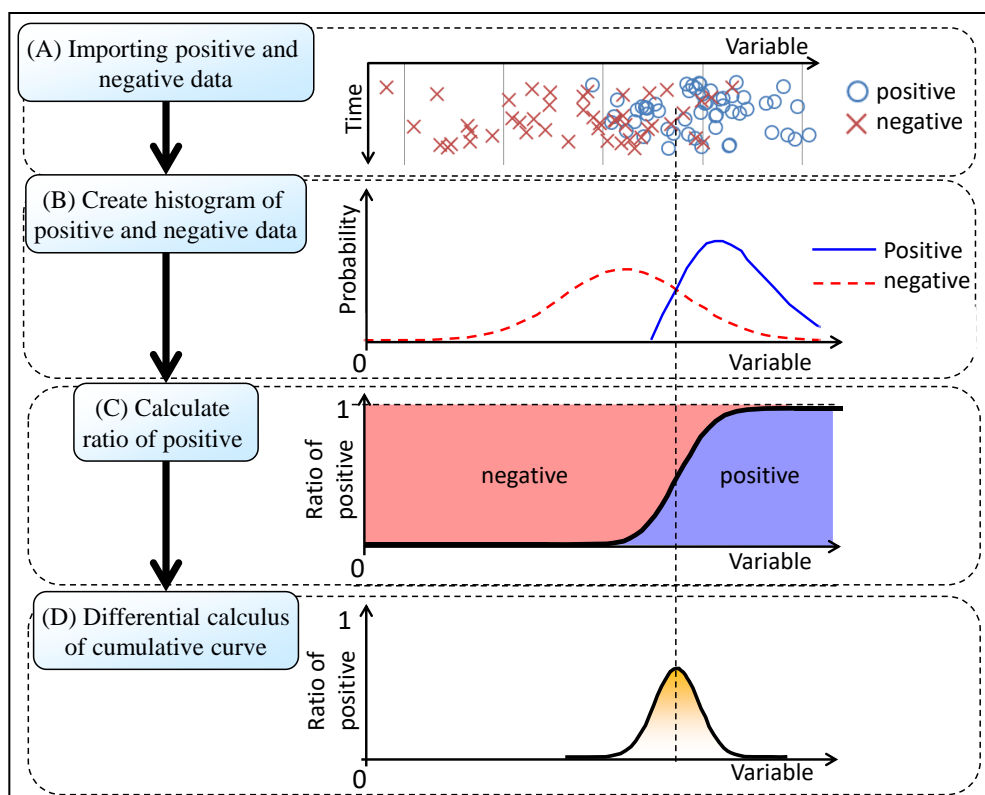
### Fragmental Real Data in Construction Project

Usually throughout one construction project, many contracts are done between the contractor, sub-contractors, and suppliers e.g. purchasing products and materials, construction equipment, hiring workers, designing and so on. These fragmental real data in the past projects is useful to prospect the value of the current focusing project. In many cases, the variety of the fragmental data is huge.

### Combining Positive and Negative Data

This research treats these variety fragmental data as in one rule: combined as one system. The rule is positive or negative. Regarding the purchasing, positive means the success of the purchasing materials/products, and negative means the sub-contractor/supplier has rejected the purchasing request. As to hiring, positive means that the candidate has accepted the salary and working conditions, and negative means that the candidate has declined the hiring offer. All events have negative and positive aspects, and there are some arithmetic variables which represent the power balance. Sometimes, the negative data is difficult to be collected compared with the positive data. Only positive data is not effective to prospect the true value of the project, because the positive data always includes some kind of margin.

Figure 3 shows the concept of how to utilize the positive and negative data. When the positive and negative data is collected (Figure 3 (A)), the histogram of both datum is calculated as in Figure 3 (B). The ratio of positive can be calculated by the collected data (Figure 3 (C)). The differential calculus of the cumulative curve represents the mean and the distribution to break even between negative and positive.



**Figure 3.** Combined distribution based on positive-negative data (Koga et al., 2016)

## Process of Revising Average Based on Real Data

Initially, the subjective mean and the deviation is defined in each element. The mean and the deviation are revised and updated by importing the real data. This paragraph describes the way to revise the mean of each value. Figure 4 represents the process of updating the mean of each hypothesis. Neighbour hypothesis is created automatically based on the initial hypothesis. In Figure 4 case, the initial hypothesis (A) is given from the subjective interviewing process. Based on the initial hypotheses (A), the new hypothesis which increases the mean of the distribution is generated (B). The odds are given to each hypothesis. The odd of the initial hypothesis is 50%, and four neighbour hypothesis share rest of 50% equally. Then, the odd of hypothesis of increasing average becomes 12.5%. This updated odd is calculated based on the Bayesian algorithms.

After receiving real data which has  $+2\sigma$  positive properties, the odds is updated newly as shown in Figure (C) (D). Table 1 represents the calculation process of the updated odds from the imported data and the current odds. The calculation process is as follows:

### (1) *Normalize the imported real data*

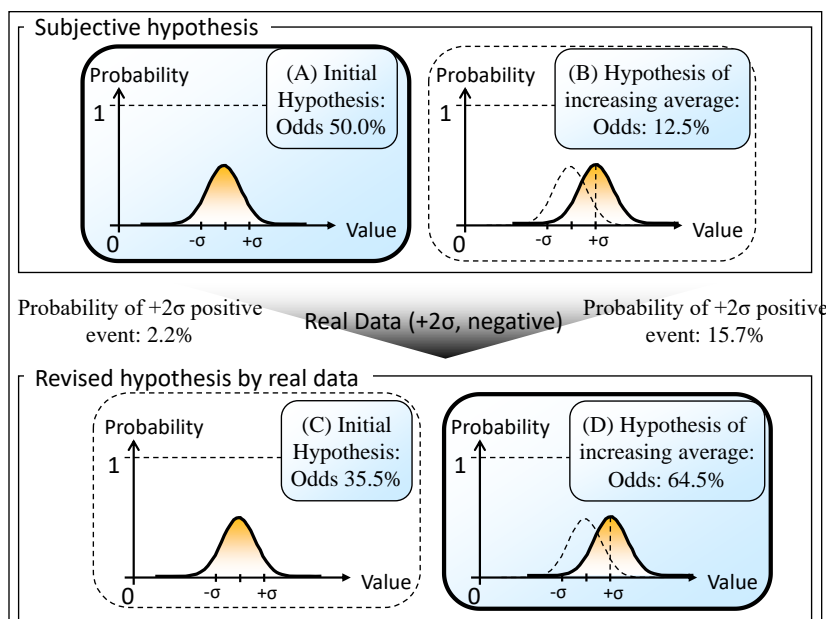
At first, the real data is imported and normalized as average is zero and distribution is  $\sigma$ .



## (2) Calculation of occurrence by cumulative curve

Second, the occurrence of each states  $C^A$  and  $C^B$  is calculated by mapping of the cumulative curve of the normal distribution. The state A represents the initial hypothesis in Figure 4, and the state B represents the hypothesis of increasing average in Figure 4.

## (3) Calculation of probability of each state



**Figure 4.** Revising average method based on real data

**Table 1.** Calculation process of new odds from imported data and past odds

Imported real data			Calculation of odds of hypothesis					
			$C^A$	$C^B$	$O^A$	$O^B$	$P^A$	$P^B$
No.	Type of event	Normalized distribution	Occurrence probability of state A	Occurrence probability of state B	Odds of state A	Odds of state B	probability of state A	probability of state B
1	positive	$+2.0\sigma$	2.2%	15.7%	50.0%	12.5%	1.1%	2.0%
2	positive	$+1.5\sigma$	6.6%	30.7%	35.9%	64.1%	2.4%	19.7%
3	negative	$+2.5\sigma$	99.3%	93.4%	10.8%	89.2%	10.7%	83.4%
4	negative	$+1.4\sigma$	92.0%	65.7%	11.4%	88.6%	10.4%	58.2%
5	positive	$-0.5\sigma$	69.0%	93.3%	15.2%	84.8%	10.5%	79.1%
6					11.7%	88.3%		

The probability of each state  $P^A$  and  $P^B$  is calculated by multiple of occurrence probability  $C^A$ ,  $C^B$  and odds  $O^A$ ,  $O^B$ . The calculated probability means that the probability of the imported data about each state A and B based on the last odds of each state. This calculation follows the Bayesian methodology.

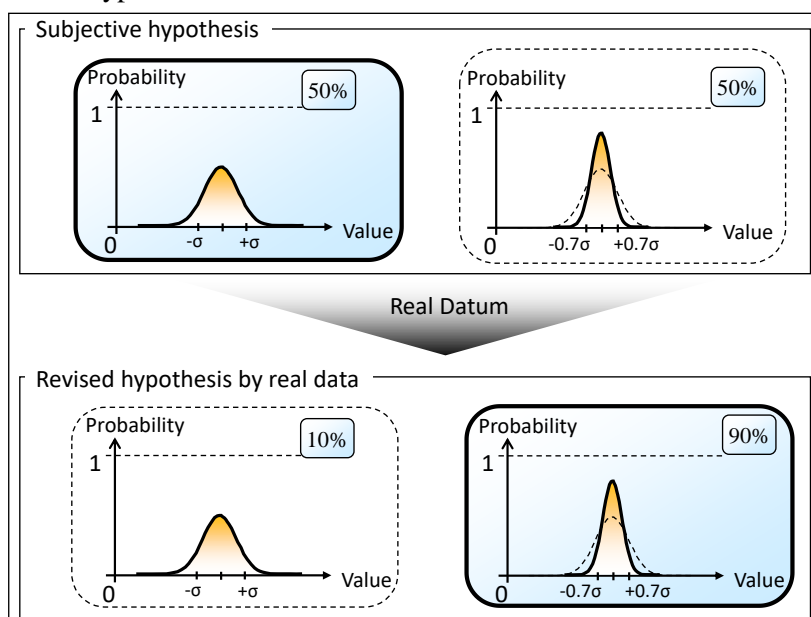
#### (4) Updating next odds

After importing the data, the odds are changed. The number of Table 1 shows the importing sequence of the real data. The next number's odds are calculated based on the previous probability of each state. The next odds  $O^A$  and  $O^B$  are defined as the ratio of each probability  $P^A$  and  $P^B$ .

Previous section represented the revising process only for average of the statistic variable. Variance of the statistic variable also may have difference between the one prospected by experts and the actual. Then, this paper also proposes an updating algorithm of the variance. Figure 5 shows the proposing method to revise the initial subjective variance by importing the real data. A neighbour hypothesis of increasing and decreasing deviation is automatically generated and the odd is given to it. The odds between the initial deviation and the neighbour deviation are updated based on the sequence of the real data.

#### Updating Method of Subjective Hypothesis Using Data

The proposed revising method for the average and the deviation of the statistic value enables us to update the hypothesis which was defined in the initial stage of the value estimation of the construction project. Figure 6 shows the updating process from the initial and the subjective hypothesis (A) to the final hypothesis (D). In this process, both the average and the deviation are updated. Firstly, the initial average which was defined by the expert interview is recognized as too small, and the new hypothesis of increasing the average is selected (B). Secondly, the deviation is recognized as too large, and the next hypothesis of decreasing the deviation is selected (C). Because the neighbour hypothesis of the average is generated based on its deviation, the distance between the current hypothesis (C) and the hypothesis of the increasing average (D) is getting close. Thirdly, more real data is imported, and the average is recognized as too small, and the neighbour hypothesis (D) is selected as the most likelihood hypothesis.

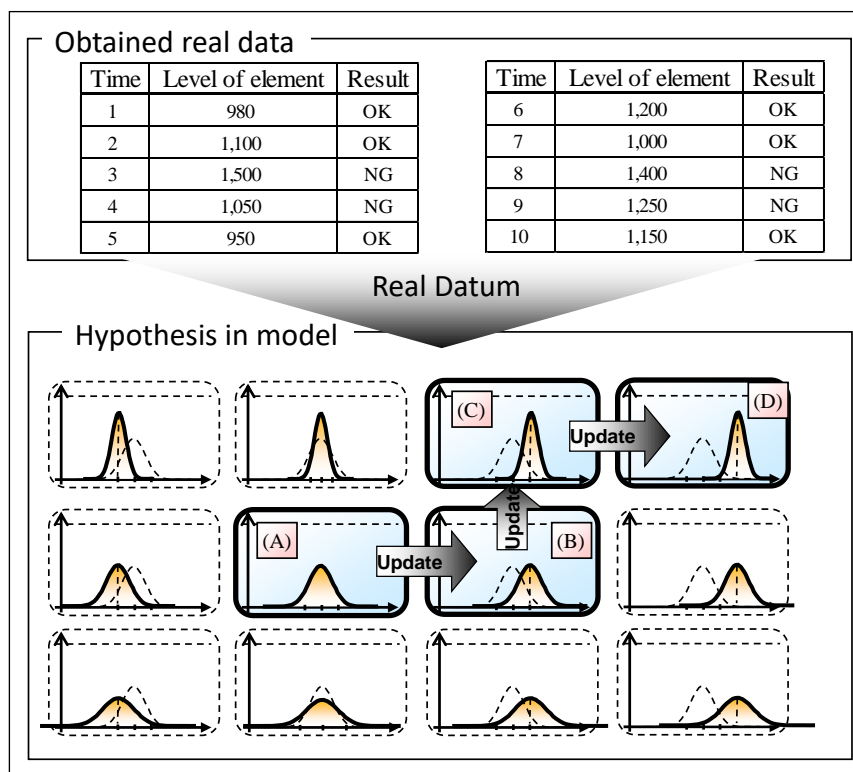


**Figure 5.** Revising method of variance based on real data

## Disremembering Algorithm of Old Data

The project environment is changing every day. Technology changes, market shifts, future economic environment is unpredictable and competitor's situation is changing. There are no environments which are the same. This is the main reason why this paper follows the Bayesian algorithm, not frequency algorithm. For frequency testing, huge size of data which is generated from totally same environment is required. In the business field, this could not happen. This means that the proposed algorithm in this paper requires disremembering method of old data.

The difference between two different environments is defined as the distance of two influence diagrams (Koga et al., 2016). This paper uses this definition of the measurement theory. Using the distance concept of environment, Figure 7 shows a filtering function for disremembering. The horizontal axis represents the ratio of disremembering of the historical real data, and the vertical axis means the time stamp of each data. When the time and the distance of environment have proportional relationship, the disremembering function has an exponential function. Human brain has two different kinds of forgetting mechanisms: (1) short memory, and (2) long memory. To emulate the short memory, this paper introduces the exponential function of the rate of disremembering. To emulate the long memory, the disremembering function has a tendency to be saturated as time passes.



**Figure 6.** Updating method of subjective hypothesis using objective data

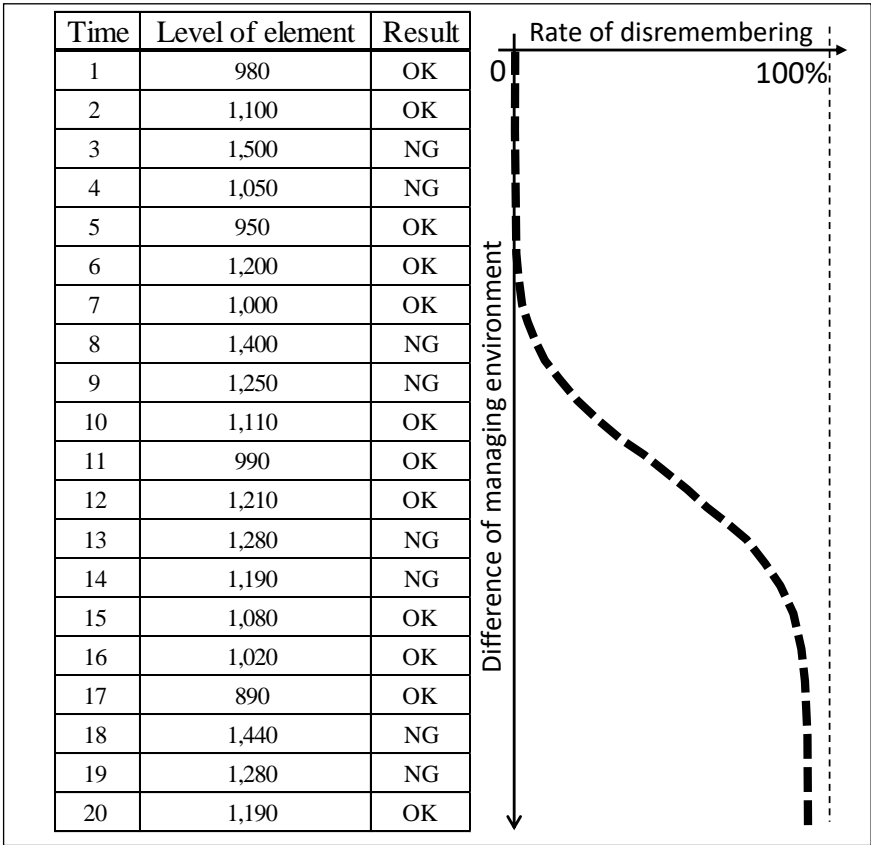


Figure 7. Appropriate disremembering based on difference of managing environment

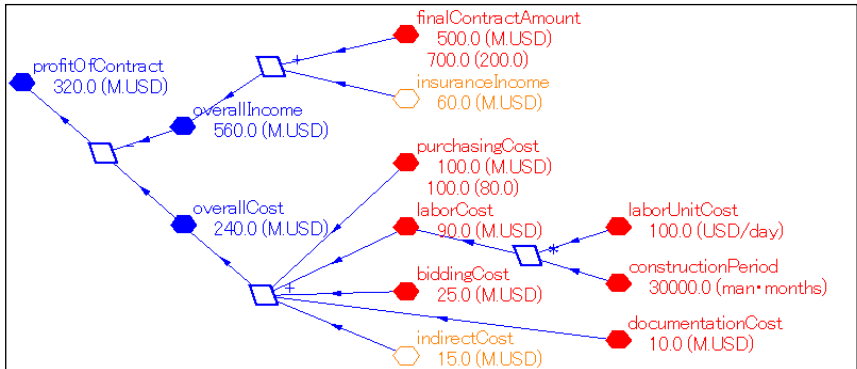


Figure 8. Reverse profit-loss diagram of an example of a subway construction project

## EXAMPLE OF VALUE ESTIMATION AND DISCUSSION

### Reverse Profit-Loss Diagram

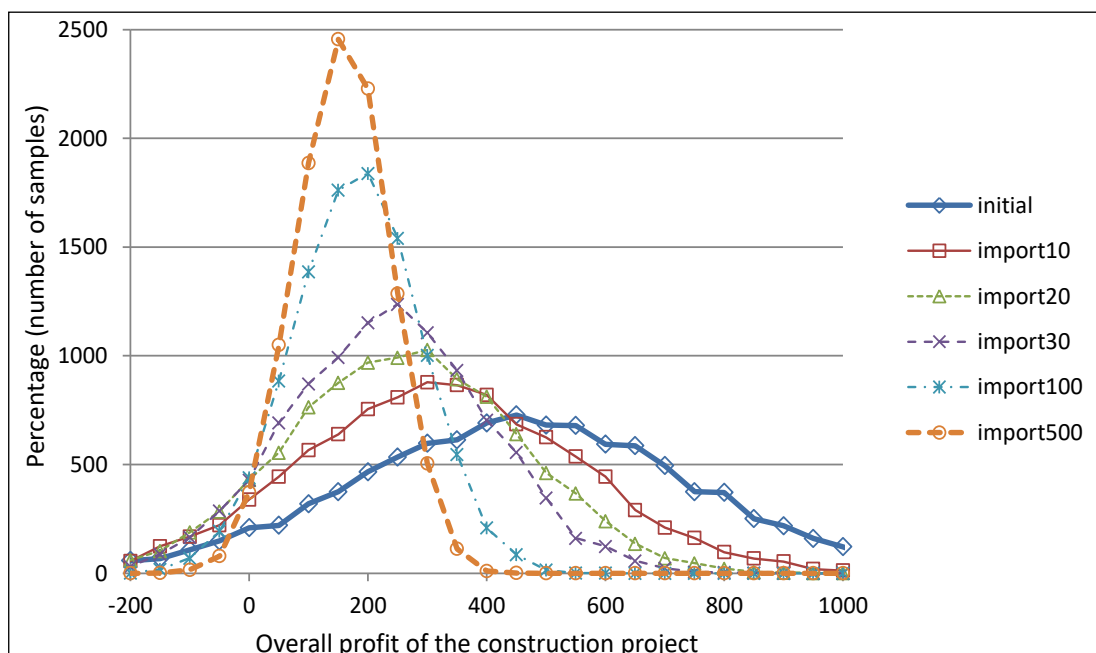
This chapter represents the application result of the proposed method to the infrastructure (subway) construction project. The construction project is based on the actual development, although the detailed numerical data is normalized to avoid the possibility of the intellectual property. Figure 8 shows the reverse profit-loss diagram to calculate the overall profit of this project. The profit is break down to income and costs, and the detailed element is defined in the branch of the income and costs.

### Importing Data and Revising the Profit Calculation

Figure 9 shows the result of importing the real-data about contracts and purchasing. Behind this calculation, an assumption that the company already has 500 number of past-contract data. The chart shown in Fig. 9 represents the overall profit in horizontal axis and possibility (by 10,000 times Monte Carlo simulation) in the vertical axis. The chart 'initial' represents the subjective estimation based on only expert's opinion. The chart 'import10', 'import20', 'import30', 'import100', 'import500' means that the revised profit calculation by importing 10, 20, 30, 100, 500 number of past contract data respectively.

### Result of Sensitivity Analysis

After importing the real data, the conceivable range of each element is changed. Figure 10 shows the result of the sensitivity analysis. The horizontal axis represents the total value of the construction project, and each impact factor is indicated in the vertical line. The upper result represents the initial result of the sensitivity analysis, and the lower result shows the result after importing 500 number of datum.



**Figure 9.** Distribution of total value of example construction project

## CONCLUSION

A systematic method to update the subjective analysis model of overall contract of massive infrastructure construction project is proposed. The application result indicates that the proposed method surely describes the elements and dependencies of the construction projects, and can calculate the overall profit from focusing contract. A numerical study based on 500 real data shows that not only the mean but also the deviation is revised by the imported data. In the example case, the deviation of the overall profit by expert's interview became reduced by importing the data. Not only shifting the average and the deviation, but also the priority was also changed. In the sensitivity analysis, the purchasing cost or the contract amount has a huge range in the initial stage, although after importing the past contract data, it became narrower than the uncertainty of the construction period and the labour cost. It means that the risk is changed according to what kind of experiences the company has. This is why the proposed method is expected to contribute to revising the precision of the profit prospection and finding what the most severe risk is.

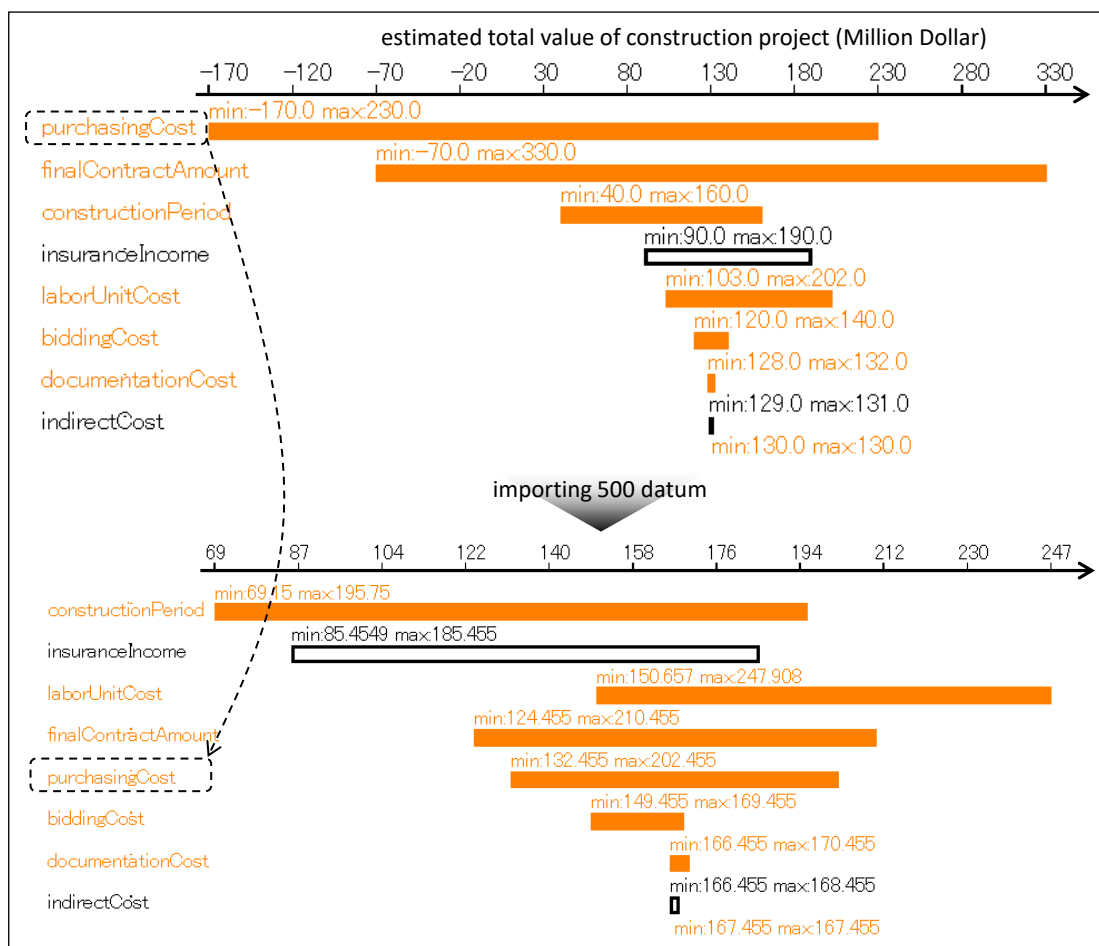


Figure 10. Impact analysis of each element change to total value of project

## REFERENCES

- Eschenbach, T. G. (1992) Spiderplots versus Tornado Diagrams for Sensitivity Analysis. *Interfaces* 22(6); 40-46.
- Fukuzawa H., Ogawa, Y. (2009) Lecture on analysis of uncertainty, First Press, Inc.
- Hukushima, K. and Nemoto, K. (1996) Exchange Monte Carlo Method and Application to Spin Glass Simulations. *Journal of the Physical Society of Japan* 65(6); 1604-1608.
- Isaka, T., Yoneda, W, and Koga, T. (2015) Proposal on Hybrid Check List Method For Bidding Decision for International Infrastructure Project, *Proceedings of the 25th conference on design and systems of Japan Society of Mechanical Engineers*, Nagano, Japan, 3105.
- Isaka, T., Yoneda, W, and Koga, T. (2016) Risk evaluation method using Scenario planning For International Infrastructure Project, *Proceedings of the 26th conference on design and systems of Japan Society of Mechanical Engineers*, Tokyo, Japan, 3201.
- Koga, T., Eguchi, T., Kaminishi K. (2016) Improving Method of Estimation Accuracy of Value of Product Development based on both of Positive and Negative Datum.

- Proceedings of International Conference on Innovation and Management (ICIM2016)*, Kuala Lumpur, Malaysia.
- McGrath, R.G. and Macmillan, I.C. (2009) *Discovery-driven growth: a breakthrough process to reduce risk and seize opportunity*. Harvard business school press.
- Mooney, C. Z. (1997) *Monte Carlo Simulation*, SAGE Publications.
- Ohtsu, H. and Ohnishi, Y. (2002) Study on risk management for contractors in the construction projects in developing countries. *Proceedings of the Japan Society of Civil Engineers* (707), 207-218, 2002.
- Wada, H. (1996) A Proposal of Product Safety Analysis Method FMFEA. *The journal of Reliability Engineering Association of Japan*, 18(2): 168-173.
- Yamasaki, Y., Yokokawa, S., and Suzuki, K. (2016) Predicting failure mode by trouble prediction table and evaluation index for reliability and safety. *The journal of Reliability Engineering Association of Japan*, 38(4): 271-283.



# MAN-HOUR ESTIMATION FOR IT SYSTEM DEVELOPMENT BY AGILE METHOD

**Hiroshi Nakanishi and Shinobu Komai**

*Management of Technology Department, Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Kuala Lumpur Malaysia*

## **Abstract**

There are two IT system software development methods named Waterfall and Agile. By the Waterfall, software making starts after all system function requirement definition is completed. By the Agile, software making starts when one of the system function requirement definition is completed. Use of the Waterfall is a major, but the Agile is sometimes used recently. There is a very few research about the man-hour in the Agile. In this paper, man-hour formula in the Agile is derived taking into account the man-hour decrease in the system function requirement definition and the man-hour increase in the software making. Comparing the man-hours in between the Waterfall and the Agile, it is made clear that the Agile is advantageous when man-hour decrease in the requirement definition is greater than the man-hour increase in the software development. This result surely gives a guideline for the selection of the Waterfall and the Agile.

**Keywords:** *IT system, Software development, Agile, Waterfall, Man-hour*

## **INTRODUCTION**

To reduce man-hours in IT system development is an extremely important issue. System development processes consist of two processes of system requirement definition and software development.

- 1) In the system requirements definition process, engineers are assigned so as to complete it adequately and shortly
- 2) In the software development phase, engineers are assigned so as to complete it adequately.

There are two major system development methods named Waterfall and Agile. In the Waterfall, the number of engineers assigned for the system function requirement definition does not change during the definition process. After the completion of the system function requirement definition, software development process starts. However, man-hours for the system function requirement definition become large because all of the engineers initially assigned for the system function definition engage in the whole definition process.

In the Agile, at every completion of definition for one of the system function requirements, software development starts for the definition completed function. And the number of engineers for the requirement definition can be reduced step by step every time when one of the function definition is completed. Hence, total man-hours for the function requirement definition can be reduced. However, software modules developed prior to the completion of total system function requirement definition sometimes subject to remaking due to the total software design correction. This results in a man-hour increase.

Which require less man-hour for the system development completion, the Waterfall or the Agile? To answer this, research has been done to formulate the man-hours in the Agile by the

authors of this paper. This paper aims to derive the formulation of the man-hours in the Agile and to compare the man-hours between the two methods.

## PRECEDING RESEARCH WORKS

Researches on the Waterfall and the Agile have been done as follows. Balaji et al. researched about the Waterfall and the Agile and clarified the pros and cons of them (Balaji & Sundararajan Murugaiyan, 2012). He mentions that the major merit of the Waterfall is that the total system function requirement definition is made clear before software making starts, while a demerit is larger amount of man-hours for the system function requirement definition. About the Agile, he mentioned that the major merit is a flexibility to respond to the changing of the system function requirements, while a demerit is that if the change of requirement is large, it becomes difficult to judge the time required for the system development completion.

Austin compared two development methods of the CMM and the Agile through the case study of the software development in a fictional company of the Harvard Business School (Austin, 2007). He mentioned that the CMM proponents pointed out the fact that some of the best software organisations in the world have used the CMM in their most important system development projects. Also he suggested that the keys for the Agile are the collaboration and commitment in the development team.

White reviewed several system dynamic models for the requirement definition process (White, 2013) and also reviewed the model of Andersson and Karlsson (Andersson & Karlsson, 2001). He proposed a new theoretical model of requirements gathering by using the Software Test Model of Cangussu (Cangussu, Member, & Decarlo, 2002) as a framework. He mentioned that the new model can be used to predict the number of the system requirements. His model can be used to operate in the Waterfall and in iterative or incremental methods (the Agile like) by selecting proper parameters such as the total number of system function requirements.

Up to now, there are no researches which formulated the man-hours of the Agile and compared the man-hours in between the two methods of the Agile and the Waterfall.

## RESEARCH RESULT

### Formulation of the Man-Hour

#### *Assumption*

Assumptions for the formulation and calculation of the man-hours are as follows.

- 1) IT system development man-hours are defined as the sum of those for the system requirement definition and for the software making. The software making processes consist of the fundamental design, detailed design, coding, testing and total testing.
- 2) The system consists of plural functions.
- 3) The number of the engineers for the requirement definition is as follows.
  - a. In the Waterfall, the number of the engineers does not change from the beginning to the end of the requirement definition.

- b. In the Agile, the number of the engineers is reduced every time when one of the requirement definition is completed.
- 4) In the Waterfall, software development starts after the full completion of the requirement definition. In the Agile, it starts every time when one functional requirement definition is completed

### *Man-hour formulation*

Below are the symbols.

N: Number of the system functions to be developed  
 K: Number of the engineers assigned for the requirement definition in the Waterfall  
 L: Total hours for the requirement definition in the Waterfall  
 i: Sequential number of the system function ( $i=1 \sim N$ )  
 Ri: Man-hours for the requirement definition of the system function i  
 R: Total requirement definition man-hours in the Waterfall  
 Di: Man-hours for the software development of the system function i  
 DPW: Total software development man-hours in the Waterfall.  
 DTW: Total system development man-hours in the Waterfall  
 P: Total requirement definition man-hours in the Agile  
 DPA: Total software development man-hours in the Agile  
 DTA: Total system development man-hours in the Agile  
 RW: Software development rework rate in the Agile

## **1. For the Waterfall**

### **1) Man-hours for the requirement definition**

The number of the system functions is N. The man-hours (Ri) for requirement definition of function i are expressed R1, R2, R3, ..., RN.

So, the total requirement definition man-hours R can be expressed by the equation (1).

$$R = \sum Ri \quad (1)$$

Also using K and L, R can be expressed by the equation (2).

$$R = K \times L \quad (2)$$

### **2) Total software development man-hours**

Total software development man-hours DPW can be expressed by equation (3).

$$DPW = \sum Di \quad (3)$$

### **3) Total system development man-hours**

$$DTW = K \times L + DPW \quad (4)$$

## 2. For the Agile

### 1) Total requirement definition man-hours in the Agile

In the Agile, it is assumed that the number of the engineers for the requirement definition is  $K$  at the beginning and can be reduced uniformly by  $K/N$  every time when the requirement definition of one of the system functions is completed. Also, it is assumed that the hours for the completion of the requirement definition of the system function  $i$  is  $L/N$ . They are;

- a. 1st function requirement definition man-hours are  $K \times L/N$ ,
- b. 2nd function requirement definition man-hours are  $(K - K/N) \times L/N$ ,
- c. 3rd function requirement definition man-hour as  $(K - 2K/N) \times L/N$ .
- 
- z. Nth function requirement definition man-hour as  $(K - (N-1) K/N) \times L/N$ .

As is clear from above, the requirement definition man-hours  $R_i$  for the function  $i$  can be expressed by equation (5) in the Agile.

$$R_i = (K - (i-1) K/N) \times L/N \quad (i=1, 2, 3, \dots, N) \quad (5)$$

So, the total man-hours for the completion of system requirement definition in the Agile can be obtained by the summation of  $R_i$  from  $i=1$  to  $N$  as expressed by the equation (6) and (7).

$$P = \sum R_i \quad (i=1, 2, 3, \dots, N) \quad (6)$$

$$= K \times L(1/2 + 1/(2N)) \quad (7)$$

It can be understood that the total man-hours for the completion of system requirement definition in the Agile are almost one half of those for the Waterfall in the case that  $N$  is very large to 1.

### 2) Total software development man-hours in the Agile

In the Agile, the programs which have already developed after the completion of the function requirement definition sometimes subject to software remaking due to the program design correction for the remaining functions. This remaking is just the rework of the software development. Re-designing and remaking of the developed programs arise.

Using the rework rate of  $RW$ , total software development man-hours  $DPA$  in the Agile can be expressed by the equation (8) where  $DPW$  is the total software development man-hours in the Waterfall.

$$DPA = DPW \times (1 + RW) \quad (8)$$

### 3) Total system development man-hours in the Agile

Summing P and DPA, shown above equations of (7) and (8), total system development man-hours DTA can be expressed by equation (9).

$$DTA = K \times L(1/2 - 1/(2 \times N)) + DPW \times (1 + RW) \quad (9)$$

### Comparison of the total system development man-hours in the Waterfall and the Agile

#### *Man-hour comparison by using the equations*

Here, it is clarified by deriving comparison equation which development method is better to reduce the total system development man-hours by using the equations (4) and (9). Following inequality (10) is solved to obtain the rework rate of RW which realizes the system development with smaller amount of man-hours in the Agile.

$$K \times L(1/2 + 1/(2 \times N)) + DPW \times (1 + RW) \leq K \times L + DPW \quad (10)$$

Solving the inequality (10), inequality (11) is derived where R is  $K \times L$ .

$$RW \leq (R / DPW) \times (1/2 - 1/(2 \times N)) \quad (11)$$

The inequality (11) gives important understandings about the Agile development.

- 1) To reduce man-hours by the Agile, the rework rate should be equal or less than half of the man-hour ratio of the total requirement definition to total software development in the Waterfall.
- 2) The rework rate becomes large in proportion to the ratio of the total requirement definition to the total software development in the Waterfall.

#### *Example of man-hour calculation*

For the calculation of man-hours in two methods of the Waterfall and the Agile, specific values are set as in the following.

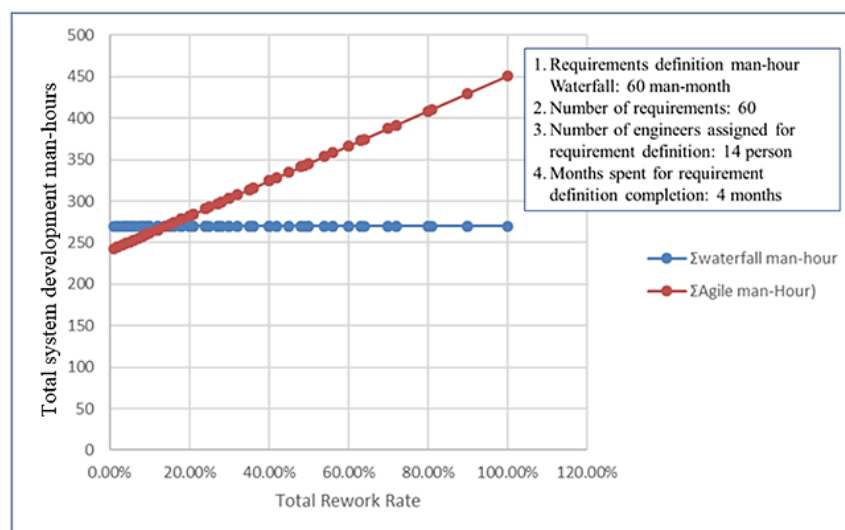
- a) Number of system functions N: 60
- b) Number of engineers assigned for the requirement definition in the Waterfall K: 16
- c) Hours for the completion of the requirement definition in the Waterfall L: 4 months
- d) Total requirement definition man-hours in the Waterfall R; 60 Man-months
- e) Total software development man-hours in the Waterfall DPW; 210 Man-months

From above, total system development man-hours in the waterfall is 270 in Man-months. Values of the man-hours of total requirement definition and the total software development in the Agile can be calculated by using the equations of (7) to (10).

Using the values shown above, the total system development man-hours were calculated using the rework rate as a variable. The result is shown in Figure 1.

From Figure 1, followings can be understood.

- 1) In the Agile, total system development man-hours increase in proportion to the rework rate.
- 2) In the Waterfall, total system development man-hour remain the same as it has no relation to the rework rate.
- 3) Total system development man-hours in the Agile are smaller than those in the Waterfall when the rework rate is below 16 percent. This conforms to the result of equation (12).



**Figure 1.** Total system development man-hours versus rework rate.

## DISCUSSION

### About the formulation of total system development man-hours in the Agile

In this paper, it is assumed that the number of engineers is reduced in the system requirement definition (SRD) in the Agile. This is reasonable for the system whose functions are not so closely related to each other. How about the assumption of linear reduction in the number engineers as SRD proceeds? This is also reasonable in case that the software development starts after the confirmation about the completed SRD of one of the functions between the system ordering side and system development side. However, it is very difficult to judge if the system functions are not so related to each other at the initial stage of SRD. So, it is important to know about the relations between the system functions through the discussions between the ordering side and development. If close relations are anticipated through the discussion, it is necessary to evaluate how closely the system functions are related at the beginning.

## About the turning-point between the Waterfall and the Agile

The turning-point between the Waterfall and the Agile stands on the rework rate in the Agile. Below, the rework rate at the turning-point is calculated by using the inequality (10). 3 systems which were developed by the Waterfall are selected to calculate the rework rate at the turning-point. Outlines of these 3 systems are clarified by Komai, et al. (2016). Values of N, K, L and DPW spent for the system development of these 3 systems are shown in Table.1.

**Table 1** Characteristics and development man-months in the Waterfall

Items	System 1	System 2	System 3
N: Number of the system functions to be developed	3	11	101
K: Number of engineers for requirements definition in the Waterfall	2	2	17
L: Total hours for requirement definition in the Waterfall	1.1	3.5	6
DPW: Total software development man-months in the Waterfall	6	22	510
Calculated turn-over rework rate	6%	14.5%	10%

The turn-over rework rate can be calculated by setting the left-hand side to be equal to the right-hand side of the inequality (11). Calculated results are written in the last row of Table 1.

From table 1, followings can be understood.

- 1) The turn-over rework rates for the system 1 and 3 are 6 and 10 in percent and smaller than 10 percent.  
These are due to the requirement definition man-hours are small compared to the software development man-hours.
- 2) The turn-over rework rate for the system 2 is 16 percent and relatively large.  
This is due to the ratio of the requirement definition man-hours to the software development man-hours is larger than those of other 2 systems.

## CONCLUSION

This research clarified an estimation method of man-hours for IT system development in the Agile. This research can be concluded as in the following.

- 1) To formulate man-hours for IT system development in the Agile, 2 reasonable things were assumed as below.
  - a. In the Agile, the number of engineers assigned for system requirement definition is reduced every time when one of the requirement definition is completed while the number of engineers remain same in the Waterfall.
  - b. In the agile, software development starts every time when one of the requirement definition is completed while software development starts after all of requirement definition is completed.
- 2) Man-hours for IT system development in the Agile were formulated by defining the rework rate which means the rate of the reprogramming of the software developed prior to the full completion of requirement definition.

Finally, total system development man-hours DTA in the Agile can be expressed by the following equation

$$DTA = K \times L(1/2 - 1/(2 \times N)) + DPW \times (1 + RW)$$

Where K, L, N, DPW and RW are defined as follows.

K: Number of engineers assigned for the requirement definition in the Waterfall

L: Total hours for the requirement definition in the Waterfall

N: Number of the system functions to be developed

DPW: Total software development man-hours in the Waterfall

- 3) Turning point of the man-hours between the Agile and Waterfall stands on the rework rate in the Agile and expressed as follows.

$$RW = (R / DPW) \times (1/2 - 1/(2 \times N))$$

Where R equals to Kx L.

## REFERENCES

- Andersson, C., & Karlsson, L. (2001). *A System Dynamics Simulation Study of a Software Development Process*. Coden:Lutedx(Tets-5419).
- Austin, R. D. CMM versus Agile: Methodology Wars in Software Development, Harvard Business School 1–17 (2007).
- Balaji, S., & Sundararajan Murugaiyan, D. M. (2012). Waterfall Vs V-Model Vs Agile: A Comparative Study on SDLC. *International Journal of Information Technology and Business Management*, 2(1), 26–30. Retrieved from <http://jitbm.com/Volume2No1/waterfall.pdf>,
- Cangussu, Ä. W., Member, S., & Decarlo, R. A. (2002). A Formal Model of the Software Test Process. *IEEE*, 28(8), 782–796.
- Kniberg, H. (2013). *The Pragmatic Programmers - Lean from the Trenches: Managing Large-Scale Projects with Kanban*. Ohmsha.
- Komai, S., Saidi, H., & Nakanishi, H. (2016). Study on Critical Success Factors Estimation in IT System Development. *Sains Humanika*, 9(1–3). <http://doi.org/http://dx.doi.org/10.11113/sh.v9n1-3.1139>
- White, A. S. (2013). A control model of the software requirements process. *Kybernetes*, 42(3), 423–447. <http://doi.org/10.1108/03684921311323671>



# STRATEGIES TO IMPROVE COST AND TIME CONTROL USING BUILDING INFORMATION MODEL (BIM); CONCEPTUAL PAPER

Muhammad Tahir Muhammad<sup>1</sup>, Nuzul Azam Haron<sup>1</sup>, Aidi Hizami Alias<sup>1</sup>, Aizul Nahar Harun<sup>2</sup>

<sup>1</sup>Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

<sup>2</sup>Department of Management of Technology, Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia

## Abstract

The demand for the use of a more advanced technology to manage projects information all through their life cycle is very important. An increase in construction sector productivity also means employing modern construction technologies, such as improved and increased mechanisation and such technologies as Building Information Model and Industrialised Building Systems. More also, it is important that skills are improved and intensify to raise productivity that can handle more sophisticated building methods. Presently it is believed to a large extent that the emergence of Building Information Model (BIM) can lead to better productivity in the industry. However, BIM as an alternative technology in Malaysia need to be studied to provide proof that it can satisfy the industry's need to improve on cost and time control. The aim of this research is to develop strategies that will be used to improve cost and time control in the industry through the use of BIM. This will be achieved through the use of a mixed method of enquiry (semi-structured interview and questionnaire).

**Keywords:** *Building Information Modelling (BIM), Causes of cost overrun, Cost and time control, Cause of delay.*

## INTRODUCTION

Control of cost and time in a construction is a standout amongst the most critical issues in development since the advent of the industry (Minchin Jr et al., 2013). In this light, an effective project ought to meet the quality yield norms, as well as the time and spending targets. Time and cost controls are key criteria for the achievement of any project. Notwithstanding, delay of construction work finishing are exceptionally common in the industry, such delays are because of issues of inadequate cost and time control (Forbes and Ahmed, 2010). The core aim of cost and time control in is to guarantee that projects are done on time and this is feasible through consistent estimation of progress, assessment of engagements and taking suitable steps on the project as it progresses (Kerzner, 2013). Buttressing this likewise is the project management body of knowledge (PMBOK) which proposes that with a specific end goal to accomplish the benchmark targets of any project, there must be an effective checking on project cost and time control (PMI, 2013).

However, construction industry has numerous branches as it layers, and in that capacity it contains much data about construction projects. These data are vital to projects, and can be the fundamental establishment for making decisions, purchases, and joint efforts. The accomplishment of a fruitful project requires cost administration among different elements to be considered before the initiation of the project (Shenhar et al., 2001). However, construction industry globally are littered with high profiled projects which are confronted with delays and cost overrun (Smith, 2014).

Presently, a number of tools that can be used for cost and time control have been developed (Mohd-Nor and Grant, 2014), some of which differ for their functions, and some are mostly designed for particular type of projects (Yamin and Harmelink, 2001). Tools such as Earned Value Management (EVM), Gantt Bar Chart, Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) (John, 2003, Lester, 2003). More also, different software have been developed to assist in the use of these project control tools such as Microsoft Project, Primavera, Asta Power Project etc. Regardless of these tools and software packages, construction projects still suffer delays and cost overruns.

However for project cost and time control, the industry have put up lots of effort techniques considering only quantitative factors, but ignoring the qualitative factors (Zhang and Gao, 2013). A research conducted by CIOB in 2008 indicated that the growth in training, education and skill levels within the construction industry in the use of time management techniques has not kept pace with the technology available. The emergence of new technology is believed to solve or minimize the issues relating project cost and time control. Furthermore it is also believed that the emergence of Building Information Model (BIM) can lead to greater efficiency by means of increasing collaboration (Zhang and Gao, 2013).

Aranda-Mena et al. (2009) stated that, *“For some, BIM is a software application, for others it is a process for designing and documenting building information, for others it is a whole new approach to practice and advancing the profession which requires the implementation of new policies, contracts and relationships amongst project stakeholders.”*

A widely cited definition of BIM is provided by the US National Institute of Building Sciences (2007) which defined it as *“a digital representation of physical and functional characteristics of a facility, and a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition”*.

Similarly, the McGraw-Hill (2009) *“The Business Value of BIM” Report [2009]*, a commonly referenced document by contractors, defines BIM as, *“the process of creating and using digital models for design, construction and operations of projects.”* This report mainly defines the contractors' perspective in defining BIM.

For the purpose of this research, the definition credited to the National BIM Standard (NBIMS) Project Committee of the Building SMART alliance (2010) will be adopted, which defines it as, *“a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward. The BIM is a shared digital representation founded on open standards for interoperability”* (Succar, 2009).

Building information model (BIM) is an optional way to deal with construction design, it does not just make less demanding the computerized representation for plans, but also all the fundamental data for any project before it is constructed. Not only is BIM resourceful design tool, it might fundamentally modify the way a construction project will be secured, built, and managed (Xiao and Respectable, 2014). The data in BIM models is exceptionally helpful and can be dissected to upgrade the design, planning and construction processes (Azhar, 2011). BIM is an innovatively improved approach that upgrades digital representation, storage,

management and sharing of building data in a way that permits access to the project database all through its lifecycle (Eadie et al., 2013).

According to Bryde et al. (2013), BIM is an appropriate tool for project managers and should be considered by the project management profession as a way to help manage construction projects. BIM has been so far proved to be a beneficial technique in construction industry, which has allowed it users in reducing uncertainties and achieving successful completion of a project. BIM can be applied on all the stages of construction processes starting from planning to operation and maintenance. Major advantages of BIM are improved scheduling, improved drawing coordinated, controlling time and cost and single detailed model (Memon et al., 2014).

## **Problem Statement**

The Malaysian construction industry contributed 10 to 12 per cent to the national gross domestic product (GDP) in the fourth quarter of 2015 in Malaysia (D.O.S, 2016). Increasing construction sector productivity also means employing modern construction technologies, such as improved and increased mechanization and such technologies as Building Information Model and Industrialised Building Systems. While the labour productivity of the construction sector is expected to rise to RM61,939 per worker by 2020 from RM39,116 in 2015. It therefore becomes very necessary that skills are improved and intensify to raise productivity that can handle more sophisticated building methods (CIDB, 2016).

The construction industry drives economic growth and development in Malaysia, but unfortunately, its projects often suffer from delays and cost overruns. The construction industry in Malaysia faces lots of trouble from cost and time overruns that transform what should have been successful projects, into those projects incurring additional costs, disagreements, litigation and in some cases abandonment (Kaming et al., 1997; Ofori, 1991; Ofori, 1993; Ramanathan et al., 2012; Shehu et al., 2014; Ting et al., 2009). A study on 359 projects estimated to cost billions of Ringgit was conducted in Malaysia in 2009, it found out that only 42 per cent out of the total projects were completed within the budget (Endut et al., 2009).

According to studies conducted on delays and cost overrun in Malaysian construction industry projects, time and cost performance is an important issue that need to be addressed in the construction industry (Alaghbari et al., 2007; Bazjanac, 2006; Ramanathan et al., 2012; Sambasivan and Soon, 2007; Shehu et al., 2014; Ting et al., 2009). As a result of this, there is a demand for the use of a more advanced technology to manage projects information all through its life cycle. Presently it is generally believed that the emergence of Building Information Model (BIM) can lead to greater efficiency by means of increasing collaboration (Zhang and Gao, 2013). However, BIM as an alternative technology in Malaysia need to be studied to provide proof that it can satisfy the industry's need to improve on cost and time control. It is also important to further find out how cost and time control can be improved using BIM technology.

## Research Objectives

The aim of this research is to study how cost and time control can be improved in construction industry upon the use of BIM technology. To achieve the aim of this study, the following specific objectives have been defined:

- To determine and rank the different causes of delay and cost overrun in Malaysian construction industry.
- To identify the main application areas of BIM in project management.
- To develop strategies to improve cost and time control using BIM in Malaysia.

## Significance of the Study

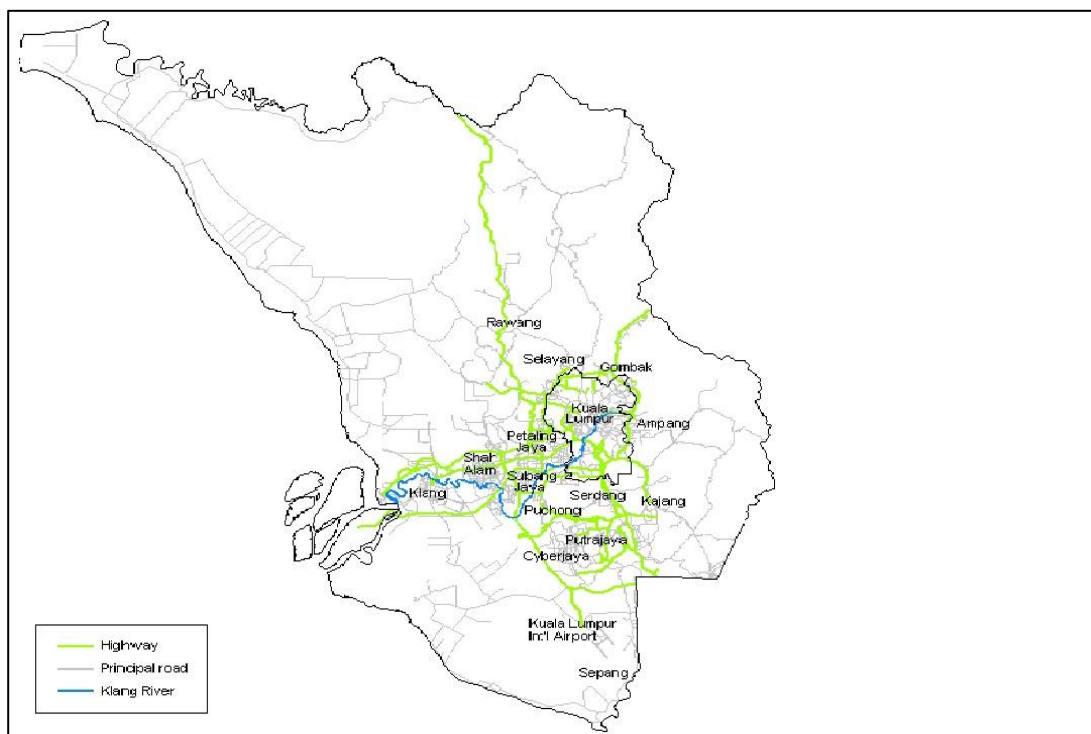
Building information model is changing the construction industry to a high productivity and high technology driven industry (Succar, 2009). Similarly, BIM has a great potential to be used by all the major stakeholders involved in a construction project. BIM technology can be used by the client to know the needs of the project, the design team make use of it to design, analyse and develop the project, and the contractor makes use of it to manage the construction phase of the project and finally by the facility manager for operation and maintenance of the project.

This research is significant as it is just in time in Malaysia and only few researches done to know its application in construction management Malaysia. This research is intended to investigate how BIM can be used to improve project cost and time control through the use of qualitative and quantitative approach. Another significance of this study is that at the end of the research, a new strategy will be developed to help improve on cost and time control in construction using BIM technology. At the end of the research, the result is expected to benefit all the stakeholders in the construction industry especially the project management practitioners through the provision of an insight on the barriers to cost and time control and how to solve the issues using BIM technology in Malaysia.

## Scope of the Study

This research will be primarily concerned with investigation on the causes of delay and cost overrun in construction and the application of building information model (BIM). The causes of delay and cost overrun will be investigated, analysed and ranked to know those that occur more in the construction industry. Data for this study will be obtained using questionnaire from construction contractors with G7 rating who are members of CIDB in Selangor (Klang Valley).

The study will also investigate the application and benefits of using BIM in construction industries. Data for this investigation will be obtained from academicians, project managers, and contractors who have knowledge of BIM. The result from both of the investigation will be correlated to determine the relationship between the two. The result from the analysis will be used to develop a new strategy for improving cost and time control in the construction industry using BIM. It is important to note that this research will not cover the control of quality.



**Figure 1:** Map Showing Klang Valley (Wikipedia, 2016).

## LITERATURE REVIEW

The review of relevant literature will evaluate critically the concepts that are been investigated in this research, which are project management, cost control, time control, existing issues on cost and time control in the construction industry, current methods of project time and cost control, building information model application are to be reviewed. These concepts are integrated and directed to relate to the research problem. Thus, in this chapter, the researcher examines, compare and contrasts previous researches done on cost and time control and analyse the selected literatures to concentrate on cost and time management in BIM technology.

### Project Time Control

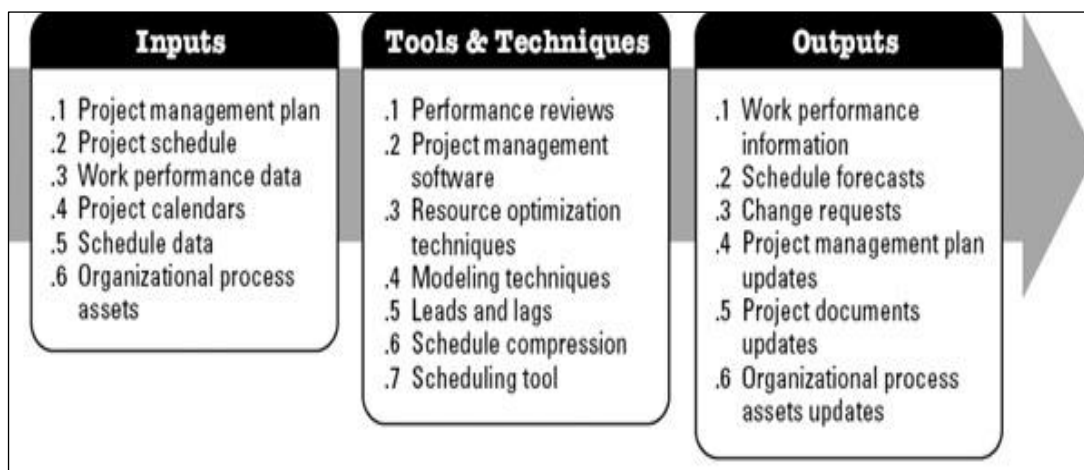
Project time control is the process of monitoring the status of project activities to update project progress and manage changes to the schedule baseline to achieve the plan (PMI, 2013). This process has a key benefit as it provides the means of recognising deviations from the actual plan and taking corrective and preventive measures and as such reduces the risk. The period of time it will take for the execution of a project is most times very important to the parties involved (Zhang, 2012). However, it is common around the world especially in developing countries and underdeveloped countries that project are most times not completed on time (Nassar et al., 2005).

Olawale and Sun (2010), in their research work titled “*Importance of Cost and Time in Construction Project: Inhibiting Factors and Mitigating Measures in Practice*”, conducted a questionnaire survey and found out that 58% of the respondents make use of time control in their projects all the time. While only 11% of the respondents said they seldom or do not apply time control to their projects. From the result above, one can say that it is important to apply time control to projects.

Many researches have been carried out to find solutions in reducing the difference between the scheduled time and the actual time taking to complete a project. Presently, there exist a number of tools that are used for time control for projects, most of them which have disparity in their functions while some are project specific (Yamin and Harmelink, 2001). Research work are still on seeking for a unified standard that will integrate the tools (Cho et al., 2010).

### *Project Time Control Process*

Project time control process involves three main parameters which are the inputs, tools and techniques, and outputs. This process is represented in the figure below.



**Figure 2:** Inputs, tools & techniques, and outputs (PMI, 2013).

## **Project Cost Management**

Project Cost Management involves planning, estimating, budgeting, financing, funding, managing, and control of cost processes to ensure the completion of the project within the approved budget. It is primarily concerned with the cost of the resources needed to complete project activities. These processes are the design of plan cost management, estimation of cost, determining budget for the project, and control of cost (PMI, 2013).

### *Project Cost Control*

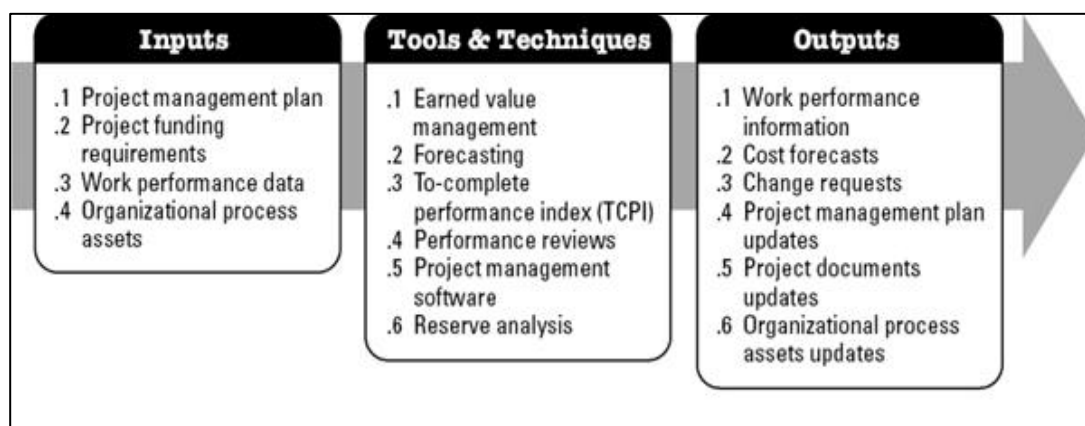
Project cost control is the process of monitoring the status of the project to update the project costs and managing changes to the cost baseline. This provides means for the recognition of variance from the plan so as to take corrective actions and reduce risk. It is

important for all companies to control cost irrespective of their sizes, it should be performed by all personnel who incur cost. According to Zhang (2012), project cost control is a vital ingredient for a successful project.

About 84% of companies and organisations make use of cost control in their various projects (Olawale and Sun, 2010). This shows how important the use of cost control techniques are in project environments. According to Gould (2005), there is need for effective cost control as it is difficult to estimate the exact cost to complete a project due to the presence of numerous factors that need to be considered.

### *Project Cost Control Process*

Project cost control process involves three main parameters which are the inputs, tools and techniques, and output. The process and its parameters are represented in the figure below.



**Figure 3:** project cost control: Input, Tools & Techniques, and Output (PMI, 2013).

### **Conventional Project Time and Cost Control Tools.**

There have been several tools developed by researchers for controlling time and cost resources in the construction industry. Most of this tools have limitations as some are project or industry specific and cannot be applied to other projects (Ismail et al., 2013). Tools used for project cost and time control also are:

- Forecasting
- To-Complete Performance Index (TCPI)
- Variance Analysis
- Performance Reviews
- Gantt Bar Chart
- Milestone Date Programming Techniques
- Earned Value Management (EVM)
- Program Evaluation and Review Technique(PERT)
- Elementary Trend Analysis/Line of Balance Method (LOB)
- Precedence Network Diagram
- Simulation
- Critical Path Method (CPM)

More also, there are computer software used for project cost and time control. This software are used for instantaneous mathematical computation of cost and duration of activities. This software includes: (a) Primavera Project Planner, (b) Microsoft Project, (c) Asta Power Project, (d) Microsoft Excel, (e) Project Commandar, (f) Deltek Open Plan.

## Causes of Delay and Cost Overrun in Construction Projects

It is important to note that the study of the different causes of delay and cost overrun in Malaysia construction projects has been carried out by many researchers also. Delay factors such as shortage of materials, change orders, delay in payment of suppliers, poor management of site, and late submission of drawings are the main causes delay (Abdul Kadir et al., 2005; Ramanathan et al., 2012). Alaghbari et al. (2007) conducted a study on the causes of delay and the results were analysed to rank the causes of delay. The researcher found out that financial problems and coordination problems are the two most important factor causing delay in construction projects in Malaysia.

Sambasivan and Soon (2007) conducted a research using questionnaire to describe the 10 main causes of delay in Malaysian construction projects which include poor site management, late payment, labour supply, improper planning, lack of experience, problems with subcontractors, and shortage of materials. While Al-Tmeemy et al. (2012) listed several causes of delay in Malaysia to include; labour productivity, slow decision making, inflation, material delivery, and insufficient equipment. Shehu et al. (2014) stated that contract delays are predominantly caused by the contractors and are factors associated with finance.

Ahmed (2003) and Al-Aghbari (2005) in their separate research, classified the factors causing delay and cost overrun in Malaysian construction projects into four (4) as shown in the table below.

**Table 1:** Showing the classification and factors causing delay and cost overrun.

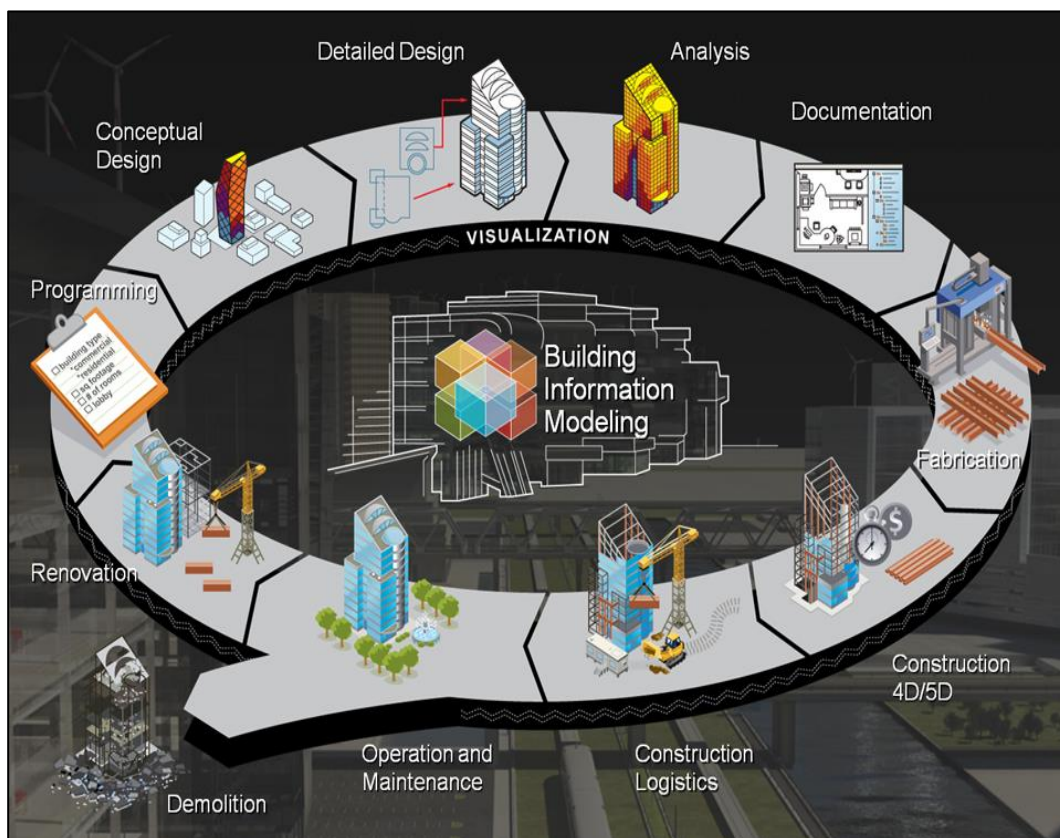
S/No.	Classification	Factors
1	Contractors responsibilities	Delay in delivery of materials to site; Shortage of materials, equipment, and tools on site; Construction mistakes and defective work; Poor skills and experience of labour; Shortage of labour; Low productivity; Financial issues; Poor coordination and site management; Lack of subcontractor's skills; Lack of site contractor's staff.
2	Consultant's responsibility	Absence of consultant's site staff; Lack of experience of the consultant; Lack of experience of the consultant's site staff; Delayed and slow supervision in taking decisions and giving instruction; Incomplete documents.
3	Owner's responsibility	Lack of working knowledge; Slowness in making decisions; Lack of coordination with contractors; Change in scope; Financial issues.
4	External factors	Lack of materials, equipment, and tools in the market; Poor weather conditions; Poor site conditions; Poor economic conditions; Changes in laws and regulations; Transportation delays; External work due to public agencies.

## Concept of Building Information Model (BIM)

BIM is basically a 3D digital representation of a facility. The model could be used in expressing the entire facility life-cycle. The quantity of material and it properties can be easily obtained, and the scope of work required can easily be defined and isolated from the model. Contract documents, drawings, procurement details, specifications, and other construction documents can easily be interrelated using the model (Bazjanac, 2006; Khemlani, 2007). The



model which is data rich, object-oriented, intelligent, and a digital representation of the facility in which drawings and appropriate information for various stakeholders can be extracted for project delivery and decision making (Rogers et al., 2015). It integrates architectural, structural, Mechanical, Electrical and Plumbing (MEP) models (Smith and Edgar, 2008).



**Figure 4;** BIM concept (BuilderStorm, 2016)

According to the BIM industry group (BIWG) (2011), it defined the levels of BIM from level 0-3 as;

- Level 0: unmanaged CAD which is most likely 2D, with paper (or electronic paper) as the exchange mechanism.
- Level 1: managed CAD in 2D or 3D format using BS1192:2007 (collaborative management process) with a collaboration tool providing a common data environment, standard data structures, and formats most likely.
- Level 2: BIM has been defined in the UK as a “*Managed 3D environment held in separate discipline ‘BIM’ tools with attached data. Commercial data managed by an Enterprise Resource Planning application (ERP). Integration on the basis of proprietary interfaces or bespoke middleware could be regarded as ‘pBIM’ (proprietary). The approach may utilise 4D programme data and 5D cost elements as well as feed operational systems*”.
- Level 3: BIM is defined as “*Fully open process and data integration enabled by web services compliant with emerging industry foundation class / international framework for dictionaries (IFC/IFD) standards, managed by a collaborative model*”.

server. It could be regarded as iBIM or integrated BIM potentially employing concurrent engineering processes”.

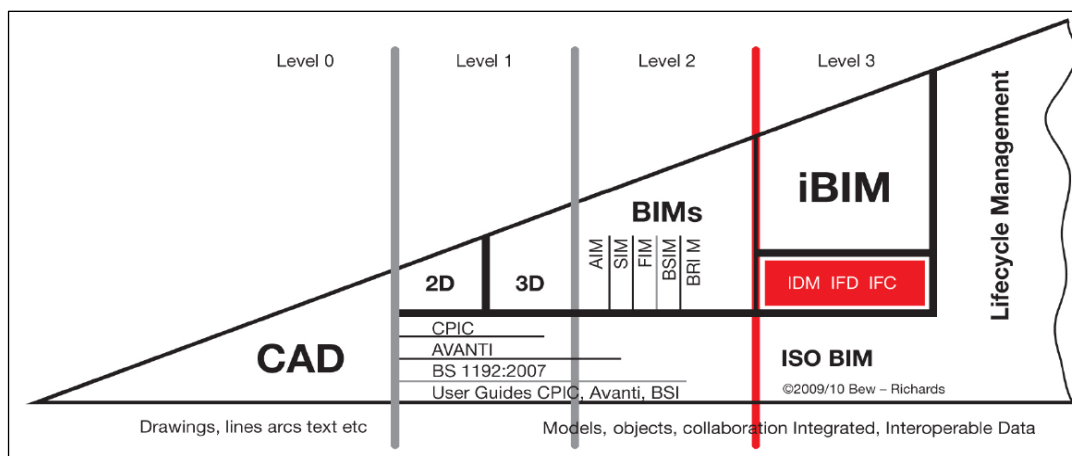


Figure 5; BIM levels (Applecore, 2016)

### BIM Tools

A lot of tools are being developed as a result of the spread of the concept of BIM in achieving its perspectives. These tools are used for management of construction projects. Most of these tools are designed for specific purposes to meet the need of it users, while few are designed for multiple functions and information collection. The type of tool to be used depends on the purpose, user, and stage in which it will be used. BIM tools enable 3D modelling and the management of information. This makes the adoption of BIM technology more than just changing to the use of software that supports it. The use of these tools makes BIM a unified system which interacts with all its parts. The table below shows BIM tools, manufacturer and its function.

Table 2: BIM Tools

Manufacturer	Tool	Function
AutoDesk	Navisworks	To manage 3D model-based design and clash detection.
Bentley	Bentley Navigator	Dynamic coordination between models and disciplines.
Vico Software	Vico Office	Analysis of various 3D models for coordination, scheduling and estimating.
Gehry Technologies	Digital Project Suit	Full featured suite: for design, review and information management.
Tekla	Tekla Structures	3D structural modelling and detailing.
Solibri	Solibri Model Checker	For quality assurance/quality control (QA/QC).
Synchro Ltd.	Synchro Professional	Scheduling of systems and planning simulations.

### Application of BIM in Project Management

The potentials of the application of Building Information Model (BIM) in the management of construction projects is similar to the PMBOK knowledge areas. As such, BIM is regarded as an important tool for effective and efficient project management as it integrates all the stakeholders in the project (Rokooei, 2015). BIM as a promising technology facilitates project management, the possibility of integrating building models and products

makes BIM to have a high potential for management of projects life-cycle (Gourlis and Kovacic, 2016). BIM can be used at all the stages of a project in its life-cycle, it is used in understanding the project needs by the owner, it is also used for analysis, design and development of the project by the design team. The contractor also makes use of it in managing the construction phase, and it is used for decommissioning, maintenance and operation by the facility manager (Grilo and Jardim-Goncalves, 2010).

In a nutshell, the application of BIM in project management are stated in table 2.3 below.

**Table 3: BIM application**

	<b>Application of BIM</b>	<b>Source</b>
1	Quality compliance management.	(Chen and Luo, 2014).
2	Reduction in information exchange (IE) and resource waste.	(Dubler et al., 2010; Bryde et al., 2013).
3	Improvement in the accessibility of facility management data.	(Kassem et al., 2015; Kang and Choi, 2015; Liu, 2010; Meadati et al. 2010; Azhar et al., 2008)
4	Sustainability of project design and building performance.	(Wong and Fan, 2013).
5	Clash detection and coordination.	(Azhar et al., 2008; Foster, 2008; Young et al., 2009; Arayici et al., 2011; Lahdou and Zetterman, 2011; Bryde et al., 2013).
6	Automated safety checking platform.	(Zhang and Gao, 2013).
7	Constructability analysis.	(Foster, 2008).
8	Visualisation and sequencing of activities.	(Ding et al., 2014; Memon et al., 2014; Tulke and Hanff, 2007; Wilson and Koehn, 2000).
9	Cost Estimation of Material and quantities.	(Azhar et al., 2008; Hergunsel, 2011; Sabol, 2008).
10	Integration of key stakeholders.	(Foster, 2008).
11	Optimization of prefabricated construction components.	(Hergunsel, 2011; Winberg and Dahlqvist, 2010).
12	Risk assessment of design component of facility for prevention through design.	(Kamardeen, 2010).
13	Scope clarification.	(Bryde et al., 2013).

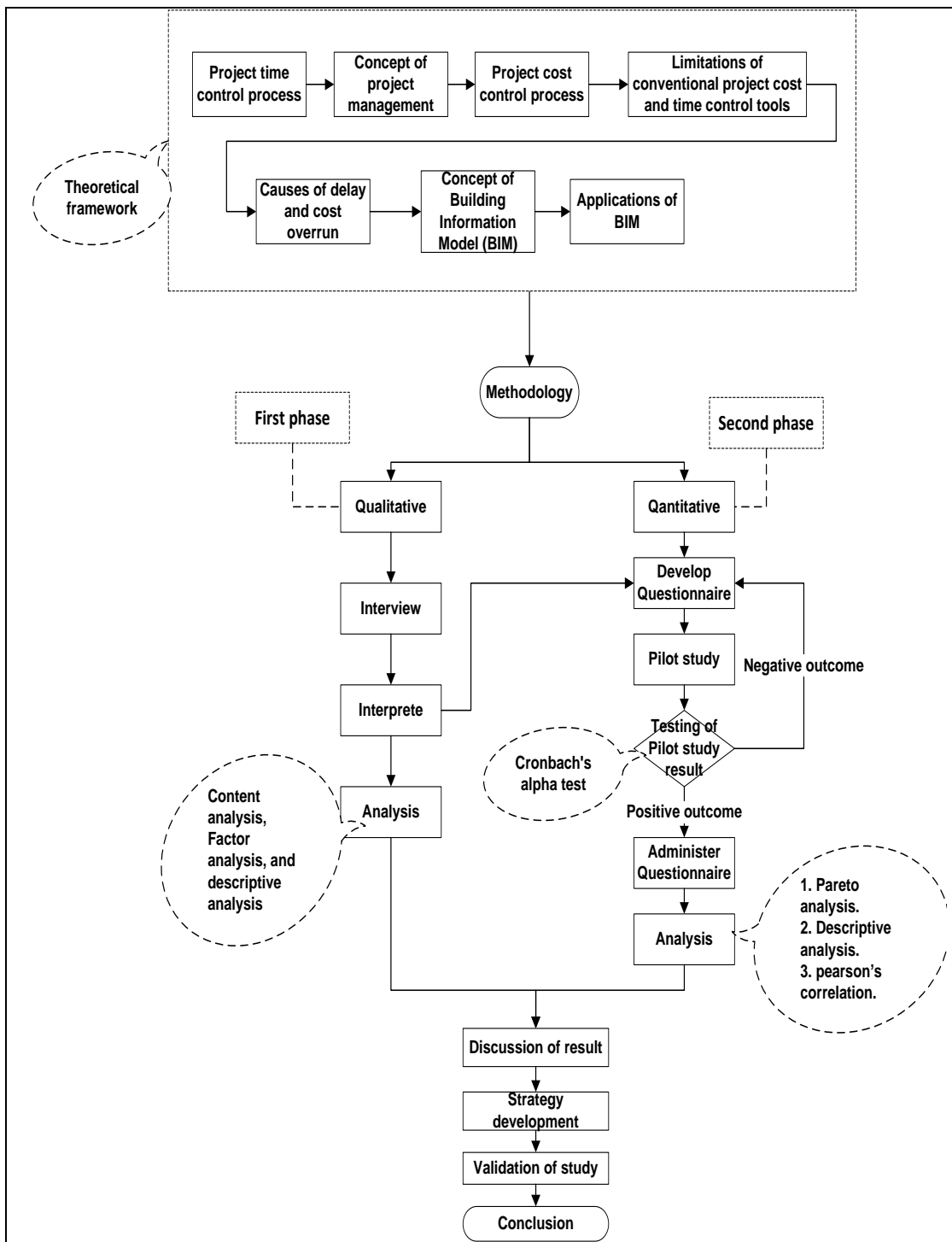
## METHODOLOGY

This research aims to develop a strategy for the control of cost and time in construction industry. This will be achieved through the processes in Figure 6. The analysis of the data obtained will be done using SPSS 23, to give accurate results which will be interpreted objectively. The proposed research method is a mixed method, which will be adopted for this research in achieving the objectives. A descriptive and exploratory research design will be used for the study. The research design for the proposed study will contain the following:

- The research problem and research questions.
- Sampling design.
- Method of data collection.
- Method of data analysis.

Similarly, the processes to be followed for the development of the strategy are shown in the figure below. For the qualitative study, expert sampling will be adopted to determine the

respondents for the semi-structured interview, this is to re-affirm the main applications of BIM from literature. This will be analysed using content analysis, factor analysis, and descriptive analysis. For the quantitative study, the target respondent for this phase of the research are the G7 member group of companies registered with CIDB Malaysia. The result from this phase of the research will be analysed using Pareto analysis to determine the main causes of delay and that of cost overrun also. The relationship between the applications of BIM and the causes of delay and cost overrun will be done using correlation and regression analysis methods.



**Figure 6:** Research methodology/strategy development process.

## CONCLUSION

The demand for the use of a more advanced technology to manage projects information all through their life cycle is very important. An increase in construction sector productivity also means employing modern construction technologies. The result from the analysis of the data collected is expected to answer all the research questions, to show the relationship between the use of BIM and the causes of delays and cost overrun in Malaysian construction industry.

More also, the result of the study is anticipated to show a negative relationship between the causes of delay, cost overrun and BIM applications. This means that, as a result of use of BIM technology, the occurrence of the causes of delay and cost overrun are reduced to the barest minimum. The result of this research is anticipated to be a breakthrough in the industry as it will give an insight and strategy model guide for contractors at all levels on how to mitigate delays and cost overrun using BIM in Malaysia. This will benefit more also, all the stakeholders in the industry as cost of construction will be optimized and the time taking for completion of construction work is known before the construction is started.

## REFERENCES

- Abdul Kadir, M., Lee, W., Jaafar, M., Sapuan, S. & Ali, A. 2005. Factors affecting construction labour productivity for Malaysian residential projects. *Structural Survey*, 23, 42-54.
- Ahmed, S. M., Azhar, S., Kappagntula, P. And Gollapudil, D. Delays in construction: a brief study of the Florida construction industry. Proceedings of the 39th Annual ASC Conference, Clemson University, Clemson, SC, 2003. 357-266.
- Al-Aghbari, M. 2005. *Factors affecting construction speed of industrialized building system in Malaysia*. Universiti Putra Malaysia.
- Al-Tmeemy, S. M. H., Abdul-Rahman, H. & Harun, Z. 2012. Contractors' perception of the use of costs of quality system in Malaysian building construction projects. *International Journal of Project Management*, 30, 827-838.
- Alaghbari, W. E., Razali A. Kadir, M., Salim, A. & Ernawati 2007. The significant factors causing delay of building construction projects in Malaysia. *Engineering, Construction and Architectural Management*, 14, 192-206.
- Applecore. 2016. BIM - Building Information Modelling. *Applecore Designs* [Online]. Available from : <http://www.applecoredesigns.co.uk/bim>.
- Aranda-Mena, G., Crawford, J., Chevez, A. & Froese, T. 2009. Building information modelling demystified: does it make business sense to adopt BIM? *International Journal of Managing Projects in Business*, 2, 419-434.
- Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C. & O'reilly, K. 2011. Technology adoption in the BIM implementation for lean architectural practice. *Automation in Construction*, 20, 189-195.
- Azhar, S. 2011. Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering*, 11, 241-252.
- Azhar, S., Hein, M. & Sketo, B. 2008. Building Information Modeling (BIM): Benefits, Risks and Challenges. McWhorter School of Building Science. *Auburn University. Auburn. Alabama, AL*.
- Bazjanac, V. 2006. Virtual building environments (VBE)-applying information modeling to buildings.

- Bryde, D., Broquetas, M. & Volm, J. M. 2013. The project benefits of building information modelling (BIM). *International Journal of Project Management*, 31, 971-980.
- Builderstorm. 2016. *BIM - Building Information Modelling - Builder Storm* [Online]. Available: <https://www.builderstorm.com/features/bim/>.
- Chen, L. & Luo, H. 2014. A BIM-based construction quality management model and its applications. *Automation in construction*, 46, 64-73.
- Cho, K., Hong, T. & Hyun, C. 2010. Integrated schedule and cost model for repetitive construction process. *Journal of Management in Engineering*, 26, 78-88.
- Ding, L., Zhou, Y. & Akin, B. 2014. Building Information Modeling (BIM) application framework: The process of expanding from 3D to computable nD. *Automation in construction*, 46, 82-93.
- Dubler, C., Kreider, R. & Messner, J. Determining the frequency and impact of applying BIM for different purposes on projects. Proceedings 6th International Conference on Innovation in Architecture, Engineering and Construction (AEC), 2010.
- Eadie, R., Browne, M., Odeyinka, H., Mckeown, C. & McNiff, S. 2013. BIM implementation throughout the UK construction project lifecycle: An analysis. *Automation in Construction*, 36, 145-151.
- Endut, I. R., Akintoye, A. & Kelly, J. 2009. Cost and time overruns of projects in Malaysia. *retrieved on August*, 21, 243-252.
- Forbes, L. H. & Ahmed, S. M. 2010. *Modern construction: lean project delivery and integrated practices*, CRC Press.
- Foster, L. L. 2008. *Legal issues and risks associated with Building Information Modeling Technology*, ProQuest.
- Gould, F. 2005. Managing the construction process: estimating, scheduling, and project control. 2005. Prentice Hall.
- Gourlis, G. & Kovacic, I. 2016. Building Information Modelling for analysis of energy efficient industrial buildings—A case study. *Renewable and Sustainable Energy Reviews*.
- Grilo, A. & Jardim-Goncalves, R. 2010. Value proposition on interoperability of BIM and collaborative working environments. *Automation in Construction*, 19, 522-530.
- Group, B. I. W. 2011. A report for the government construction client group building information modelling (BIM). *Working party strategy paper*.
- Hergunsel, M. F. 2011. *Benefits of building information modeling for construction managers and BIM based scheduling*. Worcester Polytechnic Institute.
- Ismail, I., Rahman, I. A., Memon, A. H. & Karim, A. T. A. 2013. Application of Time Management Tools and Techniques by Construction Industry Players: A Comparative Study between Kedah and Kelantan.
- John, N. 2003. *Project management for business and technology*, Prentice Hall.
- Kamardeen, I. 8D BIM modelling tool for accident prevention through design. 26th Annual ARCOM Conference, Leeds, Association of Researchers in Construction Management, 2010. 281-289.
- Kaming, P. F., Olomolaiye, P. O., Holt, G. D. & Harris, F. C. 1997. Factors influencing construction time and cost overruns on high-rise projects in Indonesia. *Construction Management & Economics*, 15, 83-94.
- Kang, T.-W. & Choi, H.-S. 2015. BIM perspective definition metadata for interworking facility management data. *Advanced Engineering Informatics*, 29, 958-970.
- Kassem, M., Ed Love, J. M., Steve Lockley, P., Kelly, G., Dawood, N., Serginson, M. & Lockley, S. 2015. BIM in facilities management applications: a case study of a large university complex. *Built Environment Project and Asset Management*, 5, 261-277.

- Kerzner, H. R. 2013. *Project management: a systems approach to planning, scheduling, and controlling*, John Wiley & Sons.
- Khemlani, L. 2007. Top criteria for BIM solutions. *A survey conducted by AECbytes*.
- Lahdou, R. & Zetterman, D. 2011. BIM for Project Managers How project managers can utilize BIM in construction projects.
- Lester, A. 2003. *Project planning and control*, Butterworth-Heinemann.
- Liu, Z. 2010. *Feasibility Analysis of BIM Based Information System for Facility Management at WPI*. Worcester Polytechnic Institute.
- Mcgraw-Hill, C. 2009. The Business Value of BIM-Getting Building Information Modeling to the Bottom Line. *SmartMarket Report*.
- Meadati, P., Irizarry, J. & Akhnouk, A. K. 2010. BIM and RFID integration: a pilot study. *Advancing and Integrating Construction Education, Research and Practice*, 570-78.
- Memon, A. H., Rahman, I. A., Memon, I. & Azman, N. I. A. 2014. BIM in Malaysian construction industry: status, advantages, barriers and strategies to enhance the implementation level. *Research Journal of Applied Sciences, Engineering and Technology*, 8, 606-614.
- Minchin Jr, R. E., Li, X., Issa, R. R. & Vargas, G. G. 2013. Comparison of cost and time performance of design-build and design-bid-build delivery systems in Florida. *Journal of Construction Engineering and Management*, 139, 04013007.
- Mohd-Nor, M. & Grant, M. P. 2014. Building information modelling (BIM) in the Malaysian architecture industry. *WSEAS Transactions on Environment and Development*, 10, 264-273.
- Nassar, K. M., Gunnarsson, H. G. & Hegab, M. Y. 2005. Using Weibull analysis for evaluation of cost and schedule performance. *Journal of Construction Engineering and Management*, 131, 1257-1262.
- Ofori, G. 1991. Programmes for improving the performance of contracting firms in developing countries: A review of approaches and appropriate options. *Construction Management and Economics*, 9, 19-38.
- Ofori, G. 1993. Research on construction industry development at the crossroads. *Construction Management and Economics*, 11, 175-185.
- Olawale, Y. A. & Sun, M. 2010. Cost and time control of construction projects: inhibiting factors and mitigating measures in practice. *Construction Management and Economics*, 28, 509-526.
- Ramanathan, C., Potty, N. S. & Idrus, A. B. Analysis of time and cost overrun in Malaysian construction. *Advanced Materials Research*, 2012. Trans Tech Publ, 1002-1008.
- Rogers, J., Chong, H.-Y. & Preece, C. 2015. Adoption of building information modelling technology (BIM) perspectives from Malaysian engineering consulting services firms. *Engineering, Construction and Architectural Management*, 22, 424-445.
- Rokooei, S. 2015. Building Information Modeling in Project Management: Necessities, Challenges and Outcomes. *Procedia-Social and Behavioral Sciences*, 210, 87-95.
- Sabol, L. 2008. Challenges in cost estimating with Building Information Modeling. *IFMA World Workplace*.
- Sambasivan, M. & Soon, Y. W. 2007. Causes and effects of delays in Malaysian construction industry. *International Journal of project management*, 25, 517-526.
- Shehu, Z., Endut, I. R. & Akintoye, A. 2014. Factors contributing to project time and hence cost overrun in the Malaysian construction industry. *Journal of Financial Management of Property and Construction*, 19, 55-75.



- Shenhar, A. J., Dvir, D., Levy, O. & Maltz, A. C. 2001. Project success: a multidimensional strategic concept. *Long range planning*, 34, 699-725.
- Smith, D. K. & Edgar, A. 2008. Building information modeling (BIM). *National Institute of Building Sciences, Washington*.
- Succar, B. 2009. Building information modelling framework: A research and delivery foundation for industry stakeholders. *Automation in construction*, 18, 357-375.
- Ting, S., Khoo, H. & Wong, S. 2009. Project Management Development in Malaysia: A Case Study. *Department of Civil Engineering, Faculty of Engineering, University Malaysia*.
- Tulke, J. & Hanff, J. 4D construction sequence planning–new process and data model. *Proceedings of CIB-W78 24th International Conference on Information Technology in Construction, Maribor, Slovenia, 2007*. 79-84.
- Wilson, J. M. & Koehn, E. E. 2000. Safety management: problems encountered and recommended solutions. *Journal of Construction Engineering and Management*, 126, 77-79.
- Winberg, A. & Dahlqvist, E. 2010. BIM-the Next Step in the Construction of Civil Structures.
- Wong, K.-D. & Fan, Q. 2013. Building information modelling (BIM) for sustainable building design. *Facilities*, 31, 138-157.
- Yamin, R. A. & Harmelink, D. J. 2001. Comparison of linear scheduling model (LSM) and critical path method (CPM). *Journal of Construction Engineering and Management*, 127, 374-381.
- Young, N., Jones, S. A., Bernstein, H. M. & Gudgel, J. 2009. The business value of BIM-getting building information modeling to the bottom line. *Bedford, MA: McGraw-Hill Construction*, 51.
- Zhang, D. 2012. *Project Time and Cost Control Using Building Information Modeling*. Masters, North Dakota State University of Agriculture and Applied Science
- Zhang, D. & Gao, Z. 2013. Project time and cost control using building information modeling. *ICCREM 2013*, 545-554.

# LEAN CONSTRUCTION MANAGEMENT: A TOYOTA WAY FOR ORGANISATIONAL LEARNING AND PARTICIPATION

**Kamal Sabri Kamarudin and Hiroshi Nakanishi**

*Management of Technology Department, Malaysia-Japan International Institute of Technology,  
Universiti Teknologi Malaysia, Kuala Lumpur Malaysia*

## **Abstract**

It is very important to analyse Lean management direction on Kaizen activity named Junshi. Currently, there are many contradictions in understanding how Lean develops their shop floor staff to support daily Kaizen, especially when most staffs themselves have different layers of understanding of Lean Management System (LMS) and skills essential in applying LMS. This paper aims to clarify the Kaizen activity named Junshi as a continuous improvement activity will analyse the technical and management aspects of lean small group activity by adopting the eight steps of Business Practices problem-solving. Through this research, it was made clear that most adoptions to imitate lean management fail because techniques are taken up in pieces with little apprehension of why or what organisational approach is needed to maintain kaizen or continuous improvement. Junshi shall serve as an exemplar of an activity of organisational implementation success of lean management.

**Keywords:** *Shop floor participation, continuous improvement, kaizen, Junshi, innovation*

## **INTRODUCTION**

Lean management system success is largely and directly attributed to their sole approach to cutting waste and added value. The Lean Management System (LMS) or more generally, “lean management” has been extensively analysed in the early of 1970s with quite a several successful followers. Therefore, operational management researchers continue trying to understand how LMS works. What styles Lean’s approach to manufacturing hard to grasp is often implicit or the perspective of the analyst, not certainly LMS itself. That is, LMS is too often studied analytically and as if it were static – despite notable examples of a contrary view (Bhasin & Burcher, 2006). For one main reason, at any given point what is called LMS is the state of a dynamic system that has developed to a point and will continue to progress.

Critics have described the lean approach as a set of contradictions (Osono, Shimizu, & Takeuchi, 2008). As Fujimoto perceives it, the unknown is that Lean management system that has evolved growing qualities that cannot all be acknowledged in advance. He perceives LMS problem solving as an “*evolving learning capability*” that is mutually “*intentional*” and “*opportunistic*” in that the company uses well-known routines to produce possible new production enhancements and at the same time is able to grasp emergent “*unintended*” or surprise enhancements and then competently institutionalize them as well (Fujimoto, 1999) and that is Business Practice (BP) for problem-solving.

The scope of this effort is to understand how lean management applies Junshi to change shop floor's worker's capability to resolve problems in daily activities and to boost problem-solving skills of the management team. Correspondingly, lean management must create an organisational philosophy where workers feel contented requesting for help and learn LMS. This report will contribute in what makes Junshi successful. A particular case study that illustrates some prominent features of Junshi inside the lean organisation is counted in. Lastly,

Junshi is deliberated as they might happen “outside” Toyota as the inventive activity ever. The aim of this study, however, is not to allow imitator mock of Quality Circle activity, but to propose an idea of persuasion that may be accommodating for those concerned inconsiderate LMS as a system.

## LITERATURE REVIEW

### Quality Control Circles

Shortly after World War II, the Japanese administration promoted the organisation of various industry organisations to aid Japan to recuperate from the war. The utmost famous of these governing bodies has been the Union of Japanese Scientists and Engineers (JUSE). The society organized leaders and professionals from all of Japan’s most important industries so that they can share best practices. This was made out with the expectation of uplifting Japan’s economy. Its main order was to regenerate Japan’s economy and improving quality by cutting waste. It continues until 1949 that JUSE started hosting statistical quality control conferences. In 1950 JUSE requested Dr. W. Edwards Deming (Deming, 2009), a U.S. government statistical advisor to address to them on the practice of statistical quality control.

Although JUSE offered Dr. Deming the royalties for his talks, he refused. JUSE, inspired by Dr. Deming’s compassion, began the Deming Prize in 1951 from those similar royalties. The prize, which is a bronze medal bearing a resemblance of Dr. Deming is given to those who have contributed to the field of quality control. The Deming Prize was originally given in two categories. It is given to *individuals* who make a vital contribution to the theory and application of quality control and similarly to *firms* that obtain outstanding outcomes in the application of quality control.

Another quality expert that similarly contributed to the culture and credibility of JUSE was Joseph Juran (Juran, 1988). He like, W. Edwards Deming, was also asked for talks to the still growing JUSE and did so in 1954 and 1960. His talks focused more on a management quality and how making quality a business strategy. His thoughts significantly supported JUSE’s principle believes in continuous improvement and quality circles. The greatest powerful facts in the history of JUSE have been its originator Ichiro Ishikawa and his son Kaoru Ishikawa. In 1946 Ichiro Ishikawa (Hung, Lien, Yang, Wu, & Kuo, 2011) planned JUSE and assisted many of them top Japanese administrators to meet and attend to W. Edwards Deming. Still, it was his son Kaoru that ruled JUSE during its prosperous and led the Japanese to internalize the knowledge of Deming and Juran.

As a professor of technology at Tokyo University, he rationalized the idea of quality measures. A Quality circle is a method to Total Quality Management that inspires shop floor workers to set up teams to extant process changes to management for carrying out. This underpins Deming’s 14th point meant for managing, “*Quality is everybody’s responsibility*” Kaoru Ishikawa headed the Japanese Quality Revolution that has given JUSE the status it enjoys today. Ishikawa left an emphasis in JUSE of training others how to practice Total Quality Management tools especially quality circles.

The quality control circle idea has become so prevalent that there are now over 426,000 listed quality control circles in Japan. These groups, or so small while others quite large,

saturate all of Japan's manufacturing and act as a major part of Japan's culture. These quality control circles have helped Japan's manufacturing flourish and often describe the workplace and community setting of many Japanese.

## **Business Practice (BP) Problem Solving**

The eight-step method intentions to break down big problems into small problems and test several countermeasures to each small problem. The eight-measure method is an agreed to use practice for developing countermeasures that prevent problems from coming back. The eight-step is effective because it links methods to results by running trials to figure out countermeasures. Cases of its use and comprehensive descriptions of its steps can be found elsewhere (Ohno, 1988) (Liker & Hoseus, 2010).

1. *Clarify the problem*
  - Identify problems at the worksite.
  - Search for problems that are related to work processes, wastage, productivity, quality, cost etc.
  - Brainstorm, Genchi Genbutsu, past records.
2. *Breakdown the problem*
  - Refer to problem statement on what data to collect (Object).
  - Check past data (if any) / Collect fresh data.
  - Analyse flowcharts (if any)/ Create flowcharts on current process (if unavailable).
  - Examine the situation over a period of time.
3. *Set the target to be achieved*
  - State where the improvement is to take place and visualize in chart or graph.
  - Make it clear what is to be done and what the goal is.
  - Express topic in terms of attacking something bad rather than improving something good.
  - Use SMART technique (Specific, Measurable, Achievable, Realistic and Time-bound).
4. *Think through to the true cause*
  - Indicate your problem statement.
  - Use Fishbone/Ishikawa/Cause & Effect Diagram.
  - Brainstorm of probable causes.
  - Do the '5 Whys'.
  - Identifying the causes of the problem.
  - Narrow the long lists of causes down to the most important ones.
  - Use facts, data, past history and personal opinions to focus on the most important cause.
  - Verify the cause whether it is true or false. Evaluate the degree of influence of each cause identified.
  - Collect data on the worthiest cause and present it on the graph.
5. *Develop countermeasures*
  - Suggest the countermeasures / corrective action based on the cause analysis,
    - Think of creative solutions.
    - Use 5W 2H (what, who, why, when, where, how and how much) to describe countermeasure.

- come out with several alternatives solution, consider the advantages and disadvantages of each countermeasure in term of its effect, cost, and practicality.
- 6. *Follow through on the countermeasures*
  - To execute countermeasures and monitor the implementation
  - Confirm the tangible and intangible results.
  - Analyse result based on quality, cost, time, and other benefits.
- 7. *Evaluate the result and the process*
  - To confirm and monitor the results of countermeasures against the target.
  - Compare the result with target set, evaluate and study why target did not achieve.
  - Confirm your achievement by checking your data.
  - Evaluate success and failure.
- 8. *Make sure the results take hold*
  - Monitor the trends of the result obtained to confirm the effectiveness of countermeasure for the long term.
  - Where results are successful, standardize the countermeasures and establish as SOP (Standard Operating Procedure).
  - Create a system in which can confirm that SOPs are followed and continue to have the desired effect (Training, Audit and Result Monitoring).
  - To standardize the countermeasures that are effective in eliminating root causes of a problem for permanent and long term effect.
  - Review the project.
    - what went well.
    - what did not go well?
  - Record the remaining problems that were not solved and select a new theme for next project.
  - Review the benefits that the team has received in being part of the project.

## Junshi

If lean is a field of study that builds up over time, and so it needs dedication and reliable leadership engagement and contribution. One factor in the existing TPS method that is of attention as a centring and can also make this representation of lean vibrant is Junshi. There have been many challenges to describe the small group activities such as Jishuken (Marksberry, 2011); however, these efforts have described only Quality Circles as a rapid shop floor activity comparable to the kaizen blitz model (Rodriguez & Lopez, 2012; Suárez-Barraza, 2013) with influences to supplier quality development for those conditions demanding urgent solutions. What is more confusing is that none of the existing efforts deliberates how lean problem solving is used or in what way this activity can deteriorate shop floor worker contribution if applied wrongly. In that respect is too little agreement of in what manner administrators can start, provision or lead problem-solving activities when they themselves need help in growing their understanding of LPS problem-solving methodology.

These descriptions of Junshi mislead by making the impression of a motionless impression, that shop floor within Toyota has a comprehensive understanding of TPS, one which they somehow accomplished instantly without demanding to develop it over time (B.-H. Lee & Jo, 2007). Seen most clearly, Junshi's, like many other TPS activities, take in

cooperation a learning development and a productivity goal: as they harness shop floor teams for problem-solving needed by the production process, Junshi helps managers continue to improve their ability to coach and teach TPS problem-solving to others, specifically production staffs.

What is significant about this process is that the Junshi team will spend much time reading and testing the current system to find the smallest possible root causes for each countermeasure. This process can consume time and cannot be rushed, which is why Junshi can take weeks or months to complete when performed right. Although Junshi may vary in time depending on the nature of the trouble, the Junshi team may match as needed to complete the problem solving out procedure. Junshi could meet continuously over a short period or spend a few hours a week over the span of several months. The course of time spent depends on the nature of the problem and what is involved in completing the problem solving out countermeasures. The only true way to recognize if a countermeasure was successful is by monitoring and monitoring through the current system. This operation can sometimes take weeks or months to complete and depending on the nature of the problem can be hard to cut through. The research method used are based on the PDCA (Plan-Do-Check-Act) cycle introduced by Dr. Deming which later it was developed further by Taichi Ohno. It is known as Toyota Business Practice (TBP) until today as the eight-step problem-solving operation.

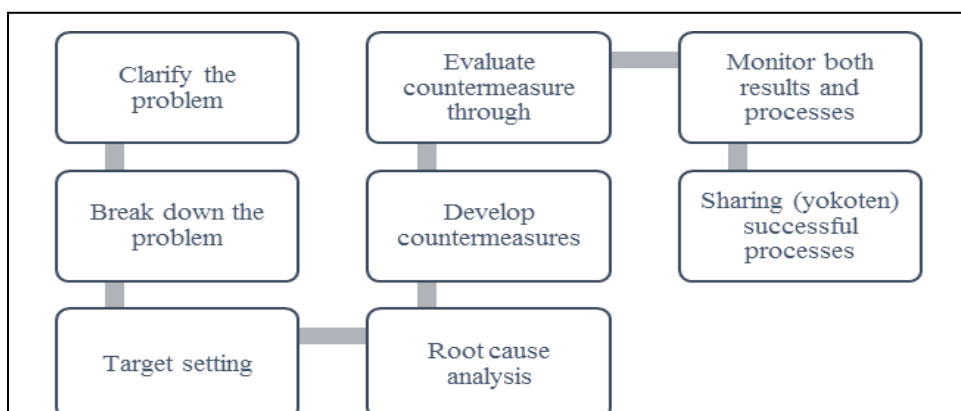
## **PROJECT BACKGROUND**

The implementation of the small group activity, namely Junshi has been carried out upon several breakthrough cases in the automotive industry. Previously, there was a worker, small group activity on complexity planning for automotive components using this attack. In this study, a project that explores innovative approaches from small group activity known as 'Inventory Reduction' is presented. In the automotive industry, inventory plays a decisive part in controlling and keeping the best stock that takes a high impact to manufacturing competitiveness in terms of cost effectiveness.

It aspires to create an opportunity to develop an own style, alongside cost reduction on the benchmarked systems. The example project in adopting, using Junshi activity was led in an OEM (Original Equipment Manufacturer). The focus area was chosen because of their incapability in controlling a full cycle production process. The cost improvement results were entered after the case implementation was made out.

## **Process flow for performing Junshi**

The general process flow for performing Junshi is explained in the follows the eight-step trouble-working process are as follows:



**Figure 1.** Process flow of Junshi Activities

### The clarification and target of stock reduction activity

Inventory plays a large role in a manufacturing environment, one most widely uses the term is Just in Time (JIT) concept, as it derives as a pillar by Taichi Ohno, the creator of Toyota's production system. The Just-in-Time approach tries to cut costs and improve workflow by carefully scheduling, material to arrive where needed at the correct quantity and at the proper time. Therefore, costs of stocks can be scaled down and the employment of space can be maximized. In this case, this approach is targeted to lower the cost of the product. Due to space limitations, inventory is high, thus the problem is surfaced.

## METHODOLOGY

Mixed methods study the relationships of management understanding, funding, and execution towards Junshi implementation.

### Qualitative method

A qualitative research Case study/Phenomenology design was carried out on one purposefully-selected Malaysian manufacturing company that has implemented lean manufacturing system deploying the Kaizen practices. Fieldwork of research diary and field notes with key informants over a period of time using descriptive, analysis and interpretation through unstructured interviews, meetings, documentation and observation to develops an insider point of view. Applying the practical approach consists of the empirical study of small group activity of the hands-on approach. It involves first-hand research through observations, data collection, and discussion groups.

1. Data collection was taken internally within the company through observation and interview techniques with these respondents.
2. The interview was transmitted with the handlers in the manufacturing company to understand the manufacturing operations and to gather exact information along with their current Kaizen system used in the installation.
3. This was followed by an on-site visit to the premise. Two managers were purposively selected as respondents for the field and interviews were taken at the respective

positions. Interviews were conducted (1 to 2 hours) using unstructured questions based upon the four research propositions. In total, 2 different managers and squad leader were interviewed. The four exploratory propositions;

- a. Junshi as an issue will improve job operation.
- b. Junshi implementation for production's development trajectory is unique.
- c. Junshi activity is dependent upon the context of the firm.
- d. Junshi maximizes general innovative activity.

The interviews were 5 hours of consultation, notes into a serial publication of reflections and quotations.

## **Quantitative method**

This type of research methods requires quantifiable data involving numerical and statistical accounts. Quantitative Research is used to quantify the problem by generating numerical data or information that can be translated into usable statistics. It is applied to quantify attitudes, beliefs, behaviours, and other defined variables and generalize results from a larger sample population. Quantitative Research uses measurable data to develop facts and reveal patterns in research.

## **Break down the problem example, using 5W2H**

1. What; To optimize stock reduction activities.
2. Where; To which focuses on the Finish Good (FG), Local parts and Completely Knock Down (CKD) parts inventories.
3. Who; A team that specialized in the automotive material management and inventory was set up and explored the stock reduction in the manufacturing organisation.
4. Why; The research goal of this study is to trim down the holding cost and towards having the right pieces at the correct measure at an appropriate time.
5. When; The duration of the case subject field was around 3 months to be finished at the conceptual level, and further 6 to 12 months to really enforce the concept into the production systems.
6. How; Junshi approach was used to explore this situation and to demonstrate how results can be achieved.
7. How much; The cost improvement results were recorded after the case implementation was completed.



## Root cause analysis and development of countermeasure

**Table 1.** Summary of identified root causes and countermeasures were taken

Root cause	Action taken
Customer Call-in not stable	Bi-monthly SAP safety stock level adjustment based on requirements and daily production control. To revise Monthly Kanban formula (E.g.: Safety stock level, lot size change) to reflect customer order.
Transport not optimized	Revise production lot size for low volume model, especially models to match lorry loading.
Line process does not match daily need	Monthly manpower meeting to decide manpower distribution at Production to suit the production order.
No proper handover from Vendor Development to Department Purchasing	Proper handover process from Vendor Development Department to Purchasing department for new and carry-over parts.
Delayed information from customer	To update Kanban using forecast figures for n+1 month (complete on week 3 of n month) for early Kanban adjustment
Improper arrangement during phase In and Out	Include standard packaging revision and order quantity for local vendors
Delivery frequency and quantity not revised or updated	Delivery frequency revision and safety stock to match production daily need (inclusive of Milk Run, Delivery Time Scheduling material)
Part packaging size is bigger than Production lot	Standard packaging review for Completely Knock Down (CKD) parts (concentrate on high volume model)
CKD Delivery frequency not revised to match production	Customer production plan improvement to match with CKD incoming plan Revise delivery frequency/timing for incoming CKD parts

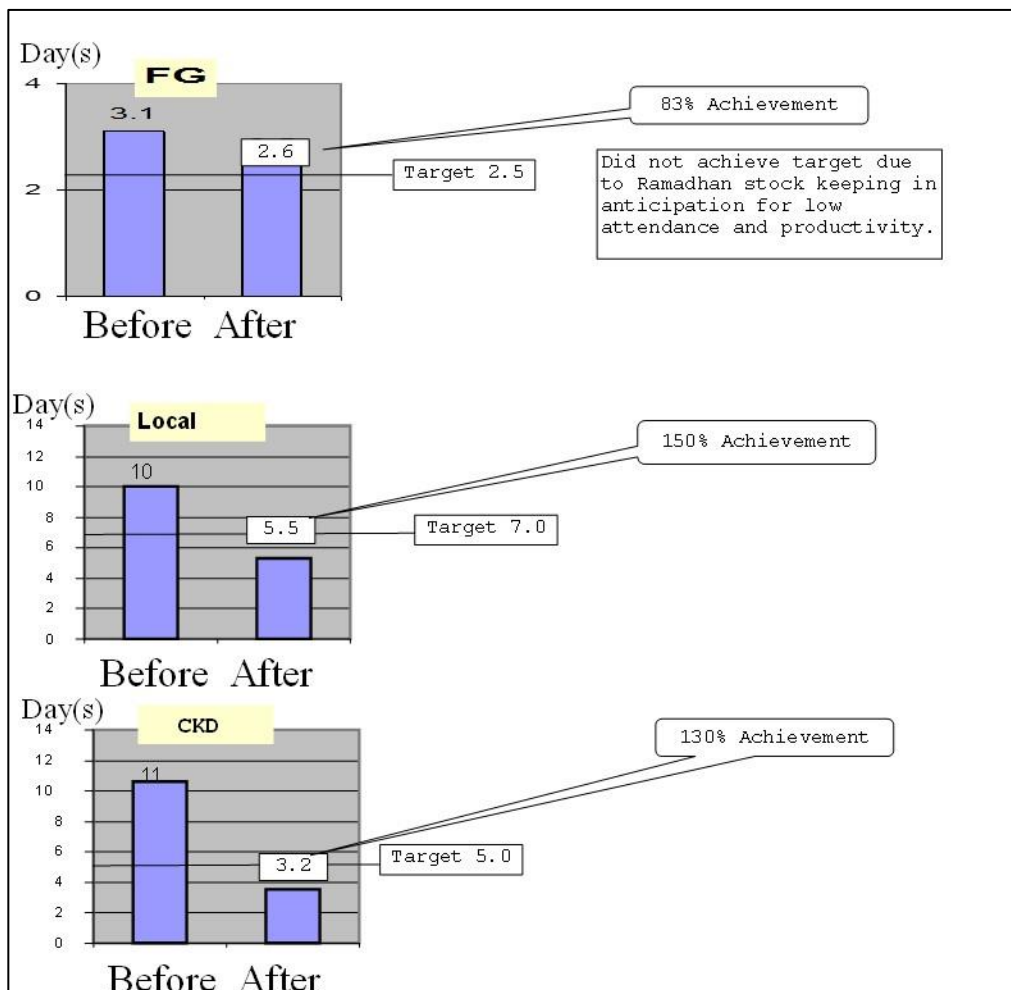
Root cause analysis looks at all three types of reasons below. It calls for considering the reasons of negative effects, detecting hidden flaws in the arrangement, and discovering specific actions that led to the problem. This frequently means that root cause analysis reveals more than one radical cause. Commonly find three basic types of causes:

1. Physical – Tangible, material items failed in some manner.
2. People – workers did something improper, or did not do something that was necessitated. people causes typically lead to physical causes.
3. Governance – A system, process, or policy that people utilize to reach decisions or do their work is incorrect.

## RESULT AND DISCUSSION

Intangible and tangible results;

- a) Increased safety for workers working at robot station.
- b) Eliminate near miss accident during robot operation.
- c) Create a safe working environment.
- d) Prevent loss time (worker injuries manpower planning)
- e) Improved shop floor worker engagement.
- f) Inventory cost reduction activity achieved.
- g) Increase worker morale and support.
- h) Improve material management and workflow.



**Figure 2.** Summary of tangible results before and after at focus area

## Summary from observation activity

1. Using a longitudinal exploratory approach better help in finding a relationship between shop floor engagement or contribution, and problem-solving skills development towards Junshi activity.
2. An observation that was carried out on a just one point in time, known as cross-sectional that offer a snapshot of what is going on in that particular process Kaizen group at that special time. Qualitative analysis brings problems out into the clear;
  - a. By definition of propositions, directions and perceptions vary across individuals.
  - b. Configurations of propositions, directions, and perceptions are not stable and stable, but potentially subject to reflective transformation.
  - c. An individual proposition may be altered to better fit lived experience and/or cope with a given state of affairs.
3. The pre-eminence of the lean production paradigm reflects the academic and practitioner effort that has been aimed towards building and transferring best practice" in operations.
4. This study has given a theoretical criticism of this generic approach and the empirical evidence presented adds further support, suggesting that contingency and complexity are the predominant characteristics of any successful implementation process.
5. The exploratory longitudinal all circumstances, the unstructured interview took place as an informal conversation, with the researcher asking follow-up questions in reaction to assertions made by the interviewees. This type of interview resulted in some irrelevant information but also allowed evidence related to the variables of interest to emerge naturally.
6. Sometimes structured interviews may be biased by the emotional involvement of the interviewee with the topic. Observations, however, can also be biased. Data collected during observations may be limited by the researcher's judgment of what is important enough to record.

Nevertheless, the direct and indirect relationships between these elements distinguish the situation far more precise than the individual factor taken into isolation

## An important difference between Quality Circle and Junshi activity

An enormous difference between a Quality circle and Junshi activity is the team members are coming from bottom up with backing and commitment from management. Thence, the date of shop floor workers in problem-solving activity is being acknowledged and spotlighted by the management. Junshi can be misunderstood as "single purpose": as only a plant improvement activity (B.-H. Lee & Jo, 2007; W. Lee, Rhee, & Oh, 2014a, 2014b; Susilawati, Tan, Bell, & Sarwar, 2013). In fact, Junshi has two main purposes: to solve problems in the workplace that need management attention and to correct, enrich and deepen understanding of TPS by management through first-hand on the job application of the problem-solving principles using hands-on activity and coaching.

It differs from problem-solving activity conducted by management ("Quality Circle" in Toyota's language) because Junshi involves only shop floor workers to find the problems and implement the countermeasures.

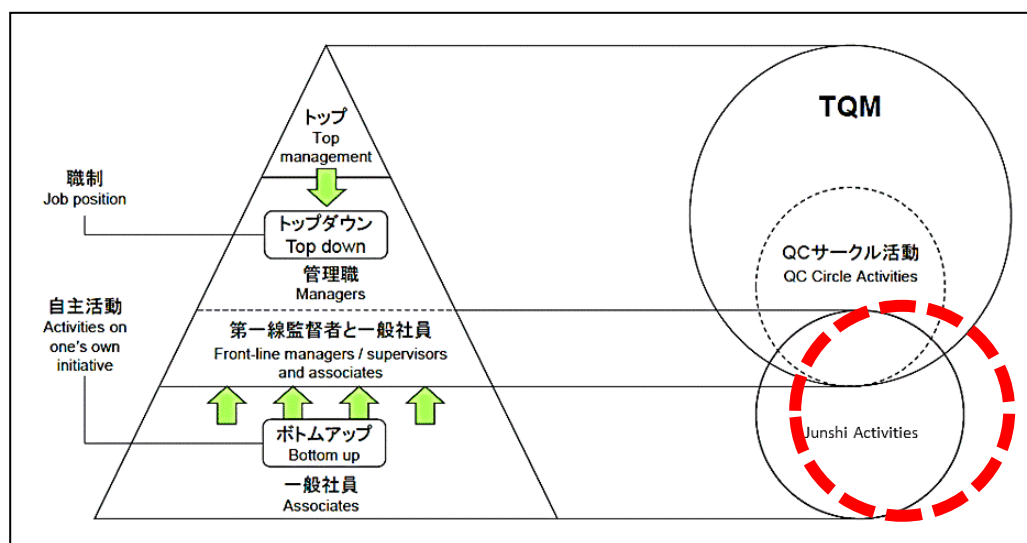


Figure 3. Scope, structure, and direction of Junshi Activities

### Significant roles and support function of management

Since in addition to their other roles, managers perform an important function in LMS as coaches and teachers for team members doing problem-solving, Junshi is both a technical problem-solving activity and a management development process that helps managers learn how to be better teachers (Liker & Morgan, 2006; Saruta, 2006). Junshi continually develops management's interpersonal skills so that they understand the right way to coach and support kaizen (Morgan & Liker, 2006). A third organisational culture function of Junshi is to send, support and reinforce the company's values, opinions and behaviours (known as the Toyota Way) (The Toyota Business Practice (Toyota Motor Corporation, 2005)). Participation in Junshi gives management a common terminology and a coarse approach to problem-solving standard across the society.

### CONCLUSION

In conclusion, establishing a culture among front line managers that values identifying and solving problems among themselves and in the production workers they teach and guide is an essential step toward establishing that culture on the shop floor. Establishing this Kaizen culture means shop floor workers demonstrates their abilities in identifying and solving problems are valued by making those abilities part of their employment, rather than a potentially causing of troublemaking that needs to be hidden (Fujio, 2006).

1. This report extends the theoretical foundation of Kaizen activity principles by analysing and analysing a practical application of the concept.
2. As a result, the case study is opportune for presenting a relevant overview of the relevance and pertinence of the research methodology. This particular case study is especially appropriate for completely new and exploratory investigations.
3. Nevertheless, the work has some failings. The primary one is the fact that the method is based on experts' judgments. To overcome this weakness, it will be necessary to extend the control board of experts and diversify them as lots as possible.

4. Moreover, the research can be based on a wider database, including other courses of the same model factory or to test it into other companies.

In the bigger sense, Junhsi can also be usefully understood as showing that Toyota Production System or Lean Manufacturing, though it can be viewed as a collection of tools and activities, is better approached as a dynamic evolving system within which those “tools” have multiple mutually reinforcing roles in developing workers’ creativity whilst, cutting the number eight muda. It could be generalized as a tool to engage and develop workers and as a management recognition of such improvement activity done by shop floor as the process owner. Since this initiative starts from workers being proactive in resolving the problem of the workplace, is the key to sustainable lean practice's success. Observing the success and standardize the activity plus recognition from the management has brought Junshi to a significant level in Lean innovation and sustainability.

## ACKNOWLEDGEMENT

This research was supported by My Ph.D. funding from Mybrain15 under Ministry of Higher Education for research of A Lean Production Management for New Malaysian industry.

## REFERENCES

- Bhasin, S., & Burcher, P. (2006). Lean viewed as a philosophy. *Journal of Manufacturing Technology Management*, 17(1), 56–72. <http://doi.org/10.1108/17410380610639506>
- Deming, W. E. (2009). W. Edwards Deming. *Library*, 1–14. <http://doi.org/10.1136/qshc.2005.015289>
- Fujimoto, T. (1999). The Evolution of Production Systems : Exploring the Sources of Toyota’s Competitiveness. *Annals of Business Administrative Science*, 11, 25–44. <http://doi.org/10.7880/abas.11.25>
- Hung, R. Y. Y., Lien, B. Y. H., Yang, B., Wu, C. M., & Kuo, Y. M. (2011). Impact of TQM and organisational learning on innovation performance in the high-tech industry. *International Business Review*, 20(2), 213–225. <http://doi.org/10.1016/j.ibusrev.2010.07.001>
- Juran, J. M. (1988). *Quality Control Handbook. 5th Ed McGrawHill* 1998. <http://doi.org/10.1177/004057368303900411>
- Lee, B.-H., & Jo, H.-J. (2007). The mutation of the Toyota Production System: adapting the TPS at Hyundai Motor Company. *International Journal of Production Research*, 45(16), 3665–3679. <http://doi.org/10.1080/00207540701223493>
- Lee, W., Rhee, S.-K., & Oh, J. (2014a). The relationships between manufacturing strategy process, manufacturing-marketing integration, and plant performance: an empirical study of Korean manufacturers. *Operations Management Research*, 7(3–4), 117–133. <http://doi.org/10.1007/s12063-014-0089-6>
- Lee, W., Rhee, S. K., & Oh, J. (2014b). The relationships between manufacturing strategy process, manufacturing-marketing integration, and plant performance: an empirical study of Korean manufacturers. *Operations Management Research*, 7(3–4), 117–133. <http://doi.org/10.1007/s12063-014-0089-6>
- Liker, J. K., & Hoseus, M. (2010). Human Resource development in Toyota culture. *Int. J. Human Resources Development and Management*, 10(1), 34–50.

- <http://doi.org/10.1504/IJHRDM.2010.029445>
- Liker, J. K., & Morgan, J. M. (2006). The Toyota Way in Services: The Case of Lean Product Development. *Academy of Management Perspectives*, 20(2), 5–20. <http://doi.org/10.5465/AMP.2006.20591002>
- Marksberry, P. (2011). The Toyota Way – a quantitative approach. *International Journal of Lean Six Sigma*, 2(2), 132–150. <http://doi.org/10.1108/20401461111135028>
- Morgan, J., & Liker, J. (2006). The Toyota Production Development System. *Productivity Press*, 22(4), 51–52. Retrieved from [http://www.ame.orgwww.ame.org/sites/default/files/target\\_articles/06-22-4-BR\\_Toyota\\_Prod\\_Dev\\_Sys.pdf](http://www.ame.orgwww.ame.org/sites/default/files/target_articles/06-22-4-BR_Toyota_Prod_Dev_Sys.pdf)
- Ohno, T. (1988). *Toyota Production System: Beyond Large-Scale Production*. Productivity Press. <http://doi.org/10.1108/eb054703>
- Osono, E., Shimizu, N., & Takeuchi, H. (2008). That Drive Toyota ' s Success. *Harvard Business Review*, (June 2008), 98–104. Retrieved from <https://hbr.org/2008/06/the-contradictions-that-drive-toyotas-success>
- Rodriguez, M. A., & Lopez, L. F. (2012). Kaizen and ergonomics: the perfect marriage. *Work (Reading, Mass.)*, 41 Suppl 1, 964–7. <http://doi.org/10.3233/WOR-2012-0271-964>
- Saruta, M. (2006). Toyota Production Systems: The “Toyota Way” and Labour Management Relations. *Asian Business & Management*, 5, 487–506. <http://doi.org/10.1057/palgrave.abm.9200198>
- Suárez-Barraza, M. F. (2013). Changing quality of life through the Personal Kaizen approach: a qualitative study. *International Journal of Quality and Service Sciences*, 5, 191–207. <http://doi.org/10.1108/IJQSS-03-2013-0015>
- Susilawati, A., Tan, J., Bell, D., & Sarwar, M. (2013). Develop a Framework of Performance Measurement and Improvement System for Lean Manufacturing Activity. *International Journal of Lean Thinking*, 4(1), 51–64.

# CORPORATE SUSTAINABILITY REPORTING ON ENVIRONMENTAL ISSUE: AN ASSESSMENT OF CSR FRAMEWORK FOR LEVER BROTHERS BANGLADESH

S. M. Zobaidul Kabir<sup>1</sup>, Fazle Rabbi<sup>2</sup>

<sup>1</sup>Adjunct Research Fellow, The University of Newcastle, NSW 2300, Australia

<sup>2</sup>School of Business, The University of Notre Dame Australia, Sydney Campus, NSW 2007, Australia

## Abstract

There has been an increasing public awareness on the environmental aspects of goods and services of any company. Being pressurized by the green consumers, companies are now sincerely taking the environmental and social issues into consideration in the production of their goods and services. However, there are many companies in developing countries do not adopt adequate tools or strategies in place to address the environmental issues occurred from their activities. The aim of this article is to assess the environmental and social performance of Lever Brothers Bangladesh Limited (LBBL) and identify the areas of improvement. This research shows that there are some limitations in its operational management regarding environmental management. The company needs a change in response to its various stakeholders in order to achieve its business sustainability from environmental perspective. Finally, this paper recommends for some effective tools and strategies to overcome the limitations. It is expected that LBBL will be able to attract more consumers by their green products and contribute in the sustainable development with these tools.

**Key words:** *Environmental performance, business sustainability, green consumers.*

## INTRODUCTION

In the wake of increased awareness and public concern over the impact of industrial products and process on environment, environmental organisations are arguing business to take responsibility for their environmental effects. The enactment of newer and restrict environmental regulation also have a far-reaching effect on business around the world. All these factors have forced the industries to implement an effective management system involving various sustainability tools in their business activity to meet the growing performance expectations and to ensure compliance with national and international regulatory requirements. Similarly in response to the environmental regulations enacted by Bangladesh government and 'green' consumers' growing demand of 'green' products, Lever Brothers Bangladesh Ltd (LBBL) needs to reshape its existing social and environmental responsibilities incorporating sustainability tools.

This paper is prepared based on the data collected from observation of LBBL's activities in addition to collection of data for sustainability tools. The authors visited the LBBS office and talked with the office staff responsible for environmental and social performance. The authors also visited various industrial locations of the company and reviewed policy documents of the company relating to corporate social and environmental reasonability.

The aim of this paper is to propose a brief on sustainable environmental management strategy incorporating relevant tools to achieve LBBL's sustainable business.

## **THEORETICAL UNDERPINNINGS: WHY DOES LBBL NEED A CHANGE?**

### **Rising Environmental Challenges**

Industry's approach to environmental issues has changed significantly over the last three decades all over the world as well as in Bangladesh. To address environmental challenges to come, we need to have proactive approach, which LBBL will strive towards 'compliance plus' approach to CSR in practice to achieve business sustainability (Howes, Skea, & Whelan, 1997; Smith, 2011). LBBL's reactive approach will not be able to tackle the future environmental and social problems associated with LBBL activities. For example, installing water treatment plant at soap production site at Chittagong as a reactive response to government regulation has led to inadequate compliance and inefficient investment for social and environmental responsibilities. Moreover, this has led to high compliance cost. Increasing stake holder's pressure from different corners has raised these environmental challenges.

### **Principal Drivers of Change**

The only reason why companies have begun to address environmental issues in a strategic way is because of social concern about impacts on human health and ecological systems (Howe, 1997). Broad social concerns are converted into specific pressures on companies to improve environmental performance. The principal actors behind this mechanism may be according to Howe (1997) are regulation, consumer preference or demand, relations with local communities and investors' requirements.

Regulation and anticipation of regulation still remains the most important driver of changing corporate decisions on CSR (Schrempf-Stirling, Palazzo, & Phillips, 2016). As a company closer to final markets, LBBL needs to be more conscious to the concerns of final consumers. The growth of green consumerism that rewards strong environmental performance has been increasingly vigorous all over the world and in Bangladesh as well. Being environmentally and socially aware with the campaign of various NGOs, consumers are evidently prepared to punish industries for their poor environmental performance through, for example, product boycotts.

As an industry of skin care products, LBBL needs to place greater emphasis on developing and maintaining an image of being good neighbours in local communities. There is also investor pressure on the company is set to increase as the degree of financial risks associated with environmental liabilities clearer.

In response to environmental pressure and stakeholders' aspiration with the impact of rapid globalization, we need to assess LBBL's existing management capacity and identify areas of improvement with proper tools if necessary. Next section will focuses on an evaluation of LBBL's existing environmental management to identify environmental and social issues as an underpinning of selection appropriate tools.



## **LBBL's Environmental and Social Obligations**

Environmental conservation Act 1995 for industries in Bangladesh requires industries to take environmental principles into account in their management decisions (DOE, 1997). Some of them, for example, are:

- Soil quality should be maintained so that next generation will have at least the same productivity from soil.
- Habitat of particular significance for species both in water and on land should be protected.
- Decision making process should be done following precautionary principles. Industries must make decision based on best available information and be continuous when information is uncertain or inadequate (DOE, 1997).

Under various international and national acts such as international Labour Law on Environmental Health and Safety (HES), like other industries, LBBL requires to meet social obligations, for example, ensuring working condition at sites, community such as general workers, quality of life and educating the workers about environmental health and safety.

## **PROFILE OF LBBL**

Lever Brother Bangladesh Ltd (LBBL) is a pioneer manufacturing company in Bangladesh. Being a subsidiary of Unilever, one of the largest consumer goods companies in the world. LBBL has been operating in the areas of home and personal care, and tea production since 1964. It has been manufacturing products categorized as household care, skin cleansing, oral care and tea based beverages. Top brands are Wheel, Lux, Lifebuoy, Fair and lovely, Close Up, Sun silk, and Lipton Taaza (tea). In early 1990s, LBBL entered the tea based beverage market introducing Lipton Taaza. Lever's flagship packet tea brand, with objective to be the most preferred tea of Bangladesh. In 2016, LBBL have paid more than AU\$100 million to the government as taxes, duties and dividends. LBBL has two sites. One is soap manufacturing site located in Chittagong, Bangladesh. The other is tea production site in Sylhet, Bangladesh. Over 5000 people are provided direct employment through the company's factories, distributors and exclusive manufacturers under LBBL.

## **Stakeholder Engagement**

LBBL involves stakeholders in the pursuit of common ground toward viable solutions and the development of relationships that lead to true value for both business and stakeholders. LBBL involves various stakeholders through social and environmental initiatives, products and services. Some of them are:

1. Consumers
2. Governments of Bangladesh (Ministry of Agriculture, Ministry of Environment, Bangladesh Standardization and Testing Institute, Consumers Association of Bangladesh)
3. Unilever- as a parent company
4. Contractors and suppliers of LBBL
5. Shareholders of LBBL
6. Employees of LBBL
7. Environmental NGOs

## Industry Sector and Market Characteristics

Soap and tea manufacturing is a sector with enormous potential and which is currently in a major growth phase in Bangladesh due to increasing number of people and their awareness on health and hygiene due to spread of non-formal education and NGO's campaign. It has been estimated that the sector will be growing with the increase of population as well as their health awareness by an annual rate of approximately five percent (LBBL, 2017). Sectoral growth is being created by production of soap and tea with new brands with new industries every year in Bangladesh. For example, LBBL had only 10 brands in 1990 had been increased up to 18 brands including soap and tea products in 2002. This supports the increasing market of soap and tea manufacturing in Bangladesh consists of 140 million of population size.

In addition to increasing people's awareness on health and hygiene, people are increasingly being concern with organisational impact on environment in Bangladesh. Some consumers, particularly green consumers are willing to pay more prices or at least prefer environment friendly products. According to Cohen-Rosenthal (2003), green consumer now represent about 3-4% market and survey showed that given similar price and quality, 70-80% of consumer will choose the products with environmental attribute. Therefore, market characteristics including consumer's behaviours to products have been changing rapidly in Bangladesh and this could be an opportunity instead of threat for LBBL's greening business.

## EVALUATION OF LBBL'S ENVIRONMENTAL PERFORMANCE

The evaluating of existing environmental performance of LBBL has been done considering the following issues:

- Environmental and social obligations applicable to LBBL's activities;
- The adequacy of information, management targets and measures and monitoring of environmental and social components of LBBL; and
- The opportunities and barriers to achieve the desired level of performance.

LBBL's sustainability/environmental and social performance has been assessed with the help of a checklist (Table 1) to identify whether existing management system is capable of achieving intended environmental performance under sustainability vision. The assessment was done addressing the criteria such as information availability, management targets, and measures to achieve management targets, presence of monitoring and auditing; and mode of disclosure of environmental performance.

**Table 1:** Assessment of LBBL's environmental performance

Key questions	Consideration	Response (Yes/no/maybe) and explanations
Is information adequate for determining whether water quality is being maintained above an agreed reference point?	Is there any quantitative data on river water quality where LBBL operates?	May be. However, there is no available information as there is no environmental accounting system and TBL reporting from LBBL.
Is there any monitoring system to maintain water and soil quality and energy use in two sites of LBBL activities?	Data gathering and documentation	Not adequate monitoring for water quality as there is no EMS that incorporates monitoring.
Are there any management targets?	Is there any 10-year or 5-year goal? Any baseline information?	Yes but inadequate. There are no comprehensive management targets as there is no five or ten-year goal. (No baseline information on social and environmental components.)
Is there any measure to achieving management targets?	Are there any social and environmental programs?	There are some environmental and social programs but inadequate to cover required management targets.
Is there any baseline information to achieve any environmental targets? If not how response to environment regulating?	Any survey for baseline information Any five or ten-year goals with particular targets.	No baseline information LBBL has reactive approach to response government regulation, for example installation of treatment plant to control water pollution.
Is there any information on employees' health and safety issues adequate for meeting relevant obligations?	Is there any program on health and safety issues or working environmental conditions?	Under existing management framework-no available information on health and safety issues to meet relevant obligation as there is no program on health and safety.

## Findings

Two bottom lines concerns related to LBBL's operational impact on environment and society were identified include:

- Gaps in information availability, monitoring and research capacity
- Limited opportunities for public to participate in LBBL's social and environmental decision-making process, other important concerns are:
- LBBL's management process has tended to respond to operational impacts only after damage to the environment has been done. The decline of soil fertility in tea production site example is an illustrative case.
- Environmental stakeholders believe that there is a need for environmental impact assessment to be undertaken to inform decision-making process about the known and unknown threats to environment and society from LBBL's activities.
- Due to lack of adequate information with existing management strategy, the ability of LBBL to fulfil its environmental and social obligation under ECA 1995 and stakeholders' aspirations to avoid or mitigate any adverse effects occur from its activities is 'severely compromised'.

- Fulfilling social and environmental obligations or go beyond the obligation requires continues improvement of management system in place.
- There is also lack of action plan in LBBL's existing strategy. Although there are some social and environmental initiatives taken as a response to legal obligation, there initiatives were developed and implemented reactively and in a piecemeal way.

Now a day, link between company and public is a prerequisite to make decision on environmental management. Lack of effective communicating tools has limited opportunity for public to participate in LBBL's environmental decision-making process.

## **WHERE TO FROM HERE**

### **Key Changes**

In order to meet increasing legal and institutional obligation, the existing environmental management strategies of LBBL need to be improved. The key changes identified from the evaluation need to be made to LBBL's management system may include:

- Retaining control and administration of operational management, action plan and its enforcement, monitoring and auditing to minimize the environmental impact of LBBL.
- Introducing requirements for the assessment and improvement of LBBL's internal environment and the environment where the company operates.
- Ensuring LBBL's activities are managed according to precautionary principle so that environmental health and safety for workers and community people, physical environment including soil erosion, water and energy use, for example, can be maintained efficiently.
- LBBL needs to improve in areas of sustainable tea production, community development, environmental health and safety to fill the information inadequacy up. Finally, it is important to remove barriers for public participation in LBBL's environmental decision-making process taking appropriate disclosure system.

## **An Overarching Framework for LBBL**

### *Objectives*

With intended changes identified above and to place our efforts most effectively and efficiently in LBBL's management in future, we need an overarching framework incorporating relevant management tools and programs with the following policy objectives:

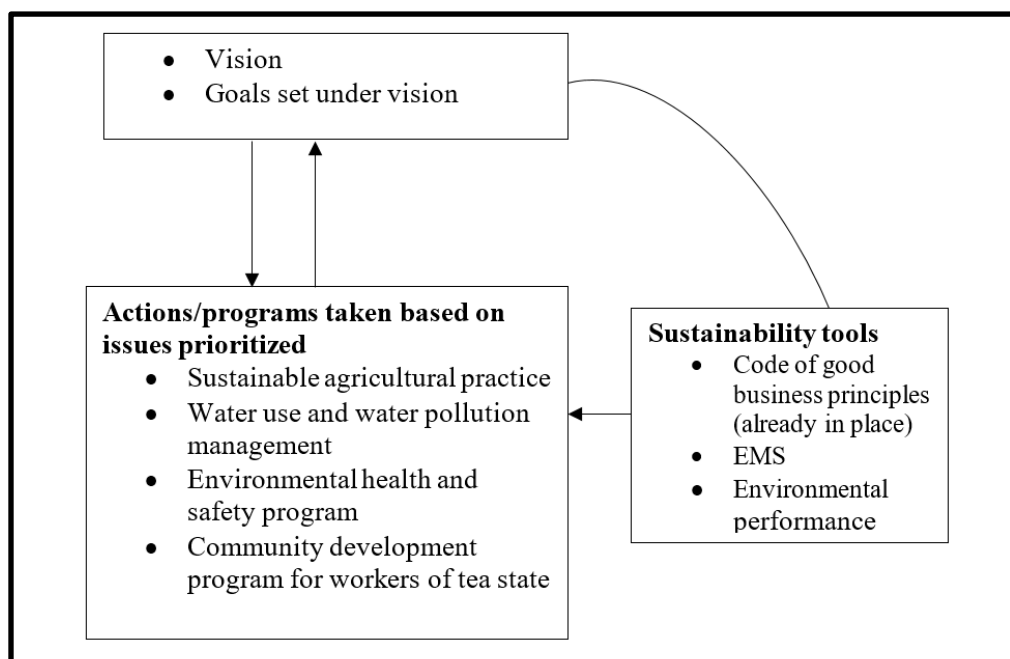
- To comply with relevant and regulation
- To maintain long-term access to resource particularly land, water and others (intergenerational equity).
- To gain community support demonstrating best CSR practice
- To operate more efficiently
- To secure market access for our product

## The Framework

The integrated management framework will assist LBBL to detect where and how and when to lift environmental performance in order to meet policy objectives. The proposed integrated management framework consists on the following components:

- Sustainability vision
- Actions to achieve policy objectives

Management tools will help in practice to achieve those goals set under vision through implementation of sustainability initiatives (programs) taken. The components are thereby being interlinked and interacted to each other provides a holistic management approach needed for LBBL's sustainable business (Figure 1).



**Figure 1:** An overarching and management approach for LBBL (Source: Own Developed, 2016)

It is expected that the framework will provide the foundation for LBBL to develop its management responses tailored to LBBL's specific needs and resources.

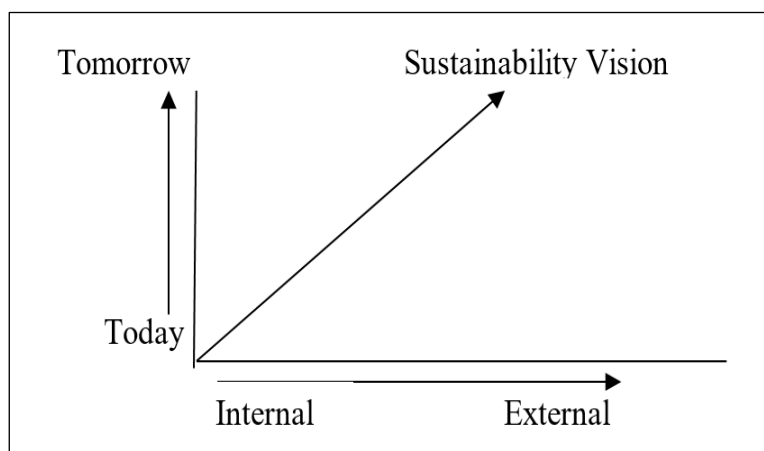
## Sustainability Vision

Considering rapid globalization and future market competitiveness, LBBL has to have 'compliance plus' proactive strategies: pollution prevention, product stewardship and clean technology to move the company toward sustainability. However, to give direction to these strategies, they need vision a future road map showing the way of sustainable business with needed competencies (Hart, 1997).

The vision of LBBL should be involving stakeholders' aspirations to lead the actions taken in a harmonized way. In this case LBBL's vision is:

- To achieve sustainable development promoting product stewardship and
- Innovation to develop new technologies, markets, products and process

The specialty of their vision is that it focusses not only on solution on internal social and environmental problems for today but also involves tomorrow's external social and environmental problems (Figure 2).



**Figure 2:** LBBL's vision (Source: Own Developed, 2016).

## SELECTION OF SUSTAINABILITY TOOLS

To tailor an overarching sustainability approach, there are ranges of tools that can be applicable to LBBL's situation in order to materialize the vision. However, based on stakeholders concerns and necessary changes identified for the improvement of LBBL's management scope, the most effective sustainable tools have been selected to lift the environment performance are:

- Code of Business principled
- Environmental Management System (EMS)
- Tripe Bottom Line Reporting

Code of Business practice is already in place. Here the purpose of sustainability tools is to provide a clear-structured overarching approach through which LBBL can manage interaction between production process and socio-physical environment where they operate. Here, objectives set under vision have played a vital role in determination of sustainability tools above beat suit to their requirements.

For example, for resolving an operational issue, code of business practice is the most likely an effective tool through which LBBL can clarify best practice measures and obligations. Similarly, to gain LBBL's public support through demonstrating good environmental practice they require a sustainability tool that measure not only their TBL

performance but also involves public disclosure and provides all possible stakeholders to put their input in LBBL's decision making related to CSR. In this case TBL reporting is the most suitable sustainability tool. In order to reach the mission set under vision, LBBL will need continuous improvement of their CSR performance making information available through monitoring and controlling operational activities and sustainable programs as well. In this case, EMS is the best suitable tool.

However, there are other sustainability tools such as certification, eco-labelling and ethical investment. In order to meet market standards to secure market access for products from LBBL, for example, they may need certification as a sustainability tool helps to demonstrate independently their attainment of standards in support their claim. These tools have not been taken into account considering LBBL's limited resource in terms of time and money as well as market context in Bangladesh. These may be required in future depend on changing situation.

## **Sustainability Initiatives**

Proposed sustainability initiatives will be taken to achieve intended environmental and social performance with the help of proposed sustainability tools. The initiatives taken would be LBBL's best interests and that management responses are tailored to suit its specific need and resources. To be specific about these options, following questions regarding LBBL's positions were considered:

- Do we want to retain the status quo?
- Do we need to do more to comply with existing regulations or keeping 'business as usual'?
- Do we want to go beyond minimum requirement that is 'compliance plus'?

LBBL is currently maintaining the level of 'business as usual'. They need to go beyond this position toward the level 'compliance plus' to achieve sustainable business. This requires both social and environmental initiatives as a process of solving LBBL's internal and external socio-environmental problems not only for today's (intergenerational) sustainability but also sustainability for 'tomorrow' (intergenerational).

Sustainability initiatives are:

- Environmental initiatives
- Sustainable Agricultural practice
- Programs of water and energy use
- Environmental health and safety program for the improvement of work place conditions.
- Social initiative
- Programs for indigenous workers of tea gardens to improve their quality of life for details of all programs.

## Cost and Benefits of Programs

Training, development of guideline, consultancy fee, and trainer fee and time will be sources of cost to implement these programs. However, it is expected that the program will have long term benefits for LBBL's business. For example, sustainable business agriculture will encourage consumers to prefer the environmental friendly one between two products with same price. Program for indigenous workers will be a vital initiative for LBBL's business sustainability when workers will be motivated to give up excess drinking as this will turn them to be involved in more productivity and peaceful family life. The next section will describe about selected tools and their link to programs.

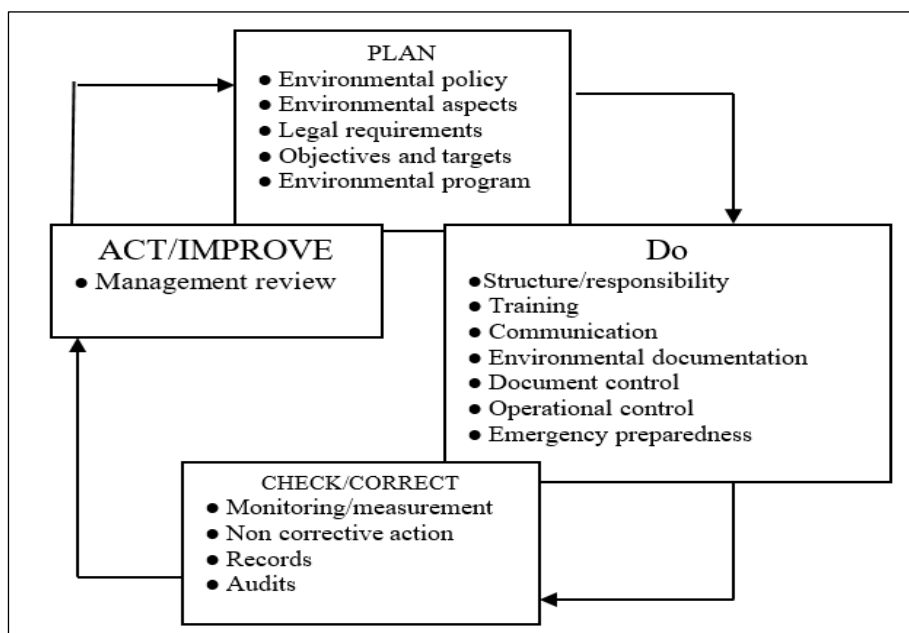
## Details on Sustainability Tools and Their Linking with Programs

### *Environmental Management Systems (EMS)*

#### What Is EMS?

EMS is a method of incorporating environmental care throughout the corporate structure. It is a problem-identification and problem-solving internal tool based on the concept of continuous improvement (Cohen-Rosenthal & Musnikow, 2003).

The main components of the system are environmental policy, environmental planning, implementation and operation, monitoring and corrective action and management review (ISO: 1996) which translates simply to plan, do, check, correct, and improve (Figure 3).



**Figure 3:** EMS framework. Source: UNEP (2016).



It is important to manage all sustainability initiatives in a harmonized and systematic way to improve the organisational overall environmental performance. A company can perform this task efficiently with the help of EMS. The main purposes to develop an EMS in LBBL are:

- To comply with rapid changing environmental laws and regulations as time to time imposed by government of Bangladesh.
- To find the ways to improve its environmental performance,
- To reduce potential environmental liabilities in future,
- To solve many environmental problems without installing expensive pollution control equipment.

### Benefits and Costs of Implementing EMS

There are potential costs and benefits of development and implementation an EMS program. Of course, we have to look at the interest of shareholders of LBBL and at the same time we need to address other stakeholders' concern of LBBL's operational impact on environments and society. Moreover, limited resource is an important factor regarding adoption of new program. Considering these factors, the potential social and financial costs and benefits for complementing EMS program are as follows (Table 2).

**Table 2:** Costs and Benefits for establishing EMS in LBBL

<u>Potential cost</u>	<u>Potential benefits</u>
<b>Internal</b> <ul style="list-style-type: none"> <li>● Staff (manager) time</li> <li>● Other employee time</li> <li>● Cost of technical resources to analyse environmental impacts and improvement options (internal labour costs represent the bulk of the resources expended by most organisations)</li> </ul> <b>External</b> <ul style="list-style-type: none"> <li>● potential consulting assistance</li> <li>● outside training of personnel</li> </ul>	<ul style="list-style-type: none"> <li>● Improved environmental performance</li> <li>● Enhanced compliance of ever regulations</li> <li>● Prevention of pollution/resource conservation</li> <li>● New customers, markets</li> <li>● Increased efficiency/reduced costs</li> <li>● Enhanced employee morale</li> <li>● Enhanced image with public, regulators, civil society</li> <li>● Employee awareness of environmental issues and responsibilities</li> </ul>

Source: UNEP (2016).

### Development of EMS through Partnership with Other Organisations

EMS will be developed by LBBL itself. However, it may follow other frameworks such as ISO 14001 or BS. LBBL needs to have continuous link with Unilever as its parent company in developing and implementing an EMS framework. As Unilever's EMS was developed based on ISO 14001, therefore LBBL's EMS could be developed in the same way.

### How Does EMS Link to LBBL's Integrated Framework?

The degree of control that a company has over its operational activities and its impact on environment is an important factor when considering EMS to be incorporated (Cohen-Rosenthal & Musnikow, 2003). LBBL has direct control over its operational activates which

are managerial, administrative, planning and design at two sites. Moreover, LBBL has direct influence over pollution, activities of its suppliers through for example contractual agreement. So EMS is suitable for LBBL to serve the purpose.

Another scope necessary for adoption of EMS is a strong commitment from top management (Cohen-Rosenthal & Musnikow, 2003). LBBL has a written environmental policy signed by top management. Therefore, to implement the policy objectives existing framework requires EMS. Moreover, EMS is a particular management strategy the goes beyond regulatory compliance. Our company's vision is 'compliance plus' directly relates the characteristic (beyond compliance) of EMS.

The proposed sustainability initiatives will be coherently implemented with the help of EMS and progress regarding environmental performance will be reflected in TBL reporting. Therefore, EMS is linked with the overarching framework.

### Sustainability Initiatives and EMS

The proposed sustainability initiatives will be implemented under the framework of EMS. Here, is an example how the 'sustainable agricultural practice' program will be embedded and implemented under EMS framework.

#### Sustainability Agricultural Practice for Greening Tea Action Plan

LBBL's environmental policy claims environmental protection at every place where the company operates (LBBL, 2017). Also Environmental Conservation Act 1995 in Bangladesh requires sustainable land management maintaining soil quality and fertility. To comply with these policy and act, LBBL requires this project to improve environmental performance with the following objectives:

##### Objectives

- Improving soil fertility by minimizing soil erosion
- Ensuring balanced fertilization
- Maximize natural regulating that is biological pest control method
- Minimizing water and energy loss
- To motivate workers how to practice sustainable agriculture that is tea production

In tea production site-Sylhet, there is no program for sustainable tea production although some companies such as Unilever-India and Unilever Kenya already have sustainable agricultural practice under the guidance of Unilever. In this case, LBBL will develop its own guideline on 'Good Agricultural Practice' for sustainable tea production in collaboration with Unilever, SAI and Bangladesh Tea Board.

##### Management Targets

The project should be implemented under a five-year plan and thereby management targets, which are consistent with LBBL policy objectives, can be as follows:

**Table 3: LBBL Policy Objectives**

<b>Objective</b>	<b>Environmental performance indicators</b>	<b>Target</b>
Minimizing water loss	Reduction of water use	10% reduction of water loss per hector per year
Ensuring balance fertilization	Increase the use of organic fertilizer	10% increase of organic fertilizer per year
Preserving soil erosion through plantation	Number of plants planted	4000 plants per year
Improve awareness among workers on sustainable agricultural practice	Number of workers trained	20% workers will be trained per year

### Activities (Do)

Responsibilities for the implementation of the project will be distributed among relevant managers. Workers will be imparted training on sustainable agricultural practice. A program on 'training for trainers' can be designed where for example supervisors will be trained as trainers. The will train the rest of workers. This will save company's money. A guideline on sustainable tea for Bangladesh may be developed for trainers encompassing the following factors:

- Soil Fertility
- Soil Loss
- Nutrients
- Pest Management
- Biodiversity
- Energy Use
- Local Economy
- Water Use

Documentation regarding such as soil quality improvement, reduction of water loss or plantation will be kept regularly. Senior management will supervise and control all activities.

### Check/Correct

Continuous internal monitoring will be done to ensure the progress on environmental performance. If any inconsistency is observed, corrective measure will be taken finding the source of difficulties. There should be a regular in-house auditing system that can be done; for example: once in two years.

### Continuous Improvement

An overall management review will be conducted to see the success and failure in the achievement of targets set. The review system will also help to identify causes of failures that need to be addressed to achieve the targets already set or the causes of failure may help to set realistic targets.

Similarly, all other sustainability programs will be implemented in a coherent way under EMS framework. Then environmental performance based on these programs and other operational activities will be formally disclosed through, for example, Triple Bottom Line (TBL) reporting.

### *Triple Bottom Line (TBL) Reporting*

#### Need for TBL reporting

LBBL needs to respond its stakeholders' concerns not only by changing its practices incorporating internal tools such as EMS, but also by informing them more openly its environmental performance against social, environmental and ethical criteria (Welford & Starkey, 2001). TBL reporting is an important tool of communication between company and key stakeholders. Therefore, to let the stakeholders know about LBBL's continues social and environmental improvement base on such as EMS, TBL reporting is the most suitable tool.

Through intensive research it was found that LBBL has yet not been publishing any report on environmental and social performance. In the wake of increased awareness and public concern over the impact of industries products and process, environmental organisation including civil society in Bangladesh are arguing companies to report their operational impacts on environment both positive and negative. Driven by various forces from different corners of society, some industries have started to report on their TBL performance. Therefore, in order to compete with other soap manufacturing companies and tea production companies in Bangladesh, such as, Kohinoor and Finley Ltd, LBBL need to incorporate 'TBL Reporting'.

#### Costs and Benefits of Environmental Reporting

##### Costs

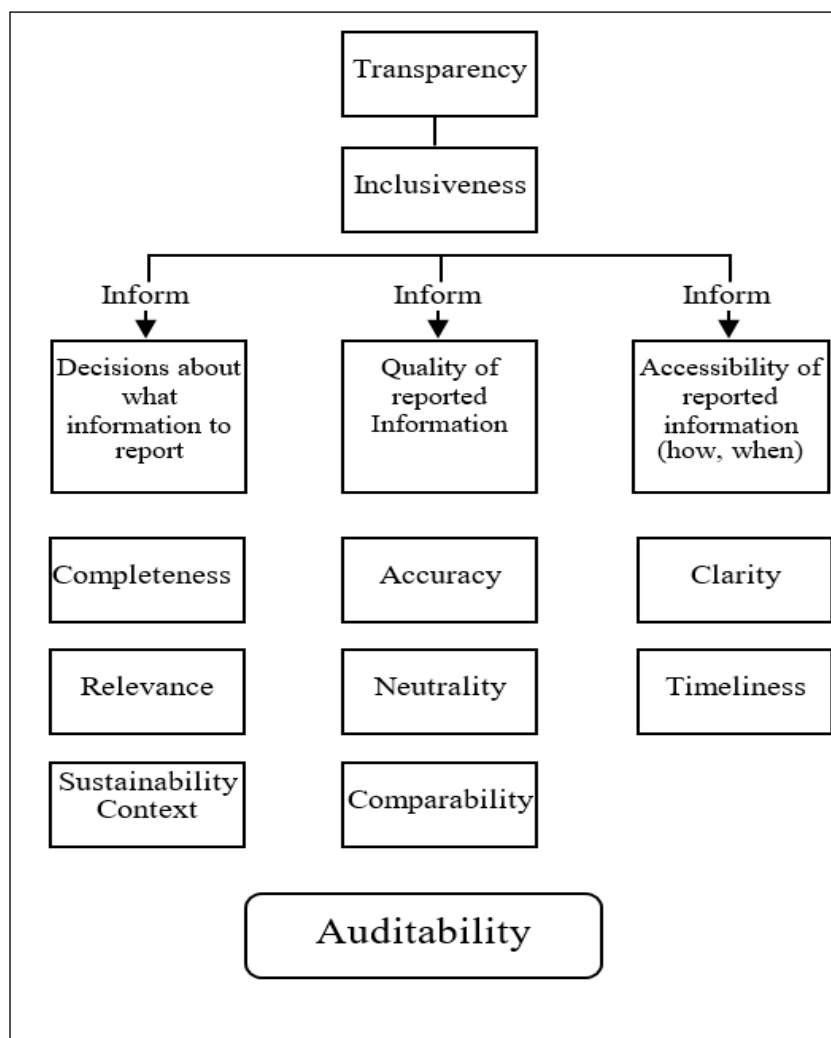
There are trade-offs for publishing a report on organisational impacts on society and environment. Bangladesh as a developing country, all shareholders may not be well concerned on the long-term benefits of environmental management done by LBBL. In this case LBBL may lose some shareholders seeking short-term financial benefits. So, there is a risk of TBL reporting when shareholder will come to know that LBBL is investing more money on environmental management. Moreover, there are direct cost involved in reporting including printing, and supply of reports to various stakeholders at home and abroad.

##### Benefits

Despite of costs involved in TBL reporting, LBBL will be benefited finically and socially in the long run. Initial cost for reporting will be higher but once the reporting system is established, cost of reporting will gradually come down. One financial benefit of reporting is to reduce volatility and uncertainty in share price and the cost of capital. Moreover, reporting acts as a process of deepening of the understanding of managers as to what is going on and how people view it (Starkey, 2001:194) and thereby reporting play as a tool of learning.

## Development of TBL Reporting

Framework of environmental reporting may be developed by LBBL at its own. Moreover, LBBL can link to Global Reporting Initiative (GRI) to have guidance on how to develop an environmental reporting. GRI involved eleven principles (Figure 4) used in environmental reporting to make the report effective. LBBL may follow those principles for its reporting. Moreover, LBBL may link with particular similar companies such as Johnson & Johnson, Values Report to have guidance on TBL reporting.



**Figure 4:** GRI Principles for Sustainability Reporting. Source: GRI (2004).

## How TBL Reporting Is Linked With Framework?

As an external sustainability tool, TBL report will be published yearly reflecting LBBL's social, environmental and ethical performance. As contents of TBL reporting not only involves TBL performance but also vision, environmental and social policies including EMS (GRI, 2004). Moreover, it demonstrates progress of environmental performance based on sustainability initiatives taken. Therefore, TBL reporting is inextricably linked with LBBL's vision, sustainability initiatives taken under vision and other management tools such as EMS; and thereby embedded in LBBL's overarching framework.

## How Programs Are Linked With TBL Reporting

The programs taken and implemented coherently and systematically under EMS framework are also an integral part of TBL reporting. These programs demonstrate that necessary actions were taken in response to the social and environmental concerns of relevant stakeholders. Therefore, all the proposed programs will be stated in TBL reporting stating both positive and negative outcomes. Indicators, in the case play a vital role to show the failure or success of an initiative.

The programs are proposed may not be adequate or there could be better alternatives to achieve sustainability goals. TBL report may express the better alternative or complementary initiatives identified through annual management review.

## Enhancement of Environmental Performance and Reporting

It is expected that the proposed integrated framework will enhance LBBL's environmental performance. LBBL will be able to have base line information with target setting with the help of indicators to see the environmental and social performance. A 5-year goal can be set to see the environmental performance under the integrated framework (Table 4).

**Table 4:** LBBL's 5-year plan for environmental and social performance, an example

Targets			Progress	
Indicator	National	LBBL	Baseline Year 2013	2014
Water use reduction	50% reduction by the & year 2018	45% reduction by the year 2018		6% based on year 2010
Energy use				
Environmental incidents	0 by year 2018	0 by 2018		25% reduction based on 2010

Indicators, an integral part of TBL reporting, have greater importance to track, control and report on the effective performance of EMS (O'Reilly, Wathey, & Gelber, 2000). Under EMS framework the following indicators, for example, can be used to assess whether EMS program is contributing to achieve environmental excellence.

**A.** Some possible indicators under proposed 'sustainable agricultural project' in tea production site located at Sylhet.

Indicators	Means of verification
Soil Fertility	% of organic matter in year X
	Soil pH and salinity/year
Soil Loss	Soil Erosion Rate/year
	% of Ground Covered by plants
Energy use	Use of renewable resources/tonne of tea production
	Green House Gas emission/ tonne of tea production
	Polluting gaseous emissions/tonne of tea production

**B.** Some possible indicator for soap production site of LBBL located at Chittagong.

Indicator	Means of Verification
Chemical oxygen demand (COD) in river water by the site	Kg/ton of soap production
Hazardous waste	Kg/ton of soap production
Non-hazardous waste	Kg/ton of soap production
Water use	Cubic meter/tonne of production
Energy use	Giga Joule/ tonne of production

Moreover, indicator is an important tool for annual reporting. Through indicator stakeholders can quickly understand the organisational performance and they compare the company with other companies in terms of: for example, environmental performance.

## Stakeholder Involvement

The proposed sustainability framework will be able to meet all target stakeholders' expectation and aspirations from different corners. As an internal tool EMS will involve all employees of LBBL from workers to top management. TBL reporting will communicate outside stakeholders such as investors, media and environmental NGOs. As a proactive approach, sustainability initiatives will be designed taking potentially affected communities' concerns into account.

## CONCLUSION

With the increasing pressure from different stakeholder and as the requirement of sustainable development, industries need to green their business in order to achieve business sustainability. This is appropriate particularly for green consumers who demand green products. To achieve business sustainability, therefore, LBBL need to employ sustainability tools as much as possible within its limited resources. This may require additional resources for the company in terms of time and money; however, LBBL will achieve long-term benefits and become model of greening business in its own sector as well as to the consumers.

## REFERENCES

- Cohen-Rosenthal, E., & Musnikow, J. (2003). *Eco-industrial strategies: unleashing synergy between economic development and the environment*: Greenleaf Publishing.
- DOE. (1997). *Environmental Conservation Rules*. Dhaka: Ministry of Environment and Forest.
- GRI. (2004). Global Reporting Initiative's First Sustainability Report, [Online], Available at: <https://www.globalreporting.org/resource/library/GRI-Sustainability-Report-2003-2004.pdf> , Accessed on: 30 June, 2016. In.
- Hart, S. L. (1997). Beyond greening: strategies for a sustainable world. *Harvard business review*, 75(1), 66-77.
- Howe, C. W. (1997). Dimensions of sustainability: geographical, temporal, institutional, and psychological. *Land Economics*, 597-607.
- Howes, R., Skea, J., & Whelan, B. (1997). *Clean and competitive? : motivating environmental performance in industry*. London: Earthscan.
- LBBL. (2017). Manufacturing Operations of Lever Brothers Bangladesh Limited, [Online], Available at: [http://www.leverbangladesh.com/ie/company\\_history.html](http://www.leverbangladesh.com/ie/company_history.html) ; Accessed on: 25 April, 2017. In.
- O'Reilly, M., Wathey, D., & Gelber, M. (2000). ISO 14031: Effective mechanism to environmental performance evaluation. *Corporate Environmental Strategy*, 7(3), 267-275.
- Schrempf-Stirling, J., Palazzo, G., & Phillips, R. A. (2016). Historic corporate social responsibility. *Academy of Management Review*, 41(4), 700-719.
- Smith, R. E. (2011). Defining corporate social responsibility: A systems approach for socially responsible capitalism, Master of Philosophy Thesis, University of Pennsylvania; [Online], Available at: [http://repository.upenn.edu/cgi/viewcontent.cgi?article=1009&context=od\\_theses\\_mp](http://repository.upenn.edu/cgi/viewcontent.cgi?article=1009&context=od_theses_mp) ; Accessed on: 12 June, 2016. In.
- UNEP. (2016). United Nations Environment Programme: Division of Technology, Industry, and Economics; Sustainable Consumption & Production Branch; [Online], Available at: <http://www.uneptie.org/scp/> ; Accessed on: 24 June, 2016. In.
- Welford, R., & Starkey, R. (2001). *The Earthscan reader in business and sustainable development*: Earthscan Publications.



# DEVELOPING BUILDING INFORMATION MODELLING (BIM) IMPLEMENTATION MODEL FOR PROJECT DESIGN TEAM

Suzila Mohd<sup>1</sup>, Juliana Brahim<sup>1</sup>, Aryani Ahmad Latiffi<sup>2</sup>, Mohamad Syazli Fathi<sup>3</sup>, Aizul Nahar Harun<sup>1</sup>

<sup>1</sup>Malaysia-Japan International Institute of Technology (MJIT), Universiti Teknologi Malaysia (UTM), Kuala Lumpur, Malaysia

<sup>2</sup>Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia (UTHM), Batu Pahat, Johor, Malaysia

<sup>3</sup>UTM Razak School of Engineering and Advanced Technology, Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia

## Abstract

Building Information Modelling (BIM) is implemented by the project design team to overcome the insufficiency of information in project design, which leads to design changes and design clashes. However, it seems difficult for project design team to implement BIM and get the benefits from its implementation in the project design stage because they do not know the right way to implement BIM especially to the beginner. Therefore, this paper proposes a model called '*BIM Implementation Model for Project Design Team*'. A literature review was carried out to explore on adaptation of BIM in the project design stage and types of maturity model in construction field. Apart from that, several semi-structured interviews were conducted with project design team to explore potential improvements to increase BIM implementation in project design stage. Both data from the literature review and the semi-structured interviews are important and contributed to the development of '*BIM Implementation Model for Project Design Team*'. This model is created to assist the project design team to improve the implementation of BIM in the project design stage and getting benefits from its implementation. The model purposes, the concept of the model, procedure of its development as well as details of the model elements presented in this paper will form the basis for the development of the '*BIM Implementation Model for Project Design Team*'.

**Keywords:** *Building Information Modelling (BIM), Construction project, Construction industry, Design stage, Maturity level, Innovation, Technology*

## INTRODUCTION

Building information modelling (BIM) is known as a human activity, which ultimately involves broad process change in the construction industry (Eastman et al., 2011). Nowadays, BIM implementation in construction projects is vital in the achievement of the construction industry development goals in many countries. Countries such as the United States of America (USA) and Finland were globally implementing BIM in their construction projects. Meanwhile, other countries such as Australia, Singapore, Hong Kong (HK) and Malaysia have started to realize the opportunity and have started to implement BIM in their construction projects (Eastman et al., 2011; Government, 2012). The countries are now starting to invest in order to implement BIM in construction projects (Government, 2012).

The main objective of BIM implementation in construction projects is to reduce any threat, which lead to construction problem such as low of construction productivity, low of project quality, project delay, construction cost overrun and disputes among construction players (Abdul Kadir et al., 2005; Eastman et al., 2011; Newman, 2013). Several authors identify one of the factors contribute to the problems is related to poor in managing project design (Gambate, 2007; Public Work Department, 2011). In order to avoid the problems, the construction players have to improve efficiency and effectiveness of managing project design.

Therefore, the implementation of BIM in project design stage is one of the best way to improve efficiency and effectiveness of construction projects in reducing construction problems (Klinger, 2006; Eastman et al., 2011).

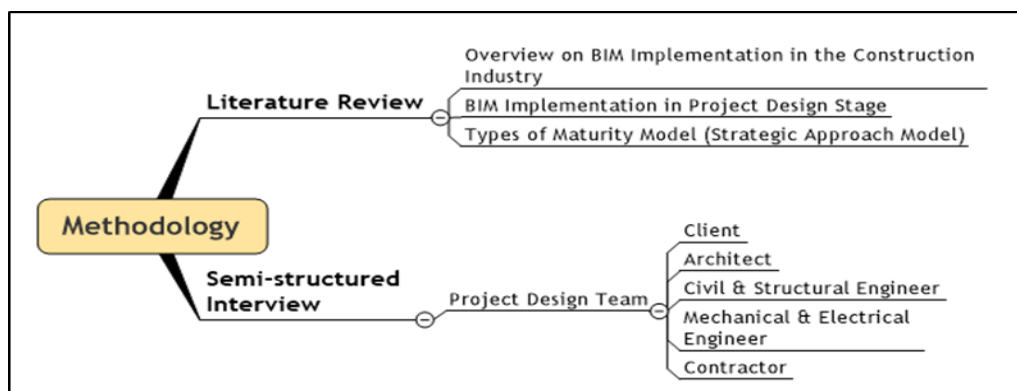
Many construction players agreed to implement BIM in their project because they believe that BIM could increase their works performance based on their projects performance especially in preparing project design (Crotty, 2013). Most of construction players especially the project design team agreed that the process of preparing project document is faster by using BIM compared with project without BIM (Eastman et al., 2011; Reddy, 2011; Crotty, 2013). For example, the ability of BIM in visualise project design in form of 3 dimensional (3D) has increase client understanding on project design compare to 2 dimensional (2D) design (Kymmell, 2008). Therefore, client can identify any changes earlier and it help design team to produce a better project documents faster than conventional process.

Moreover, the BIM uses is not only limited to project design stage. It could be used for the whole project lifecycle. There are twenty-six (26) types of BIM uses that could be applied in a construction project. BIM could be implemented in all stages of construction project, which are pre-construction stage, construction stage and post-construction stage. In order to get used all the BIM uses in construction projects and get the benefits from its implementation, it is necessary to have a proper guideline to assist the right way to implement BIM.

Therefore, this paper highlight on the barriers and challenges of BIM implementation, potential improvement to increase BIM implementation in the project design stage as well as presents a maturity roadmap to facilitate the BIM implementation among the project design team.

## DATA AND METHODOLOGY

There are two (2) methods used to develop *BIM Implementation Model for Project Design Team*. Figure 1 illustrates the methods.



**Figure 1.** Method used for developing the BIM Implementation Model for Project Design Team

Based on the figure, literature review and semi-structured interviews were conducted to gather information on BIM implementation in project design stage. The literature review was conducted to obtain information on adaptation of BIM in project design stage and types of

maturity model in the area subject to BIM and construction field. The literature review was made by referring to books, journal articles, international conference papers and materials available on the internet.

Moreover, semi-structured interviews with project design team (client, architect, civil and structural engineer, mechanical and electrical (M&E) engineer and contractor) were conducted to explore potential improvements to increase BIM implementation in project design stage. The face to face interviews involved eight (8) respondents, which have used and currently using BIM in project design stage. The respondents come from different organisations; public and private sectors. All respondents are responsible to manage project design. Apart from that, all respondents have been asked based on a set of interview questions.

The aim of the interview questions is to obtain data on the current practices of BIM implementation in project design stage in the Malaysian construction industry. All data gained from the interviews were recorded with the permission of respondents, transcribed and analysed using content analysis. Content analysis is one of technique used in this paper to analyse all data from semi-structured interviews, which all data will be presented in form of texts, tables, figures and expressions.

Both data, from the literature review and findings from semi-structured interviews with respondents were used to develop *BIM Implementation Model for Project Design Team*. Detail on the model development will be discussed on following section.

## RESULTS

This section discusses on results and findings from the interviews. The interviews provided an in-depth analysis of BIM implementation in project design stage among client, architect, civil and structural engineer, M&E engineer and contractor. Discussion on results and findings were reported into three (3) sub-sections as follows:

- i. Respondent's background;
- ii. Barriers and Challenges of BIM Implementation in Design Stage;
- iii. Potential improvements to increase BIM implementation in project design stage.

All the information lead to development of *BIM Implementation Model for Project Design Team*. Details results on each sub-section are discussed in the following section.

### Respondent's Background

The respondents consist of BIM principle director, BIM coordinator, project manager, client, architects, civil & structural engineers as well as M&E engineer. Brief on respondent's background is shown in Table 1.

**Table 1.** Respondent's background

<b>Respondent</b>	<b>Position in Project Using BIM</b>	<b>Experience in Project Using BIM (Year)</b>	<b>No. of Project Using BIM</b>
R1	BIM Principle Director	6	3
R2	BIM Coordinator	4	2
R3	Project Manager	3	3
R4	BIM Coordinator	4	4
R5	Client	5	2
R6	Civil & Structural engineer	3	4
R7	M&E engineer	3	2
R8	Architect	4	4

Based on the table, all the respondents have experienced in managing project design using BIM in between three (3) to six (6) years. All respondents are responsible in managing project design in construction project using BIM. Most of projects using BIM conducted by all respondents are residential project and commercial building. Based on the respondents' positions and experiences in project using BIM, it is reasonable to conclude that all respondents have knowledge on BIM implementation in project design stage. Moreover, the longer the experiences of the respondent in project using BIM, the greater of their understanding and knowledge on BIM implementation in project design stage. This is supported by Mendenhall, Oddou and Osland (Mendenhall et al., 2013), where they stated that personal experience is the essential element in knowledge creation.

### **Barriers and Challenges of BIM Implementation in Design Stage**

There are several factors and causes contributed to barriers and challenges of BIM implementation in design stage. Based on the interviews, all respondents agreed the first factor contributed to slow implementation of BIM in project design is people. With regards to the people, all respondents agreed that, most of construction players are comfortable with traditional or conventional process in managing project design hence they refused to implement BIM in managing project design.

In addition to that, all respondents acknowledged that, lack of awareness on BIM among clients and top managerial is one of the reasons why construction players are comfortable with traditional process in managing project design. This problem contributes to slow implementation of BIM in construction projects. Apart from that, lack of encouragement by top managerial in an organisation to implement BIM in construction projects also contributed to the lack of knowledge and skill on BIM (Lee et al., 2008).

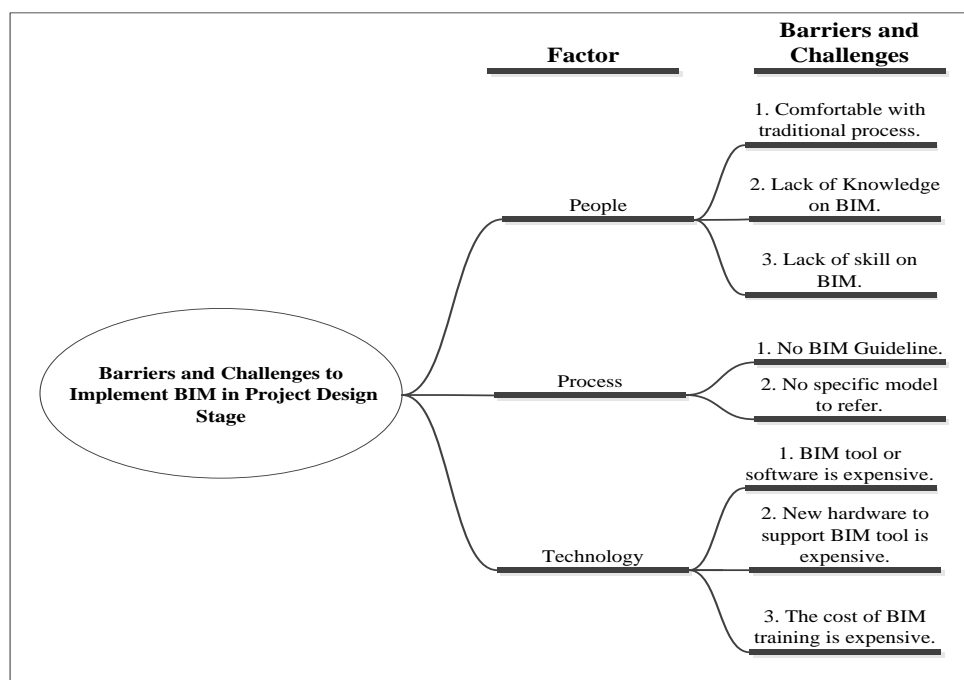
The second factor contributed to barriers and challenges of BIM implementation in design stage is the process. All respondents agreed that, there is no standardisation guideline in the Malaysian construction industry that they can follow. Consequence to that, construction players are mostly implement BIM improper way and failed to get the benefits (Gambate, 2007; Ahmad Latiffi et al., 2013; Construction Research Institute of Malaysia, 2014). This issue causes the construction players were despairing to implement BIM in their next projects.

The last factors, which contribute to barriers and challenges to implement BIM in design stage is technology. According to all respondents, the elements of tools or software, hardware and BIM training are related to the technology as a barrier and challenges to implement BIM.

They agreed that most of top managerial in construction organisations refuse to invest on BIM tools or software, hardware and trainings. This might be due to the cost issue as the total amount to implement BIM in construction project could reach RM 15,000.00 to RM 30,000.00. As a result, only large organisations can afford to own the technology.

From the interviews, all respondents agreed that the number of BIM expert in the Malaysian construction industry is limited due to reluctance of construction players to implement BIM in their projects. This is in line with Ahmad Latiffi et al. (2013) and Construction Research Institute of Malaysia (2014) where the reluctance of construction players to implement BIM is contributed to slow adoption of BIM in the Malaysian construction industry.

Based on the discussion regarding barriers and challenges to implement BIM, it can be concluded that most of Malaysian construction players are not ready to implement BIM in construction projects especially in managing project design. Therefore, the barriers and challenges of BIM implementation must be addressed in order to increase BIM implementation among construction players. Figure 2 illustrates barriers and challenges stated by all respondents.



**Figure 2.** Barriers and Challenges to Implement BIM in Project Design Stage

## Potential Improvements to Increase BIM Implementation in Project Design Stage

All respondents have suggested several potential improvements in order to improve BIM implementation in managing project design stage. There are seven (7) potential improvements to increase BIM implementation in project design stage revealed from the interviews. The potential improvements are the ways to increase BIM implementation in project design stage.

All respondents agreed, the first approach to increase BIM implementation in project design stage is by educating top managerial in construction organisation to understand and aware on benefits of BIM in project design stage. Understanding and awareness of top managerial on BIM benefits is important to increase its implementation in projects. This is because, the top managerial have the right to instruct their staff to implement BIM (Gu and London, 2010; Construction Specifications Institute, 2011).

On top of that, R2 and R5 explained the best way to increase knowledge and skills on BIM is by participating in training and seminar related to BIM. The training and seminar will benefit construction players in their career, organisation and construction projects. However, awareness of BIM must be extended to top managerial in the organisation, as top managerial is the indicator to encourage their staff to implement BIM (Gu and London, 2010; Construction Specifications Institute, 2011).

Furthermore, four (4) respondents (R3, R6, R7 and R8) agreed that other way to increase BIM implementation in project design stage is cooperation from any government bodies in construction projects. The enforcement in implementing BIM by the government can help to increase BIM practices in construction projects (Ahmad Latiffi et al., 2013). Apart from that, R1, R2 and R3 also agreed that the government should provide BIM guideline, where the guideline can assist construction players to implement BIM. Further to that, R6, R7 and R8 explained that their organisation (public authority) is developing BIM guideline for government projects. Therefore, the guideline can be used by construction players in order to manage BIM government projects. R6, R7 and R8 also stated that toward the beginning of 2016 all construction players, which interested to involve in government projects are required to implement BIM. BIM guideline is one of the approaches to increase BIM implementation in construction projects (Construction Specifications Institute, 2011).

Furthermore, all respondents agreed that any strategic approach or model is required in order to assist construction players to implement BIM in construction projects. R1 and R4 explained that, the model must able to assist construction players to implement BIM in a right ways. Another potential improvement to increase BIM implementation in project design stage stated by all respondents is by educating undergraduate or postgraduate students in any institutions on BIM. R2, R5 and R6 explained that, the cooperation between practitioner and academia as well as researchers can give early exposure to students on BIM. Apart from that, the role of researchers is also important in order to share current practices on BIM in the Malaysian construction industry through research publication. This approach at once could increase knowledge on current practices of BIM in construction projects with other construction players. Apart from that, the cooperation between government, BIM practitioners and researchers can increase BIM implementation in construction projects by assisting construction players on how to implement BIM in construction projects.

Overall, in order to increase BIM implementation in construction projects, all parties, which are construction players, the government, researcher and academician have to cooperate. Cooperation among them can increase knowledge on BIM implementation in construction projects among construction players and youth in any institutions. All respondents agreed that, the cooperation among all the parties accelerate the process to increase awareness of BIM in the construction industry. Table 2 shows the summary of the potential improvements to increase BIM implementation in project design stage.

**Table 2.** Potential Improvements to Increase BIM Implementation in Project Design Stage

No	Approaches	Respondent	Total Respondent
1	Early understanding by top managerial in an organisation on BIM.	R1, R2, R3, R4, R5, R6, R7, R8	8
2	Awareness on BIM by undertaking training and attending seminar on BIM.	R1, R2, R3, R4, R5, R6, R7, R8	8
3	Encouragement from top managerial in organisation to implement BIM.	R1, R2, R3, R4, R5, R6, R7, R8	8
4	Enforcement on implementing BIM by the government in construction projects.	R3, R6, R7, R8	4
5	Government should provide BIM guideline.	R1, R2, R3, R4, R5, R6, R7, R8	8
6	A strategic approach model is needed to assist construction players to implement BIM in construction projects.	R1, R2, R3, R4, R5, R6, R7, R8	8
7	Educate and expose on BIM to undergraduate and postgraduate students in any institutions.	R1, R2, R4, R5, R6, R7, R8	7

### **Development of *BIM Implementation Model for Project Design Team***

There are two (2) methods used in order to develop the *BIM Implementation Model for Project Design Team*. The first method is data from past literature review on types of maturity model and the second method is data from the current studies of BIM implementation in project design stage based on semi-structured interviews with project design team. Both methods were used in developing the model, so that it is more relevant and can be used in the current situation.

Maturity concept has been used to develop the research model because the research model has the same intention with the concept, which is to point out the current position to the desire position with the intention of giving benefits to project design team. There are four (4) steps to develop the BIM implementation model for project design team, which has been adopted from Bim<sup>3</sup>, Construction Supply Chain Maturity Model and Performance Measurement (PM) Migration Path Model. The models have described a clear steps on how to develop a model, which based on maturity concept. The steps are as follows:

- Step 1: Model purposes;
- Step 2: Concept of the model;
- Step 3: Procedure of model development; and
- Step 4: Details of the model elements.

All the steps have been adopted to develop *BIM Implementation Model for Project Design Team*. Details on each step will be discussed in following sections.

### *Step 1: BIM Implementation Model for Design Team Purposes*

Maturity model is a platform towards achieving a mature process (Paulk, 1993). Each level in maturity model indicates a level of capability process. Meanwhile, others author assumed that maturity model as that progress towards goal achievement that comes in stages (Lockamy III and McCormack, 2004). Therefore, the progress toward goal achievement for BIM implementation model for project design team will comes in stages or levels. The purpose of the maturity model is used to develop BIM implementation model for project design team, will help construction organisation or project design team to structure and organise BIM activities in project design stage. The maturity shows the currents position of project design team in the project design stage and the next level to be achieved by them. The *BIM Implementation Model for Project Design Team* is developed as follows:

- i. To classify the maturity of BIM implementation in project design stage of an organisation;
- ii. To guide project design team in an organisation towards an effective of BIM implementation in project design stage; and
- iii. To assists project design team in a place to start and follow several elements in each level of the model. Each element in each level of the model must be fulfilled by project design team in order to move to the next level.

### *Step 2: Concept of BIM Implementation Model for Project Design Team*

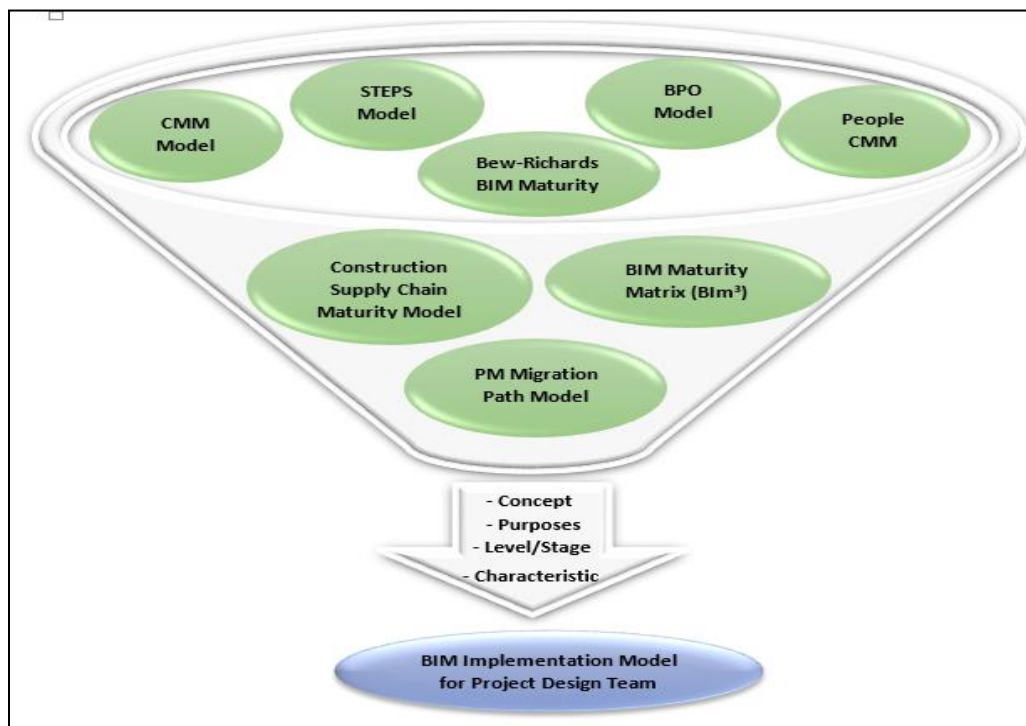
There are seven (7) maturity models used as reference to develop research model as illustrated in Figure 3. The main reason for choosing CMM (Paulk, 1993), The BPO maturity model (Lockamy III and McCormack, 2004), People CMM (Curtis et al., 2002), STEPS maturity model (Seow et al., 2006), Construction Supply Chain Maturity Model (Meng et al., 2011) and Performance Measurement Migration Path Model (Ahmad Latiffi, 2010, Ahmad Latiffi, 2012) as references for the research model development is that the research model has similar purposes with the other models. The purpose of the research model is to provide a structured approach to assist project design team to implement BIM in project design stage.

Moreover, CMM was adopted in developing research model because other maturity models adopted in this research have been developed based on CMM as reference. Although CMM was created for a different area, but it can still be accepted as main reference to develop *BIM Implementation Model for Project Design Team*. Moreover, the Bew-Richards BIM maturity model (Jayasena and Weddikkara, 2013) and BIm<sup>3</sup> (Succar, 2009) are used as reference to discuss on current level of BIM maturity in the Malaysian construction industry. Nevertheless, the purpose of all the models was assisting individual, organisation and industry to achieve something more and better from its current position.

All adopted models consisted of several levels, stages or phases, which the pattern of each model shows the lowest level to the highest level in the model. Moreover, each level describes different characteristics to achieve success of each level. The selected levels from each model



have been used as references to develop the *BIM Implementation Model for Project Design Team*.



**Figure 3.** Concept of BIM Implementation Model for Project Design Team

### *Step 3: Procedure to develop BIM Implementation Model for Project Design Team*

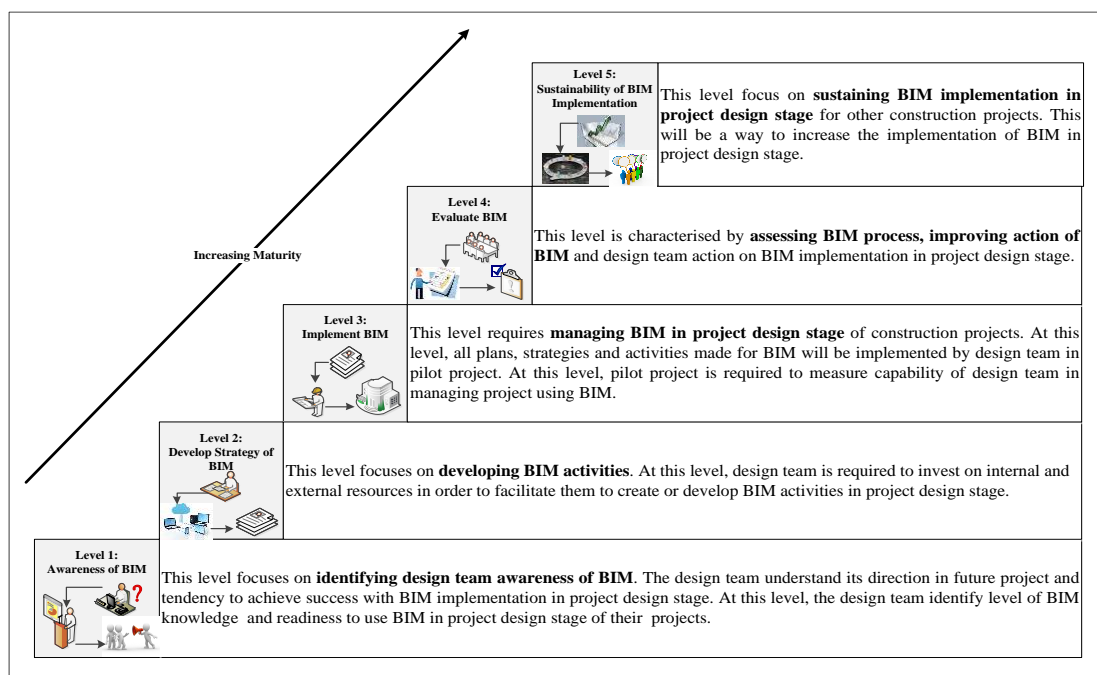
Construction Supply Chain Maturity Model (Meng et al., 2011) and Performance Measurement (PM) Migration Path Model (Ahmad Latiffi, 2012) has considered four (4) things to develop maturity model. The things have been considered and adopted in developing a maturity model for '*BIM Implementation Model for Project Design Team*'. The things are as follows:

- i. Identify criteria to be considered in implementing BIM in project design stage;
- ii. Identify number of levels needed for the model;
- iii. Identify the first element should be in the first level and later. Give consideration to what should be achieved at each level, and action taken by whom; and
- iv. Identify the lowest level of the model should demonstrate an understanding of BIM concept and processes. The highest level should show that the design team has awareness of expanding BIM implementation in project design stage to other stage in construction projects process.

In this research, all these things have been considered before developing '*BIM Implementation Model for Project Design Team*'. Details on model development are discusses in the next sub-section of this section.

#### Step 4: Details of the 'BIM Implementation Model for Project Design Team'

The 'BIM Implementation Model for Project Design Team' could help project design team to implement BIM in project design stage. It also helps project design team to benchmark their implementation efforts and guide them in improving their construction projects in order to achieve their targets. The result from using the model will takes time and it depends on project design team success to fulfil each element at each level of the model. There are several factors, which influencing the differences. The factors are lack of awareness on BIM, lack of knowledge and skills on BIM among project design team, the ability of project design team to manage BIM implementation in project design stage, lack of support from top managerial in organisation to invest on new hardware and software. Figure 4 shows the 'BIM Implementation Model for project Design Team'.



**Figure 4.** 'BIM Implementation Model for Project Design Team'

Based on the figure, the model consists of five (5) levels of maturity. The levels are **Level 1: Awareness of BIM**, **Level 2: Develop Strategy of BIM**, **Level 3: Implement BIM**, **Level 4: Evaluate BIM** and **Level 5: Sustainability of BIM Implementation**. Based on the figure, the arrows indicate the direction of movement of each level. Each level moves from Level 1 to Level 5. Level 1 is the lowest level, meanwhile Level 5 is the highest level. Each level in maturity model consists of several main aspects that need to be addressed. The level 1 is the initial level in maturity model and it is the lowest level. Readiness of the project design team to implement BIM in project design stage was identified in this level. Level 5 (the highest level), is where project design team has awareness to sustain BIM implementation in project design stage in their future construction projects. Each level in the model contains several key aspects as follows:

- **Level 1: Awareness of BIM.** This level focuses on identifying project design team awareness of BIM. The project design team understand its direction in future project and tendency to achieve success with BIM implementation in project design stage. At this level, the project design team identify level of BIM knowledge and readiness to use BIM in project design stage of their projects.
- **Level 2: Develop Strategy of BIM.** This level focuses on developing BIM activities. At this level, project design team is required to invest on internal and external resources in order to facilitate them to create or develop BIM activities in project design stage.
- **Level 3: Implement BIM.** This level requires managing BIM in project design stage of construction projects. At this level, all plans, strategies and activities made for BIM will be implemented by project design team in pilot project. At this level, pilot project is required to measure capability of project design team in managing project using BIM.
- **Level 4: Evaluate BIM.** This level is characterised by assessing BIM process, improving action of BIM and project design team action on BIM implementation in project design stage.
- **Level 5: Sustainability BIM Implementation.** This level focus on sustaining BIM implementation in project design stage for other construction projects. This will be a way to increase the implementation of BIM in project design stage.

## CONCLUSION

This paper has revealed that BIM implementation in project design stage could improve construction projects effectiveness by reducing construction problems. It also gives benefits to construction projects in term of project duration, construction cost and quality of end product. In order to increase BIM implementation in project design stage, a model has been created to assist project design team to implement BIM in project design stage. The model is called as *BIM Implementation Model for Project Design Team*. Maturity models concept has been adopted to build the model. The model is developed to assist project design team a place to start and follow several elements in each level of the model. Each element in each level of the model needs to be fulfilled by project design team in order to increase their performance in managing project design stage.

Further research will be conducted to evaluate the capability of the model in assisting project design team to implement BIM in project design stage. The evaluation will be conducted with several evaluators, which have experiences in managing project using BIM. The evaluation result will show either the model is capable to assist project design team to implement BIM in a right way or not. The results are good in order to improve the model.

## REFERENCES

- Abdul Kadir, M., Lee, W., Jaafar, M., Sapuan, S. and Ali, A. (2005). Factors Affecting Construction Labour Productivity for Malaysian Residential Projects. *Structural Survey*, 23, 42-54.
- Ahmad Latiffi, A. (2012). *Performance Measurement For Construction Businesses*. Ph.D. Thesis, Loughborough University.
- Ahmad Latiffi, A., Carrillo, P. M., Ruikar, K., and Anumba, C. J. (2010). Development of Performance Measurement Migration Path For Construction Organisations. *Third International Conference on Construction In Developing Countries (ICCIDC-III) "Advancing Civil, Architectural and Construction Engineering & Management"*
- Ahmad Latiffi, A., Mohd, S., Kasim, N. and Fathi, M. S. (2013). Building Information Modeling (BIM) Application in Malaysian Construction Industry. *International Journal of Construction Engineering and Management*, 2, 1-6.
- Construction Research Institute of Malaysia, C. (2014). Issues and Challenges in Implementing BIM For SME's in the Construction Industry.
- Construction Specifications Institute, C. (2011). *The CSI Construction Contract Administration Practice Guide*, John Wiley.
- Crotty, R. (2013). *The Impact of Building Information Modelling: Transforming Construction*, Routledge.
- Curtis, D. B., Hefley, W. E. and Miller, S. A. (2002). *The People Capability Maturity Model: Guidelines for Improving the Workforce*, Addison-Wesley.
- Eastman, C., Teicholz, P. and Sacks, R. (2011). *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*, John Wiley & Sons.
- Gambate, J. A., Pocock, J.B. and Dunston, P.S. (2007). Constructability: Concepts and Practice. *American Society of Civil Engineers*. .
- Government, M. (2012). Building Information Modelling (BIM), Industry Strategy: Government and Industry in Partnership.
- Gu, N. and London, K. (2010). Understanding and Facilitating BIM Adoption in the AEC Industry. *Automation in Construction*, 19, 988-999.
- Jayasena, H. S. and Weddikkara, C. Assessing the BIM Maturity in a BIM Infant Industry. *Proceedings of the Second World Construction Symposium 2013: Socio-Economic Sustainability in Construction*, 2013. 14-15.
- Klinger, M., and Susong, M. (2006). *The Construction Project: Phases, People, Terms, Paperwork, Processes*. , United States of America, American Bar Association.
- Kymmell, W. (2008). *Building Information Modeling: Planning and Managing Construction Projects with 4D CAD and Simulations (McGraw-Hill Construction Series): Planning and Managing Construction Projects with 4D CAD and Simulations*, McGraw Hill Professional.
- Lee, A. H., Chen, W.-C. and Chang, C.-J. (2008). A Fuzzy AHP and BSC Approach for Evaluating Performance of IT Department in the Manufacturing Industry in Taiwan. *Expert systems with applications*, 34, 96-107.
- Lockamy Iii, A. and McCormack, K. (2004). The Development of a Supply Chain Management Process Maturity Model using the Concepts of Business Process Orientation. *Supply Chain Management: An International Journal*, 9, 272-278.

- Mendenhall, M. E., Osland, J., Bird, A., Oddou, G. R., Maznevski, M. L., Stevens, M. and Stahl, G. K. (2013). *Global Leadership 2e: Research, Practice, and Development*, Taylor & Francis.
- Meng, X., Sun, M. and Jones, M. (2011). Maturity Model for Supply Chain Relationships in Construction. *Journal of Management in Engineering*, 27, 97-105.
- Newman, S. (2013). Building Information Modeling: Enabling Smart Design, Construction Facilities Management. *Research Publication*.
- Paulk, M. (1993). *Capability maturity model for software*, Wiley Online Library.
- Public Work Department, P. (2011). *Unit Building Information Modelling (BIM)* [Online]. Available: [https://www.jkr.gov.my/prokom/index.php?option=com\\_content&view=article&id=84&Itemid=435&lang=ms](https://www.jkr.gov.my/prokom/index.php?option=com_content&view=article&id=84&Itemid=435&lang=ms).
- Reddy, K. P. (2011). *BIM for building owners and developers: making a business case for using BIM on projects*, John Wiley & Sons.
- Seow, C., Hillary, R., Robinson, H., Anumba, C., Carrillo, P. and Al-Ghassani, A. (2006). STEPS: a knowledge management maturity roadmap for corporate sustainability. *Business Process Management Journal*, 12, 793-808.
- Succar, B. (2009). Building information modelling maturity matrix. *Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies*, IGI Global, 65-103.

## THEME 2: INNOVATION MANAGEMENT

# LINKING BUSINESS STRATEGY WITH ORGANISATIONAL INNOVATION

Rosmaini Tasmin<sup>1</sup> and Muhammad Shafiq<sup>2</sup>,

<sup>1</sup>*Department of Production and Operation Management, Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia.*

<sup>2</sup>*COMSATS Institute of Information Technology, Wah Cantt, Pakistan*

## Abstract

Recently, the emerging competitions in the business environment compel organisations for developing dynamic business strategies to be innovative for competitive advantage. Few organisations are using defender, prospector, analyser and reactor business strategy for the competitive advantages. However, limited empirical evidences are available to show the linkage of these business strategies with organisational innovation, either open or closed innovation. This paper examines the influence of the business strategies on organisational innovation. For this purpose, we used a quantitative research design and collected data from 250 employees of SEMs in Malaysia through a self-administrated questionnaire. The results indicated that the defender and prospector business strategies are not linked with open innovation while reactor business strategy is not linked with closed innovation. While analyser and reactor business strategies are positively influencing the open innovation in the organisation and the defender, prospector and analyser strategies are positively influencing towards close innovation.

**Keywords:** *Organisational strategy, innovation, Malaysia*

## INTRODUCTION

Strategy is an ongoing process which determines where organisation will lead, not just a briefing or an idea. There have been several engaged platforms, including opportunities and possibilities, which are discussed as strategy. In literature, Miles and Snow's *strategy types* impacted and opened many debates in management literature. Scholars and consultants and leaders had been directly influenced by these ideas. Four different strategic types have been defined in 'The Miles and Snow typology': Defenders, Prospectors, Analysers and Reactors. The Defender, Prospector and Analyser strategy types are reflected to display different, yet steady conduct, the way to evaluate circumstances, scope of domains, innovativeness and solving problems. While, Reactors strategy find it difficult to find solutions of problems. Reactor strategy type is usually deliberated unfeasible and not encouraged. There have been numerous studies on strategy and its relationship with innovation. (Williamson, 2003; Kim and Mauborgne, 2005). Interestingly and realistically, innovation is generally considered the backbone and life blood of organisational survival and growth. Product, process, and executive innovations are flagships in corporate efforts to improve efficiency and compete in the world. Innovation has generally been characterized as open and close innovation. There have been many researchers in the association and linkage between strategies and innovation. Tasmin and Woods (2007) proposed substantial linkages between knowledge management strategy and firm's innovation capability among large manufacturers in Malaysia. However, there is a clear shortage of empirical evidences about the relationship. The present literature presents the relationship between four strategy types and open plus close innovation types statistically and analytically. Our approach is to provide an analytical frame of different forms of strategies and its linkage with open and close innovations and the associated advantages and disadvantages for each type. This paper is focused in determining the relationship of four strategies with innovation types. It is important as to strategic innovation has always been a

hall mark for the management literature and grasped interest of the researchers and organisations.

## LITERATURE REVIEW

Strategy is top management level planning and implementation to achieve desired goals for the organisation under particular existing constraints and risks. These include opportunities and possibilities which have been widely discussed as strategy. Based on literature, strategy is just not ideas but the implementation of thinking process. According to Pugh and Bourgeois (2011), strategy is just not the result but a process. In last four decades, many frameworks of strategy have been developed since Five Forces (Porter, 1979; Oster, 1999), the Profit Zone (Slywotzky and Morrison, 2002), Blue Ocean Strategy (Kim and Mauborgne, 2005), the Resource-Based View (Collis and Montgomery, 2008), strategy as Options (Williamson, 1999, Beinhocker 1999), Effectual Reasoning (Sarasvathy, 2008), and the BCG or McKinsey matrices (Bourgeois, 1997).

Strategy, learning and discovery have improved the current positioning. It is only after much homework and intellectual sweat that the inventions and potential blue oceans sparked by strategic intuition come to the fore. This leads to strategic invention and innovation (Pugh and Bourgeois, 2011). Scholars and consultants have relied heavily on Miles and Snow's insights in developing practical tools and prescriptions for managers. And some managers have read and been directly influenced by their book (Hambrick, 2003). Since its development in 1978, the Miles and Snow typology of corporate-level strategies has formed the basis of many studies. Indeed, articles published in leading management and strategy journals confirm the continuing relevance of the typology. A primary reason for the popularity of the Miles and Snow typology is that it offers a simple and miserly characterization of the strategic stance of organisations (Hambrick and Crozier, 1985).

## Organisational Strategy Types

Whilst numerous empirical studies have been conducted to validate the existence and characteristics of the Miles and Snow strategy types in different domains, in this study researchers will focus on strategies' relationship with innovation. The Miles and Snow typology defines four distinct strategic types: Defenders, Prospectors, Analysers and Reactors. The Defender, Prospector and Analyser strategy types are considered to exhibit distinct, yet consistent and repetitive behaviour in terms of the way they analyse their environment (Parnell and Hershey, 2005), their breadth of product/market domains (Snow and Hrebiniak, 1980), their innovativeness (Parnell and Hershey, 2005) and their use of technology for solving problems (Miles et al., 1978). By contrast, Reactors lack a consistent strategic approach to solving problems. As a result, the Reactor strategy type is generally considered unviable (Conant et al., 1990) and is frequently omitted from studies (Shortell and Zajac, 1990). Because Reactors may vary their behaviour at different times to exhibit the characteristics of a Defender, Analyser or Prospector type, they are also difficult to characterize at a single point in time using objective approaches. During the period of time since its publication, the Miles and Snow typology has been debated and supported by many researchers (e.g. Hawes and Crittenden, 1984; McDaniel and Kolari, 1987; Snow and Hrebiniak, 1980; Zahra and Pearce, 1990). These studies and debates have contributed significantly to the body of knowledge on these strategic types. Studies have found support



for either some or all of the strategy types across a number of domains (Atkins, 1994; Hambrick, 1983; Parnell and Wright, 1993; Smith et al., 1986, 1989; Snow and Hrebiniak, 1980; Subramanian et al., 1993; Tan, 1997; Weisenfeld-Schenk, 1994; Zajac and Shortell, 1989). Tasmin et al. (2016) reported that furniture manufacturers in Southern Peninsular Malaysia were practicing the strategy of mostly the analyser and prospector approaches.

**Defenders:** Narrow product market defines defenders organisations, where the CEO has the expertise in his short domain. Opportunities are not looked for outside the organisational domain. Here the focus mainly remains on quality for operational efficiency (Miles & Snow, 1978).

**Prospectors:** These organisations always look for new domains and markets. Their thirst for new opportunities though increase their breadth, and competitors have to remain on toes, but it effects the organisational efficiency though always having potential for business (Miles & Snow, 1978).

**Analysers:** These organisations work in both stable and changing environments, in stable circumstances, the organisation is formal and focused on processes and routine tasks, having operational efficiency for market edge. But in the changing environment, the top management looks for new markets like prospectors to have an eye on environment for opportunities and adopting by competitors (Miles & Snow, 1978).

**Reactors:** These organisations react only when they must react to take corrective actions in their organisations. These organisations do not adjust according to demands of time but only react when they are forced (Miles & Snow, 1978).

## Organisational Innovation

Innovation is widely considered the life line of organisational survival and growth. Innovations are now a centrepiece in the ongoing corporate efforts to improve productivity and compete globally (Zahra, 1993). To create value from innovation, executives must make two interrelated decisions (Kotabe, 1990). The first is to select the types of innovations that are compatible with their firms' goals. The second is to decide whether their companies should rely exclusively on internal or external sources for their innovation or to imitate their rivals (von Hippel, 1988).

Recognizing, investigating and developing openings are among shared attributes of organisations which effectively evolve business processes for timely creation of value. There have been many examples of strategizing and innovation, as mentioned in literature, be it high quality modern agriculture products internationalization and production, or acquisitions and merging in technological firms. The same applies to even bakery industry as described in literature, the company Polarbröd, a bread producer from Northern Sweden, has managed to think outside the box to identify new business opportunities and increased its sales and profitability, becoming the third largest producer of bread in Sweden, in an otherwise shrinking industry. Polarbröd identified opportunities, made mistakes but still got internationalization through innovation and experience Dahlander and Gann (2010). As evident from above examples, organisations use their resources in a balanced way for strategic growth, which usually comprises business model revision or development.

These strategies enable the design of business model. As recent literature on business models had pointed out that business models need to change over time, it was still unclear which strategies and activities would be necessary to achieve such change. According to Dahlander and Gann (2010), if a strategy is good in one context may be otherwise in other contexts. Companies which manage to successfully adapt and renew their business models over time typically display all of these strategizing actions and capabilities in pronounced form. These are not only interlinked, they are complementarities, meaning that their combined use facilitates even more sustained value creation. From a theoretical point of view, each type of innovation has significantly different characteristics.

## Open Innovation

A number of papers draw on the openness construct to depict and explain different aspects of the innovation process. Open innovation has been one of the most debated topics in management research in the last decade (Chesbrough, 2003; Christensen et al., 2005; Gassmann, 2006; Vanhaverbeke, 2006; West and Gallagher, 2006). The open innovation model corresponds to companies that are really able to manage a wide set of technological relationships, that impact the whole innovation funnel and involves a wide set of different partners. The extant literature presents the concept of openness in quite different ways; Laursen and Salter (2006a) equate openness with the number of external sources of innovation, whereas Henkel (2006) focuses on openness as revealing ideas previously hidden inside organisations. Our approach is to provide an analytical frame of different forms of openness and the associated advantages and disadvantages for each type.

It is an emerging innovation management paradigm comprised of two dimensions:

- (i) *Inbound Open Innovation*, which is the practice of establishing relationships with external organisations or individuals with the purpose of accessing their technical and scientific competences for improving internal innovation performance and
- (ii) *Outbound Open Innovation*, which is the practice of establishing relationships with external organisations with the purpose of commercially exploiting technological knowledge. (Davide C, Vittorio C and Fedricco F, 2010)

Open innovation is described by a high tension towards technological leadership and internationalization of activities, even R&D; technology and represent critical success factors and require excellent and diversified competencies; R&D and innovation activities have a very high level of risk, both technical and commercial and the level of R&D spending is quite high (as a percentage of sales). This allows to manage and control innovation networks as a whole, from the definition of objectives and risks, through partners' analysis and selection, to the definition of each organisation's specific role and contractual form of collaboration, the detailed planning of activities and the measurement of actual results. Obviously, designing and implementing such a complex organisational process requires advanced managerial competencies (Dodgson et al., 2005).

## Close Innovation

The closed innovators' model corresponds to external sources of knowledge only for a specific, single phase of the innovation funnel and typically in dyadic collaborations, to invest

in their internal R&D effort and believe that keeping the innovation process closed allows them to avoid significant costs and risks. In other words, they perceive the openness and the relationships to be too difficult and costly compared to the potential benefits (Laursen and Salter, 2006). The idea is that all the resources (people, money, competencies) and managerial ability should be focused internally to develop innovation.

Therefore, these firms develop most technologies in-house. Technological leadership is expected to be mainly the result of an internal effort instead of being the result of an innovation network. The R&D risk is not too high and there is little need to share it with other parties. It can be managed by the company itself, by using sophisticated managerial tools and techniques. Subsequently, technical alliances are occasional involving a few allies having long-term relationships and restricted threat of rift.

## Hypotheses Development

Integration of the business strategy with organisational innovation strategy is central to the competitive advantage. Organisations are consistently looking for new mechanisms of the integration of the both. There have been many researchers focusing on the relationship of strategy and innovation, as few have been mentioned in below Table 1. Zahira and Covin (1994) mentioned the financial implication of the integration of the organisational strategy with its innovation practice. Williamson (2003) focused on the strategic intent and the organisational innovation. Kim and Mauborgne (2005) related blue ocean strategy with organisational innovation. More recently, Evans *et al.* (2009) linked strategic thinking with organisational innovation. Nuntamanop *et al.* (2013) presented a new model for linking the business strategy and organisational innovation. However, none of these studies focused on the relationship of different types of the business strategy with both open and close innovation (Zahira and Covin, 1994; Gimenez, 2010; Joseph, 2001; Sundbo, 1996). Geminiez (2000) have also discussed in detail the limitations and roles of each strategy type in different scenarios, especially focussing SME's. To create value from innovation, executives must make two interrelated decisions (Kotabe, 1990). The first is to select the types of innovations that are compatible with their firms' goals. The second is to decide whether their companies should rely exclusively on internal or external sources for their innovation or to imitate their rivals (von Hippel, 1988).

**Table 1.** Studies on business strategy and organisational innovation

Authors	Framework	Constructs
Zahira and Covin (1994)	The financial implications of fit between competitive strategy and innovation types and sources	Strategy and innovation
Fernando and Gimenez (2000)	Coherent strategy for innovation	Miles and Snow Model with innovation in SME's
Williamson (2003)	Strategy innovation	Strategic intent, innovation
Kim and Mauborgne (2005)	Blue ocean strategy	BOS and innovation
Beown (2005)	The evolving role of strategic management development	Strategic formulation, innovation
Evans <i>et al.</i> (2009)	Strategic thinking about disruptive technology	Strategic thinking and innovation
Nuntamanop <i>et al.</i> (2013)	A new model of strategic thinking competency	Strategy and innovation

This paper focuses more on relationship between strategy types and appropriate innovation types. Following hypotheses have been developed, after through study of literature from Snow & Miles' four strategy types of Defender, Prospector, Analyser and Prospector, and innovation types.

- H1: Defender business strategy has a positive influence on the open innovation**
- H2: Prospector business strategy has a positive influence on the open innovation.**
- H3: Analyser business strategy has a positive influence on the open innovation.**
- H4: Reactor business strategy has a positive influence on the open innovation.**
- H5: Defender business strategy has a positive influence on the close innovation.**
- H6: Prospector business strategy has a positive influence on the close innovation.**
- H7: Analyser business strategy has a positive influence on the close innovation.**
- H8: Reactor business strategy has a positive influence on the close innovation.**

This results in how a firm will focus those innovations which are dependable with its strategy. This study is based on the basic concept of strategic management. Strategic management is a set of decisions and actions that result in the formulation and implementation of plans designed to achieve an organisation's objectives (Pearce and Robinson, 2000), and relates to innovation.

We hope that this paper will inspire researchers to build on the concept and theorize in a way that helps explain which conventional strategy is more relevant to which innovation type

## METHODOLOGY

### Sample

The data for this research paper was collected from the Small and Medium Enterprises two hundred and fifty employees in Malaysia. Organisation was the unit of analysis in this research. Demographic analysis is highlighted in the following sections using frequency tests of the respondents. 55.6% of the respondents belong to the 30 to 40 years age group. Respondents of the age category of 26-30 years are followed as 35.2%, remaining 19% are from other groups. Gender wise investigation represent that 58.3% were male respondents, representing male dominant SME in Malaysia. Master's level education (22.5%) and high secondary certificate were 18.8% while most of the respondents were graduates (47.8%).

### Measures

Market orientation scale of Narver and Slater's (1990) was adopted as measurement scale; market orientation as single construct based on five items was used in this study. 5-point Likert scale was used to measure all items, ranging from 'strongly disagree' to 'strongly agree'. Sisodiya (2008) scale was used to measure inbound open innovation. Five items were used to measure the construct based on 5-point Likert scale ranging from strongly disagree to strongly agree. The scale of Lichtenthaler (2009), of five items was used to measure the outbound innovation.

This study adopts 26 items of Segev's (1978) instrument to measure firm's strategy. According to the description of four types of Miles and Snow's strategy, nine items were

developed to evaluate defender type of strategy, 6 items for prospector, five and four items were used to measure analyser and reactor strategy respectively.

## DATA ANALYSIS AND RESULTS

### Measurement Model

As a required step in testing the conceptual models, the suitability of the computed variables must be assessed. Confirmatory factor analysis (CFA) was conducted by using AMOS 18. The results of the CFA indicated that all of the values are within the acceptable ranges as shown in Table 2. The factor structure of each model fits the data and all fit indices met the respective criteria with  $\chi^2$ =Chi-square; DF= Degree of Freedom; CMIN= Minimum Chi-square; GFI= Goodness of fit index; RMR= Root Mean Square Residual; RMSEA= Root Mean Square Error of Approximation; NFI= Normed Fit Index; TLI= Tucker Lewis Index; CFI = Comparative Fit Index and AGFI= Adjusted Goodness of Fit Index. The criteria for eliminating the items were set on the basis of the factor loadings and the residual values of the each item. The factor loadings  $>.50$  was selected to retain the items.

**Table 2:** Confirmatory factor analysis (CFA) tabulated construct results

	CR	AVE	Open Innovation	Defender	Prospector	Analysed	Reactor	Close Innovation
Open Innovation	0.897	0.685	<b>0.828</b>					
Defender	0.911	0.673	0.521	<b>0.820</b>				
Prospector	0.867	0.522	0.620	0.516	<b>0.722</b>			
Analysed	0.839	0.512	0.672	0.791	0.598	<b>0.716</b>		
Reactor	0.884	0.605	0.603	0.715	0.514	0.590	<b>0.778</b>	
Close Innovation	0.862	0.624	-0.290	-0.028	-0.096	-0.139	-0.158	<b>0.790</b>

Figure 1 showed the results of measurement model. At the first stage, all latent constructs were correlated to test the measurement model fitness of all constructs. The model showed a good fit as the values to CMIN/DF=1.40, df = 808,  $\chi^2$ = 1130.476, GFI= .918, RMR= .058, RMSEA=.057, TLI=.896, AGFI=.848, CFI=.915. These values indicated a good model fit for the measurement validation through CFA.

Convergent validity is the construct indicators that reflect a large amount of the mutual proportion of variance among factors. It determines the amount of correlation among the measures of the same concept (Amran, 2006, Arbuckle, 2011; Hair et al., 2010). Convergent validity deals with construct loadings, average variance extracted (AVE) and construct reliabilities. Average variance extracted is the sum of square of standardized factor loadings to represent how much variation in each item is explained by latent. The average variance extracted is the average percentage of variation explained by the measurement items in a construct. The standard value of AVE is .50 or greater. Table 2 shows the average variance extraction of each construct and results showed that all the constructs have more than .50 of

average variance extraction, that shows all the constructs have sufficient amount of convergent validity. Range of Average Variation Extractions are 0.512 - 0.685.

The threshold value of the construct reliability is .70 or above (Amran, 2006; Cooper and Schindler, 2011). Table 2 shows that all the constructs have adequate reliability of all constructs ranges from .817 to .911. Therefore, the current study does not violate the convergent validity of the constructs. Discriminant validity referred to the extent to which an instrument contains a construct that was truly distinct from all others. Discriminant validity is the degree to which similar constructs have distinct values. In this type of validity, the responses are measured without cross loading in terms of latent constructs (Arbuckle, 2011; Hair et al., 2010). Discriminant validity is violated when the correlation among exogenous constructs is more than 0.85 (Cooper and Schindler, 2011). In discriminant validity the value of the square root of average variance extraction should exceed than the value of inter-construct correlations. Table 2 shows the inter-construct correlations. Results indicate that all the constructs have adequate discriminant validity as the square root of average variance extracted is greater than the inter-construct correlation of each variable and also the values of inter construct are less than 0.85. It means results provide sufficient evidence of discriminant validity of the constructs.

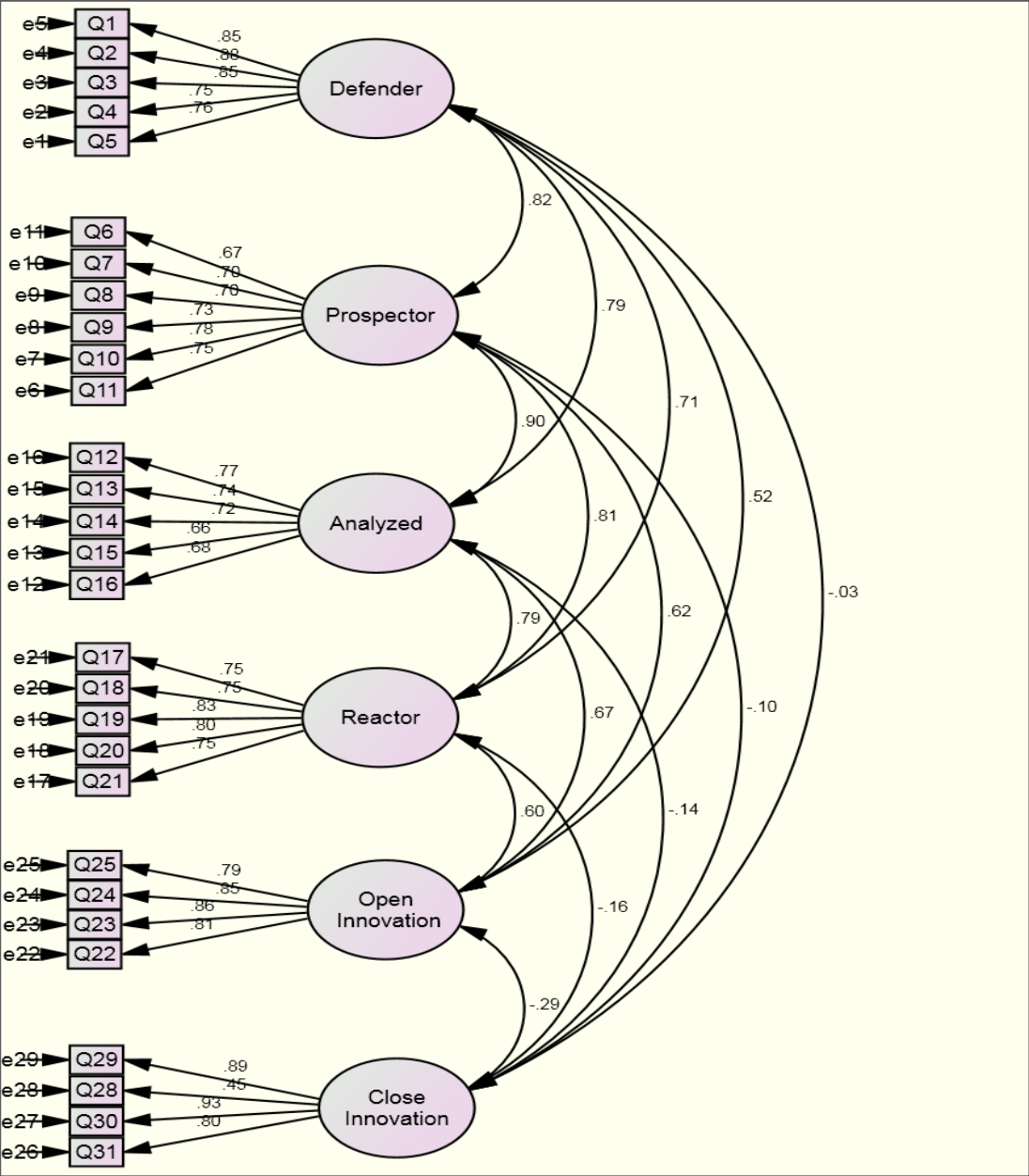


Figure 1: Measurement Model

## Hypotheses Testing

The proposed structural model consists of 8 hypotheses, as indicated in Figure 2. Structural model composed of basic six constructs which are namely defender, prospector, analysed and reactor business strategy, open innovation and closed innovation.

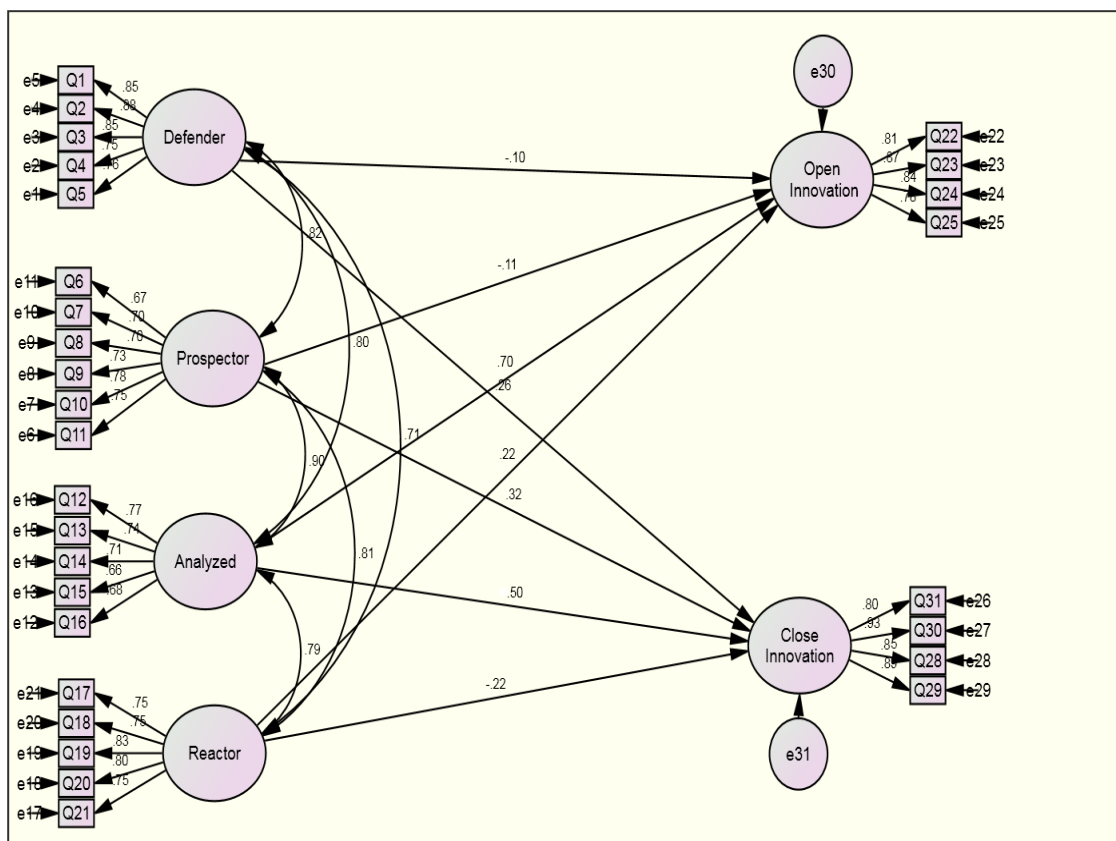


Figure 2: Structural Model of the Six Constructs

First hypothesis of the study states that **H1: Defender business strategy has a positive influence on the open innovation.** So, the standardized path coefficient of this was -.10 and unstandardized path coefficient was -.113 with p value above than 0.05. Thus, this provides enough evidences to reject research hypothesis H1. Thus, this study found no relationship between defender business strategy and open innovation. Second hypothesis of the study states that **H2: Prospector business strategy has a positive influence on the open innovation.** So, the standardized path coefficient of this was -.11 and unstandardized path coefficient was -.120 with p value above than 0.05. Thus, this provides enough evidences to reject research hypothesis H2. Thus, this study found no relationship between prospector business strategy and open innovation.

Third hypothesis of the study states that **H3: Analyser business strategy has a positive influence on the open innovation.** So, the standardized path coefficient of this was .70 and unstandardized path coefficient was .910 with p value less than 0.05. Thus, this provides enough evidences to accept research hypothesis H3. Thus, this study found positive



relationship between analysed business strategy and open innovation. Fourth hypothesis of the study states that **H4: Reactor business strategy has a positive influence on the open innovation.** So, the standardized path coefficient of this was .21 and unstandardized path coefficient was .243 with p value less than 0.05. Thus, provides enough evidences to accept research hypothesis H4. Thus, this study found positive relationship between reactor business strategy and open innovation.

Fifth hypothesis of the study states that **H5: Defender business strategy has a positive influence on the close innovation.** So, the standardized path coefficient of this was .26 and unstandardized path coefficient was .321 with p value above than 0.05. Thus, this provides enough evidences to accept research hypothesis H5. Thus, this study found positive relationship between defender business strategy and close innovation. Sixth hypothesis of the study states that **H6: Prospector business strategy has a positive influence on the close innovation.** So, the standardized path coefficient of this was .32 and unstandardized path coefficient was .356 with p value above than 0.05. Thus, provides enough evidences to accept research hypothesis H6. Thus, the current study found positive relationship between prospector business strategy and close innovation.

Seventh hypothesis of the study states that **H7: Analyser business strategy has a positive influence on the close innovation.** So, the standardized path coefficient of this was .50 and unstandardized path coefficient was .684 with p value less than 0.05. Thus, this provides enough evidences to accept research hypothesis H7. Thus, this study found positive relationship between analysed business strategy and close innovation. Eighth hypothesis of the study states that **H8: Reactor business strategy has a positive influence on the close innovation.** So, the standardized path coefficient of this was -.22 and unstandardized path coefficient was -.262 with p value above than 0.05. Thus, this provides enough evidences to reject research hypothesis H8. Thus, this study found no relationship between reactor business strategy and close innovation. Table 3 below shows the results of the path analyses between the innovation and the strategy

**Table 3:** Path analyses of the business strategies and the innovations

Path			Estimate	S.E.	C.R.	P	Label
Open_ Innovation	<---	Defender	-.113	.113	-.999	.318	Not significant
Open_ Innovation	<---	Prospector	-.120	.205	-.584	.559	Not significant
Open_ Innovation	<---	Analysed	.910	.246	3.697	0.00	Significant
Open_ Innovation	<---	Reactor	.243	.114	2.132	.033	Significant
Close Innovation	<---	Defender	.321	.146	2.202	.028	Significant
Close Innovation	<---	Prospector	.356	.026	13.59	0.00	Significant
Close Innovation	<---	Analysed	.684	.300	2.283	.022	Significant
Close Innovation	<---	Reactor	-.262	.146	-1.787	.074	Not significant

Regression Weights: (Group number 1 - Default model)

## DISCUSSION AND CONCLUSION

Researcher aims to examine the relationship of business strategy with organisational innovation strategy. For this, we proposed eight hypotheses related to the business strategies (i.e. defender, analyser, prospector and reactor) and its relationship with organisational innovation, either closed or open innovation. Our results suggested that the defender business

strategy focus on the passive approach and strives to work with the current status of the organisation. Thus, it is more likely that the organisations having defender business strategy will resist organisational innovation importing from the outside of the organisational boundaries. However, defender business strategy is more linked with the closed innovation performance of the organisation. Similarly, this is the case of the prospector business strategy. The organisation having prospector business strategy are more focused to enhance their business and mostly focused on the new opportunities to promote their business activities. These organisations are ready for in-house innovation and rely on their capabilities. Thus, prospector business strategy is closely linked with closed innovation strategy. Meanwhile, analyser business strategy focuses on the market information and closely analyse the dynamic situation of the business environment and have the ability to cope any situation and turbulence. Thus, analyser business strategy is positively related with both open and close innovation. Finally, the reactor business strategy is a passive business strategy and it contemplates on the changes in markets environments. Mostly, it is impossible for this type of the organisation to meet the competitive dynamic business challenges, through closed innovation. In addition, organisations having high levels of reactor business strategy are positively linked with open innovation.

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Note: Muhammad Shafiq, corresponding author is PhD scholar of Technology Management and Business in UTHM, and a member of academics in COMSATS Institute of Information Technology, Wah Cantt, Pakistan. His alternative email id is [consult.shafiq@gmail.com](mailto:consult.shafiq@gmail.com)

## REFERENCES

- Brian R. Golden. The Past Is the Past--Or Is It? The Use of Retrospective Accounts as Indicators of past Strategy. *The Academy of Management Journal*, 1992, 35(4), 848~860
- Bourgeois, L.J. Note on portfolio techniques for corporate strategic planning (M), UVA-BP-0292 1997
- Beinhocker, E.D. Robust adaptive strategies, *Sloan Management Review*, 1999, 95~106
- Collis, D. J., & Montgomery, C. A. Competing on resources. *Harvard Business Review*, 2008, 86(7/8):140~150
- Dr. John A. Parnell Dr. Lewis Hershey. The Strategy-performance relationship revisited: The blessing and curse of the combination strategy, *International Journal of Commerce and Management*, 2005, 15(1): 17~33
- David J Teece. Business Models, Business Strategy and Innovation, *Long Range Planning*, 2010, 43:172~194
- Davide C, Vittorio C and Fedricco F. Unravelling the process from Closed to Open Innovation: evidence from mature, asset-intensive industries, *R&D Management*, 2010, 40(3)
- Dahlander, L and Gann, D. M. How open is innovation?, *Research Policy*, 2010, 39:699~709
- Fernando A.P. Gimenez. The benefits of coherent strategy for innovation and corporate change: A study applying Miles & Snow's Model in the context of small firms, *Creativity and Innovation Management*, 2010, 9(4):235~244
- Hambrick, D. C, & Crozier, L. M. Stumblers and starts in the management of rapid growth, *Journal of Business Venturing*, 1985, 1:31~45
- Hambrick, D. C. On the staying power of defenders, analysers and prospectors, *Academy of Management Executive*, 2003, 17(4):115~118
- Jon Sundbo. The balancing of empowerment, *Technovation*, 1996, 16(8):397~409
- Joseph, E.M, Anna Y, Leon G, Jonathan DH Jr, Strategic goals and practices for innovative family business, *Journal of small business management*, 2001, 39(1):50~59
- Porter M.E. How competitive Forces Shape Strategy? *Harvard Business Review*, Mar-Apr 1979.
- Pugh, J. and Bourgeois, L.J III. Doing strategy, *Journal of Strategy and Management*, 2011, 4
- Joachim C D, Dileep K M, Rosman M Y, M I Qureshi, Modeling Market Orientations For SME Performance, *JURNAL TEKNOLOGI*, 2015, 72(1)1, 1~6, [www.jurnalteknologi.utm.my](http://www.jurnalteknologi.utm.my) eISSN 2180-3722
- Kim, W.C and Mauborgne, R. *Blue Ocean Strategy: How to Create Uncontested Market Space and Make Competition Irrelevant*, Harvard Business School Press, Boston, MA, 2005
- Karen Blackmore and Keith Nesbitt. Verifying the Miles and Snow strategy types in Australian small and medium-size enterprises, *Australian journal of Management*, 2012, 38(1):171~190
- Achtenhagen, L. Melin, L. Naldi, L. Dynamics of Business Models – Strategizing, Critical Capabilities and Activities for Sustained Value Creation, *Long Range Planning*, 2013, 46(6):427~442

- Miles, R.E. & Snow, C.C. *Organisational Strategy, Structure and Process*. New York: McGraw-Hill, 1978.
- Miles, R.E. Snow, C.C. Meyer, A.D. Coleman, H.J. et al. Organisational strategy, structure, and process, *Academy of Management Review* 1978, 3(3): 546~562
- Masaaki Kotab. The Relationship between Offshore Sourcing and Innovativeness of U.S. Multinational Firms: An Empirical Investigation, *Journal of International Business Studies*, 1990, 21(4): 623~638
- Nuntamanop, P. Kauranen, I. and Igel, B. A new model of strategic thinking competency, *Journal of Strategy and Management*, 2013, 6 (3):242~264
- Oster, S. *Modern Competitive Analysis*. New York: Oxford University Press, 1994.
- Oliver E. Williamson. Strategy Research: Governance and Competence Perspectives, *Strategic Management Journal*. Dec 1999. 20(12) pp. 1087-1108
- Snow, C.C. & Hrebiniak, G. Strategy, Distinctive Competence, and Organisational Performance, *Administrative Science Quarterly*. 1980. 25(2):317~336
- Shortell, S.M. & Zajac, E.J. Perceptual and archival measures of Miles and Snow's strategic types: a comprehensive assessment of reliability and validity, *Academy of Management Journal*, 1990. 33(4):817~832
- Slywotsky, Adrian, J., Morrison David J. & Alderman, Bon, *The Profit Zone: How strategic business design will lead you to tomorrow's profits*. New York: Times Books/ Random House, 2001.
- Sarasvathy, S. & Dew, N. Effectuation and over-trust: Debating Goel and Karri (J), *Entrepreneurship Theory and Practice*, 2008, 32(4): 727~737
- Stanley, F. Slater, Eric M. Olson, G. Tomas M. Hult. Worried about strategy implementation? Don't overlook marketing's role, *Business Horizons*, 2010, 53:469~479
- Tasmin, R. & Woods, P. Relationship between corporate knowledge management and the firm's innovation capability, *International Journal of Services Technology and Management*, 2007, 8(1):62~79.
- Tasmin, R. Takala, J. Abu Bakr, A.A. Shylin, D. Nizialek, I. & Che Rusuli, M.S. Sustainable Competitive Advantage (SCA) Analysis of Furniture Manufacturers in Malaysia: Normalized Scaled Critical Factor Index (NSCFI) Approach, *Management and Production Engineering Review*, 2016, 7(2): 73~85
- Valentina, L. & Raffaella, M. Different Modes of Open Innovation: A Theoretical Framework and an Empirical Study, *International Journal of Innovation Management*, 2009, 13(4):615~636
- Williamson, P.J. *Strategy Innovation*. The Oxford Handbook of Strategy: A Strategy Overview and Competitive Strategy edited by Faulkner, D.O. and Campbell, A. Ed, Oxford University Press: Oxford. 2003
- Zahra, S.A. & Johan, A.P. Research Evidence on the Miles-Snow Typology, *Journal of Management*, 1990, 16(4):751~768
- Zahra, S.A. & Covin, J.G. The Financial Implication of Fit between Competitive Strategy and Innovation Types and Sources, *The Journal of High Technology Management Research*, 1994, 5(2):183~211

# MILITARY EXPENDITURE AND STOCK MARKET CAPITALIZATION: EVIDENCE FROM AN EMERGING MARKET

Assad Ullah<sup>1</sup>, Yang Qingxiang<sup>1</sup>, Zahid Ali<sup>2</sup>, Nadia Hidayat<sup>2</sup>, Muhammad Asif Khan<sup>3</sup>

<sup>1</sup>*School of Management Huazhong university of Science and Technology, Wuhan China*

<sup>2</sup>*School of Accounting Zhongnan university of Economics and Law, Wuhan China*

<sup>3</sup>*School of Economics Huazhong university of Science and Technology, Wuhan China*

## Abstract

This research work explores the relationship between military spending and stock market capitalization in Pakistan. We employed the methodology of ARDL bounds testing to cointegration over the period 1990-2012. The series stationarity properties were checked via Augmented Dicky Fuller (ADF) test. The conventional measure of military spending has been augmented by a comprehensive index-The Global Militarization Index. We observed cointegration among military expenditure, interest rate, trade openness, growth in GDP and stock market capitalization. Hence, the long run relationship among the variables has been verified. A negative and significant association has been established between military spending and stock market capitalization. The study concludes that military expenditure is a vital determinant of stock market capitalization in Pakistan. A steady reduction in military spending is required for the enhancement of stock market performance.

**Keywords:** *Military Spending, Stock Market Capitalization, Co-integration, Pakistan*

## INTRODUCTION

Since McKinnon's seminal work in 1973, numerous studies have highlighted the importance of capital markets e.g., it enhances economic growth by speeding up the domestic and foreign resources mobilization and facilitates investment Bencivega et al. (1996), furnishes an opportunity for growth driven firms to raise low-cost capital (Marone, 2003) and reduces the dependency on bank financing which is vulnerable to fluctuations in interest rates Yartey (2008). Apart from the enhancement of capital formation, an efficient stock market will also increase the current stock of capital of an economy. The overall performance of the agriculture, industry and services sector is improved with the help of capital markets—it provides accessibility to financial resources. In nutshell, stock market is a vital element for the enhancement of economic development. In the last decade considerable growth has been shown by emerging markets till 2008 during which the global financial crisis struck the global markets which instigated uneasiness for policy makers. Recovery has been witnessed in the economic activities for the majority of emerging markets in the later part of 2010. Since that time they maintained their tempo to pull an increasing amount of investment.

Pakistan has undergone numerous contrasting developments in the last decade. Political uncertainty has remained very severe throughout the 1990's and the overall economy was impaired by inadequate fiscal control, rapid increase in public debt burden, poverty and higher unemployment. Nine different Governments ruled Pakistan during 1998 to 1999 followed by the military coup in October 1999.

The new millennium brought a fresh period of macroeconomic steadiness in Pakistan. In order to bring financial discipline, economic reforms were introduced in the regime of President Musharraf. The attacks of September 11, 2001 enhanced the economic growth and

its steadiness by pulling in large multilateral donors and foreign capital flows based on Pakistan's assistance in the war on terror (Khwaja et al., 2010). The unexpected surge in capital inflows combined with the policies of the government pertaining to privatization and monetary policy reforms granted liquidity to the local markets. The stock market capitalization of Pakistan increased from \$5 billion in 2001 to \$70 billion in 2007. The structural reforms coupled with political and economic stability enabled Pakistan to attain consistent economic growth during the course of 2000-2007. It is intriguing to evaluate the primary factors associated with intense stock market growth in Pakistan. A few possible sources have been reported regarding this fact. Some research studies have correlated the growth in the period 2001-2007 with the geopolitical condition of the region. For instance, Khwaja et al., (2010) contend that the unexpected event of September 11, 2001 resulted in rise of capital flows towards Pakistan. The rise in capital inflows is partly shown by Pakistan's assistance in the war against terrorism after September 11, 2001, since sanctions were removed and also the loans outstanding were rescheduled. A rejuvenated collaboration with the developed countries provided the opportunity for bilateral and multilateral foreign aid. The significant growth during the period 2001-2007 is additionally related macroeconomic reforms being launched by the government of Pakistan in the year 2000. These types of reforms not only assisted Pakistan to entice a huge amount of direct foreign investment to Pakistan but at the same time led to a sharp increase in workers remittances and foreign exchange reserves.

After 2007, Pakistan has become the major victim of terrorism and is facing severe consequences. Pakistan has now been considered to be the most dangerous territory all over the world Riedel (2008). Nearly all of the terrible incidents of terrorism happened in Pakistan in the last decade. In comparison to Afghanistan and Iraq, Pakistan suffers from the most number of suicide bombings casualties (Global terrorism database). Terrorism results in investors' uncertainty problem thereby making them more risk averse which has an extremely negative effect on the economic growth of a country. In Pakistan, terrorism has affected nearly every channel e.g., economic growth, volume of trade, GDP per capita thereby resulting in high budget deficit, soaring inflation, and higher military expenditures, which has eventually made the country miserable (Ali, 2010). Significant slump pertaining to economic activities has been observed recently in Pakistan including the decrease foreign investment. Because of terrorism Pakistan has endured the cost of about 33% of real national income (Mehmood, 2014). In Pakistan terrorism consumes around 1% of growth in real per capita GDP annually (Mehmood, 2014).

Since 1947, severe enmity continues between India and Pakistan after their separation. The issue of Kashmir is the main dispute between the two countries not to mention the dispute over water as well as border dispute. Both countries set aside a substantial part of their GDP in order to boost their defence sector. Nuclear tests were carried out by India in 1974 which motivated Pakistan go for nuclearization and the arm race between the two countries still goes on. The Pak-India rivalry has directed Pakistan in bigger disadvantage i.e. not only it has to maintain the army of a million men but the country must also assign approximately 40 percent government expenditure to defence sector.

In order to deal with intimidations countries need some level of security but additional funds utilized on these security measures also carry opportunity costs i.e. they can be used for welfare. Each increment on defence spending is linked to trimming down the welfare

expenditure such as health and education expenditures; a high budget deficit and rising inflation (Dunne, 2012). Defence industries attracts skilful engineers and labour which results in draining effect on the availability of human capital for private organisations (Melman, 1983). Arms accumulations may unsettle foreign investors and may compel them to shift their capital from the country of investment. Doing so will reduce companies valuations. Apart from this if loans are backing the military expenditure, then the debt amount will inevitably rise. In the same way if the import of military weapons will take place then it will affect balance of trade and thus can trouble the local businesses.

Keeping these backdrops in mind it is pertinent to inquire the relationship between military spending and stock market capitalization in Pakistan. This research is novel in the sense that pertaining Pakistan's stock market capitalization determinants, it will use a new proxy for military expenditure i.e. the Global militarization index. Previously studies in the literature have used data from Stockholm International Peace Research Institute (SIPRI). Moreover, a recently developed technique of Cointegration ARDL-bounds testing approach will be utilized for analysing long-run association among variables. ARDL Cointegration approach carries several advantages over other methods of Cointegration. Unlike other conventional techniques of cointegration, there is no restrictive assumption in ARDL for the integration order of variables. This approach can be applied on variables having same, mixed or fractionally integrated order. The ARDL test is suitable for small size whereas, other conventional cointegration techniques show sensitivity to the sample size. The ARDL technique also renders unbiased estimates for the long-run model; and gives validation to t-statistics even if there are some endogenous regressors (Harris and Sollis, 2003).

## LITERATURE REVIEW

Literature pertaining to economic consequences of military spending started from the work of Benoit (1973, 1978) who was of the view that military spending and development go side by side. Since then a lot of research work has been done on this subject. Researchers supporting the work of Benoit are (Yildirim and ocal 2016; Yildirim Sezgin and Ocal, 2005). Researchers which are not in favour of Benoit's findings and confirmed negative association between defence spending and development are Abu-Bader and Abu-Qarn (2003), Klien (2004) and Chang et al., (2011). Majority of the economists are of the view that defence expenditure take place of other productive civilian expenditures and therefore bear negative effect on the economy. Dunne and Uye (2010b) surveyed 102 studies regarding economic consequences of military spending. They stated that majority of single and cross-country studies observed negative relationship between military spending and economic growth. Furthermore, 20% of studies found this relationship to be positive both for single and cross-country studies. Hou & Chen (2013) states that although defence expenditure is one of the vital aspects of government expenditure especially in the context of developing countries, but it also sucks funds from other important sectors such as health and education sectors. According to Feder type model there is no significant effect of military expenditure over economic growth. This model also favours loosely positive relationship between the two. On the contrary, the Deger-type models show that the effect of military spending on economic growth is negative. To summarize, the empirical studies on economic consequences of defence spending have been found to be mixed. These mixed results are not only because of sample time periods and countries i.e., single or cross countries, but it is also because of the difference in applied models and methodologies.

The nexus between military spending and debt is akin to the defence-growth nexus i.e., no consensus has been developed among the researchers i.e., the results of empirical findings are mixed. For example, Smyth and Narayan confirmed positive association between military spending and external debt. On the other side of the coin Dunne, Perlo-Freeman, and Soydan (2004b) found that for Chile military expenditures and debt are positively correlated in the period 1970-2000 whereas, negative relationship was demonstrated by the results for other two countries i.e. Argentina and Brazil. Friedman (2005) attempted to explore the military-debt relationship. He concluded that pertaining to developing countries the impact of military expenditure on debt negligible.

Since the literature regarding macroeconomic consequences of military spending is vague therefore it is difficult to establish the link between military expenditure with other macro-economic indicators such as stock market development as very few studies have attempted to explore the association between the two. DiPietro, Anoruo, and Sawhney (2008) investigated the association between military spending and stock market growth. The countries included in the study were US and UK covering the period 1914-2001. They established significant positive link between military spending and stock market capitalization. Solarin and Sahu (2014) analysed the effect of military spending on the appreciation of stock market. The methodology of system GMM was employed over the period 1989-2010 and the sample consisted of 36 countries. Their obtained results showed a negative and significant association between expenditure on military and stock market capitalization for the selected countries.

## MODEL

Following DiPietro, Anoruo and Sawhney (2008) and other earlier studies pertaining to factors determining stock market development, the following model has been proposed.

$$\text{LogSMC}_t = f(\text{ME}_t, \text{INT}_t, \text{TO}_t, \text{GGDP}_t) \quad (1)$$

The linear form of equation is:

$$\text{LogSMC}_t = \beta_0 + \beta_{\text{MEXP}} \log \text{ME}_t + \beta_{\text{INT}} \log \text{INT}_t + \beta_{\text{TO}} \log \text{TO}_t + \beta_{\text{GGDP}} \log \text{GGDP}_t + U_t$$

Where,

SMC = Stock Market Capitalization (Percentage of GDP)

MEXP = Military Expenditures

INT = Real interest rate

TO = Trade openness (ratio of imports plus exports to GDP)

GGDP = Annual GDP growth

$U_t$  = Residual Term

## DATA AND ESTIMATION METHODOLOGY

Stock Market capitalization data has been obtained from the Global Development Finance. Military expenditure being proxies by Global Militarization Index is obtained from the Bonn International Centre for Conversion. The data for trade openness as a percentage of GDP has been taken from World Development indicators (WDI) online database. Finally, the data for real interest and GDP growth were retrieved from State Bank of Pakistan.

The technique of ARDL bounds testing to co-integration by Pesaran, Shin, and Smith (2001) is applied for examining the long-run relationship among variables. Compared to other



conventional methodologies (Engle and Granger 1987; Johansen & Juselius 1990; Phillips and Hansen) this technique possesses many advantages. For conventional techniques a unique level of integration is necessary for variables. The approach of bound testing is flexible pertaining to integration order of variables. Variables having different order of integration i.e.  $I(0)$ ,  $I(1)$  or combination of  $I(0)$  and  $I(1)$  are accommodated by the bounds testing approach Pesaran & Pesaran (1997). Huang (2002) stated that ARDL is appropriate for data having small range and render good results in comparison with other conventional techniques of co-integration. Linear specification has been used by the approach of bounds testing for dynamic ECM which holds the long-run relationship information Banerjee and Newman (1993). The ARDL unrestricted error correction method is applied for the determination of F-statistic and empirical equations as:

$$\begin{aligned}\Delta \text{LogSMC}_t = & \gamma_1 + \gamma_2 \text{LogSMC}_{t-1} + \gamma_3 \text{LogME}_{t-1} + \gamma_4 \text{LogINT}_{t-1} \\ & + \gamma_5 \text{LogTO}_{t-1} + \gamma_6 \text{LogGGDP}_{t-1} + \sum_{i=1}^p \gamma_{\text{SMD}} \Delta \text{LogSMC}_{t-i} \\ & + \sum_{j=0}^q \gamma_{\text{ME}} \Delta \text{LogME}_{t-j} + \sum_{k=0}^r \gamma_{\text{INT}} \Delta \text{LogINT}_{t-k} \\ & + \sum_{l=0}^s \gamma_{\text{TO}} \Delta \text{LogTO}_{t-l} + \sum_{m=0}^t \gamma_{\text{GGDP}} \Delta \text{LogGGDP}_{t-m} + \epsilon_t\end{aligned}\quad (2)$$

$$\begin{aligned}\Delta \text{LogME}_t = & \lambda_1 + \lambda_2 \text{LogSMC}_{t-1} + \lambda_3 \text{LogME}_{t-1} + \lambda_4 \text{LogINT}_{t-1} \\ & + \lambda_5 \text{LogTO}_{t-1} + \lambda_6 \text{LogGGDP}_{t-1} + \sum_{i=1}^p \lambda_{\text{ME}} \Delta \text{LogME}_{t-i} \\ & + \sum_{j=0}^q \lambda_{\text{SMD}} \Delta \text{LogSMC}_{t-j} + \sum_{k=0}^r \lambda_{\text{INT}} \Delta \text{LogINT}_{t-k} \\ & + \sum_{l=0}^s \lambda_{\text{TO}} \Delta \text{LogTO}_{t-l} + \sum_{m=0}^t \lambda_{\text{GGDP}} \Delta \text{LogGGDP}_{t-m} + \epsilon_t\end{aligned}\quad (3)$$

$$\begin{aligned}\Delta \text{LogINT}_t = & \rho_1 + \rho_2 \text{LogSMC}_{t-1} + \rho_3 \text{LogME}_{t-1} + \rho_4 \text{LogINT}_{t-1} \\ & + \rho_5 \text{LogTO}_{t-1} + \rho_6 \text{LogGGDP}_{t-1} + \sum_{i=1}^p \rho_{\text{INT}} \Delta \text{LogINT}_{t-i} \\ & + \sum_{j=0}^q \rho_{\text{SMD}} \Delta \text{LogSMC}_{t-j} + \sum_{k=0}^r \rho_{\text{ME}} \Delta \text{LogME}_{t-k} \\ & + \sum_{l=0}^s \rho_{\text{TO}} \Delta \text{LogTO}_{t-l} + \sum_{m=0}^t \rho_{\text{GGDP}} \Delta \text{LogGGDP}_{t-m} + \epsilon_t\end{aligned}\quad (4)$$

$$\begin{aligned}
\Delta \text{LogTO}_t = & \psi_1 + \psi_2 \text{LogSMC}_{t-1} + \psi_3 \text{LogME}_{t-1} + \psi_4 \text{LogINT}_{t-1} \\
& + \psi_5 \text{LogTO}_{t-1} + \psi_6 \text{LogGGDP}_{t-1} + \sum_{i=1}^p \psi_{TO} \Delta \text{LogTO}_{t-i} \\
& + \sum_{j=0}^q \psi_{ME} \Delta \text{LogME}_{t-j} + \sum_{k=0}^r \psi_{SMD} \Delta \text{LogSMC}_{t-k} \\
& + \sum_{l=0}^s \psi_{INT} \Delta \text{LogINT}_{t-l} + \sum_{m=0}^t \psi_{GGDP} \Delta \text{LogGGDP}_{t-m} + \epsilon_t \quad (5)
\end{aligned}$$

$$\begin{aligned}
\Delta \text{LogGGDP}_t = & \Omega_1 + \Omega_2 \text{LogSMC}_{t-1} + \Omega_3 \text{LogME}_{t-1} + \Omega_4 \text{LogINT}_{t-1} \\
& + \Omega_5 \text{LogTO}_{t-1} + \Omega_6 \text{LogGGDP}_{t-1} + \sum_{i=1}^p \Omega_{GGDP} \Delta \text{LogGGDP}_{t-i} \\
& + \sum_{j=0}^q \Omega_{ME} \Delta \text{LogME}_{t-j} + \sum_{k=0}^r \Omega_{INT} \Delta \text{LogINT}_{t-k} \\
& + \sum_{l=0}^s \Omega_{TO} \Delta \text{LogTO}_{t-l} + \sum_{m=0}^t \Omega_{SMD} \Delta \text{LogSMC}_{t-m} + \epsilon_t \quad (6)
\end{aligned}$$

In order to check the existence of co-integration among variable the calculated F-statistic will be compared with the critical bounds. To do so we will check the hypothesis of no co-integration in the equation 2 i.e.  $H_0: \gamma_{SMC} = \gamma_{ME} = \gamma_{INT} = \gamma_{TO} = \gamma_{GGDP} = 0$ ,  $H_0: \lambda_{SMC} = \lambda_{ME} = \lambda_{INT} = \lambda_{TO} = \lambda_{GGDP} = 0$ ,  $H_0: \rho_{SMC} = \rho_{ME} = \rho_{INT} = \rho_{TO} = \rho_{GGDP} = 0$ ,  $H_0: \psi_{SMC} = \psi_{ME} = \psi_{INT} = \psi_{TO} = \psi_{GGDP} = 0$ ,  $H_0: \Omega_{SMC} = \Omega_{ME} = \Omega_{IN} = \Omega_{TO} = \Omega_{GGDP} = 0$  against the alternative hypothesis  $H_a: \gamma_{SMC} \neq \gamma_{ME} \neq \gamma_{INT} \neq \gamma_{TO} \neq \gamma_{GGDP} \neq 0$ ,  $H_a: \lambda_{SMC} \neq \lambda_{ME} \neq \lambda_{INT} \neq \lambda_{TO} \neq \lambda_{GGDP} \neq 0$ ,  $H_a: \rho_{SMC} \neq \rho_{ME} \neq \rho_{INT} \neq \rho_{TO} \neq \rho_{INT} \neq 0$ ,  $H_a: \psi_{SMC} \neq \psi_{ME} \neq \psi_{INT} \neq \psi_{TO} \neq \psi_{GGDP} \neq 0$ ,  $H_a: \Omega_{SMC} \neq \Omega_{ME} \neq \Omega_{INT} \neq \Omega_{TO} \neq \Omega_{GGDP} \neq 0$ .

Cointegration will exist if the F-statistic (computed) is greater than UCB; the decision will goes in favour of no co-integration if the LCB has been observed to be greater than F-statistic. The decision will be uncertain, if F-statistic is between the UCB & LCB. In this research Narayan (2005) critical bounds values were used instead of Pesaran, Shin, and Smith (2001) because of small sample size—Narayan (2005) values tend to be well suited for data of small sample size. For checking the variables integration order Augmented Dicky Fuller test has been employed in order to clarify that not a single variable is I (2) integrated as I (2) render invalid F-statistic Narayan & Narayan (2005). Furthermore, for choosing the optimal lag length Akaike information criterion has been followed. The exact information regarding lag order is critical as the selection of lag length has an effect on the ARDL F-statistic value.

## RESULTS AND DISCUSSION

Although ARDL bounds testing methodology is flexible pertaining to integration order of variables we need to make sure that not a single variable included in the model is higher than  $I(1)$  because the F-statistic computations becomes will be deemed invalid if  $I(2)$  variable is included in the model. For this reason, we have employed ADF test. Table 1 presents the outcomes of ADF test, which show that both stock market development and GDP growth are level stationary i.e.  $I(0)$  whereas, the rest of variables are integrated of the order  $I(1)$ . This means that for empirical estimation the variables selected in the models have mixed integration.

**Table 1** ADF Test Results

Variables	Levels		1 <sup>st</sup> Difference	
	Constant (5% critical value)	Constant & trend (5% critical value)	Constant (5% critical value)	Constant & trend (5% critical value)
<b>SMC</b>	-1.08312 (-3.0403)	-4.6877* (-3.6736)	--	--
<b>ME</b>	-0.551638 (-3.004861)	-2.087918 (-3.632896)	-4.368212* (-3.012363)	-4.240616* (-3.644963)
<b>INT</b>	-1.576983 (-3.004861)	-2.636017 (-3.673616)	-4.066086* (-3.020686)	-3.964465* (-3.658446)
<b>TO</b>	-2.466694 (-3.004861)	(-2.563067) (-3.632896)	-6.379784* (-3.012363)	-6.206532* (-3.644963)
<b>GGDP</b>	-3.400959* (-3.004861)	(-3.356229) (-3.632896)	--	--

Where, \* indicates  $p < .05$

Source: Author's own calculations

Table 2 exhibits the results of ARDL. In this table the calculated F-statistic value for long-run association among variables is (6.1782) which are greater than the upper critical bound by Narayan (2005) at 5% significance level. This result confirms the long run association among variables for the period 1990-2012 in context of Pakistan. Moreover, the classical assumptions related to error term normality, serial correlation and heteroscedasticity hold for ARDL model. Diagnostics tests results have been presented in Table 5.

**Table 2** Bounds Testing to Co-integration

Estimated Equation: $\text{LogSMC}_t = f(\text{ME}_t, \text{INT}_t, \text{TO}_t, \text{GGDP}_t)$		
<b>Optimal lag structure</b>	(1, 0, 1, 2, 1)	
<b>F-statistics</b>	6.178292**	
<b>Significance level</b>	Lower bounds, $I(0)$	Upper bounds, $I(1)$
<b>1 percent</b>	3.74	5.06
<b>5 percent</b>	2.86	4.01
<b>10 percent</b>	2.45	3.52

Where, \*\* indicate  $p < .05$

Source: Author's own calculations

The validation of long run association among variables guide us to interpret the effect of our predictors that is military spending, real interest rate, trade openness and GDP growth on stock market development. Table 3 presents the long-run coefficients. Empirical analysis reveals a negative and significant relationship between military spending and stock market development at 5% significance level hence validating our posited statement. A 1% increase in the level of military spending will decrease stock market development by 2.0732%. In the literature these results are similar with the findings of Solarin and Sahu (2014). To cope with

terrorism Pakistan government has been compelled to propel the defence Budget. Besides this a substantial amount of funds are allocated for the nuclear weapons advancement in the Budget. Pakistan is doing so because of severe rivalry with India. A significant negative association has been observed between real interest rate and stock market development implying that 1% increase in real interest rate will depress the stock market development by 0.0062%. In the results these finding are found to be consistent with the findings of Akmal (2007). An expected significant positive relation has been noticed between openness in trade and stock market capitalization in the long-run. Although no association has been noticed in the findings of this study between the GDP growth and stock market capitalization, but the long-run coefficient of GDP growth is still carrying its correct sign.

**Table 3** Long-run Analysis

Dependent variable: $SMC_t$			
Variable	Coefficient	Stand. Error	T-statistic
$ME_t$	-2.073164	0.915302	-2.265004**
$INT_t$	-0.810405	0.240108	-3.375165***
$TO_t$	4.285845	0.740915	5.784529***
$GDP_t$	0.314248	0.218231	1.439976
Constant	4.8403	1.2816	3.7764***
R-squared	0.923661		
Adjusted R-squared	0.861201		
F-statistics (Prob-value)	14.78813***		
Durbin-Watson	2.625001		

Where, \*\*  $p < .05$ ; \*\*\*  $p < .001$  respectively

Source: Author's own calculations

Analysing the short-run effect of the explanatory variable over the explained variable (stock market capitalization) is the next step. These results have been depicted in table 4. The lagged error term carries a negative and significant sign hence confirming the cointegration association among variables.  $ECM_{t-1}$  implies that variations in explained variable i.e. stock market capitalization are function of variations in the explanatory variables (military spending, interest rate, trade openness and economic growth). The  $ECM_{t-1}$  standard value lies within the range of 0 and 1 Kremers et al. (1992). In our results the value of  $ECM_{t-1}$  is (0.7121) which means that yearly short-run to long-run change will correct stock market capitalization at a rate of 71.21%. Table 4 shows that rise in military spending affect the stock market negatively though the relationship is insignificant. Trade openness is exhibiting a significant positive association with stock market development at 1% significance level implying that it is a vital variable for increase in stock market capitalization. Interest rate and stock market capitalization are linked negatively. The variable of GDP growth and stock market capitalization were found to have no significant relationship.

**Table 4** Short-run Analysis

Dependent variable: $SMC_t$			
Variable	Coefficient	Stand. Error	T-statistic
$\Delta ME_t$	-1.476358	0.988000	-1.494289
$\Delta INT_t$	-0.292403	0.075555	-3.870054***
$\Delta TO_t$	2.015890	0.556652	3.621454***
$\Delta GDP_t$	0.143044	0.118187	1.210317
$ECM_{t-1}$	-0.712128	0.204066	-3.489688***

Where, \*\*\*  $p < .001$

Source: Author's own calculations

## Reliability of the model

The results for the reliability of the model have been presented in table 5. Both the issues of auto-correlation and heteroscedasticity have not been observed and the obtained residual were noticed to be normal. Furthermore, stable plots were obtained for CUSUM and CUSUM of square tests hence, implying that the model specifications are correct.

**Table 5** Diagnostics Check

Diagnostics tests		
	F-statistics	P-value
LM test for Auto correlation	1.4751	0.2792
Brush-Pagan-Godfrey test for Heteroskedasticity	1.4226	0.2560
Jarque-Bera for Normality	1.1921	0.5509

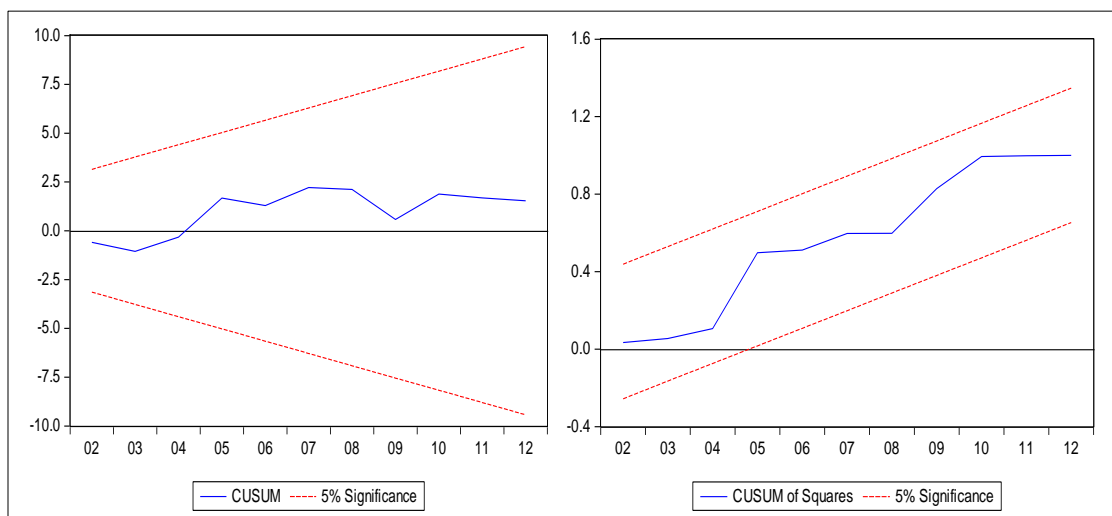
Source: Author's own calculations

## Multicollinearity check

Variance inflation factor (VIF) test has been utilized for the detection of multicollinearity. Multicollinearity can be checked via

$$\text{VIF} = 1/1-R^2$$

The obtained  $R^2$  value for the model is 0.92 so by incorporating this value in the given formula the obtained value of VIF is (7.28) which is not greater than 10% thereby, indicating that multicollinearity issues were handles during the estimation of the model.



**Figure 1.** CUSUM and CUSUM of Squares Tests Plots

## CONCLUSION AND POLICY IMPLICATIONS

The principal aim in this research was determine the relationship between military spending and stock market capitalization in Pakistan. The methodology of ARDL bounds

testing to cointegration has been applied for this aim. The outcomes of this technique confirmed the cointegration among stock market capitalization, military expenditure, interest rate, trade openness and economic growth. The empirical outcomes of the study revealed a negative and significant relationship with the stock market capitalization in the long run and also in the short run nevertheless, the result is not significant in the short run. A negative and significant association has been established between interest rate and stock market growth both in the short and long-run. Both for the short and long run trade openness has verified the extant research by displaying a significant positive connection with the growth in stock market. No connection has been found between GDP growth and stock market capitalization in this particular study.

When huge amount from the budget will be allocated for the defence expenditures, it means that least amount will be allocated to welfare and other development projects. This is certainly wastage of resources. Such kind of practices can also shift the mood of foreign investors to those countries who assign reasonable amount to their defence related activities. Moreover, arms accumulation has an adverse effect on foreign relations. Developing countries are of the view that defence sector acts as a strategic tool thereby linking it to national defence or the sovereignty—they set aside large amount from their budget for this sector. Such kinds of policies have a tendency to distort private returns on capital therefore decrease the amount of foreign investment De Mello (1999). In an effort to attain stock market development, military spending needs to be minimized.

A Gradual and systematic reduction in military expenditure will be favourable as private sector will probably not be able to take place of this particular government spending promptly which can have an adverse impact on the economy. In a nutshell, it will be significantly better when the military expenditure cut backs take place over a period of time instead of all at one time which could create a risk of economic downturn for Pakistan thereby, ultimately will affect its stock market capitalization. Apart from military spending, interest rate and trade openness were observed to be significant predictors of stock market growth hence these predictors need to be taken into account together with military expenditure reduction.

## REFERENCES

- Abu-Bader, S., & Abu-Qarn, A. S. (2003). Government expenditures, military spending and economic growth: causality evidence from Egypt, Israel, and Syria. *Journal of Policy Modeling*, 25(6), 567-583.
- Akmal, M. S. (2007). Stock returns and inflation: An ARDL econometric investigation utilizing Pakistani data. *Pakistan economic and social review*, 89-105.
- Ali, A. (2010). Economic cost of terrorism: A case study of Pakistan. *Strategic Studies*.
- Banerjee, A. V., & Newman, A. F. (1993). Occupational choice and the process of development. *Journal of political economy*, 274-298.
- Bencivenga, V. R., Smith, B. D., & Starr, R. M. (1996). Equity markets, transactions costs, and capital accumulation: an illustration. *The World Bank Economic Review*, 10(2), 241-265.
- Benoit, E. (1973). Defence and economic growth in developing countries.
- Benoit, E. (1978). Growth and defence in developing countries. *Economic Development and Cultural Change*, 26(2), 271-280.

- Chang, H.-C., Huang, B.-N., & Yang, C. W. (2011). Military expenditure and economic growth across different groups: A dynamic panel Granger-causality approach. *Economic Modelling*, 28(6), 2416-2423.
- DiPietro, W. R., Anoruo, E., & Sawhney, B. (2008). The Effect of the Size of the Military on Stock Market Performance in the United States and the UK. *Kyklos*, 61(1), 33-44.
- Dunne, J. P. (2012). Military spending, growth, development and conflict. *Defence and Peace Economics*, 23(6), 549-557.
- Dunne, J. P., Perlo-Freeman, S., & Soydan, A. (2003). Military Expenditure and Debt in Small Industrialised Economies: A Panel Analysis. *Defence and Peace Economics*.
- Dunne, J. P., & Uye, M. (2010a). Defence spending and development. *Department of Economics, British University in Egypt and University of the West of England. A paper is based on work undertaken for Oxfam*.
- Dunne, J. P., & Uye, M. (2010b). Military spending and development. *The global arms trade: a handbook*. London: Routledge, 293-305.
- Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: Journal of the Econometric Society*, 251-276.
- Harris, R., & Sollis, R. (2003). *Applied time series modelling and forecasting*: Wiley.
- Haug, A. A. (2002). Temporal aggregation and the power of cointegration tests: a Monte Carlo study. *Oxford Bulletin of Economics and Statistics*, 64(4), 399-412.
- Hou, N., & Chen, B. (2013). Military expenditure and economic growth in developing countries: Evidence from system GMM estimates. *Defence and Peace Economics*, 24(3), 183-193.
- Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica: Journal of the Econometric Society*, 1551-1580.
- Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52(2), 169-210.
- Khwaja, A. I., Mian, A., & Zia, B. (2010). Dollars dollars everywhere, nor any dime to lend: Credit limit constraints on financial sector absorptive capacity. *Review of Financial Studies*, 23(12), 4281-4323.
- Klein\*, T. (2004). Military expenditure and economic growth: Peru 1970–1996. *Defence and Peace Economics*, 15(3), 275-288.
- Kremers, J. J., Ericsson, N. R., & Dolado, J. J. (1992). The power of cointegration tests. *Oxford Bulletin of Economics and Statistics*, 54(3), 325-348.
- Marone, M. H. (2003). *Small African stock markets: the case of the Lusaka Stock Exchange*: International Monetary Fund.
- Mehmood, S. (2014). Terrorism and the macroeconomy: Evidence from Pakistan. *Defence and Peace Economics*, 25(5), 509-534.
- Melman, S. (1983). *Profits without production*: Alfred a Knopf Inc.
- Narayan, P. K. (2005). The saving and investment nexus for China: evidence from cointegration tests. *Applied Economics*, 37(17), 1979-1990.
- Narayan, P. K., & Narayan, S. (2005). Estimating income and price elasticities of imports for Fiji in a cointegration framework. *Economic Modelling*, 22(3), 423-438.
- Pesaran, M. H., & Pesaran, B. (1997). *Working with Microfit 4.0: interactive econometric analysis;[Windows version]*: Oxford University Press.
- Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics*, 16(3), 289-326.

- Raby, G. (2003). *The Costs of Terrorism and the Benefits of Cooperating to combat Terrorism*. Paper presented at the Secure Trade in the APEC Region (STAR) Conference.
- Riedel, B. (2008). Pakistan and terror: The eye of the storm. *The ANNALS of the American Academy of Political and Social Science*, 618(1), 31-45.
- Solarin, S. A., & Sahu, P. K. (2015). The effect of military expenditure on stock market development: panel evidence from system GMM estimates. *Defence and Peace Economics*, 26(3), 271-287.
- Yartey, C. A. (2008). The determinants of stock market development in emerging economies: Is South Africa different? *IMF Working Papers*, 1-31.
- Yildirim, J., & Öcal, N. (2016). Military expenditures, economic growth and spatial spillovers. *Defence and Peace Economics*, 27(1), 87-104.
- Yildirim†, J., Sezgin, S., & Öcal, N. (2005). Military expenditure and economic growth in Middle Eastern countries: a dynamic panel data analysis. *Defence and Peace Economics*, 16(4), 283-295.



# THE EFFECT OF ENTREPRENEURSHIP TRAINING ON THE CAPACITY BUILDING PROGRAM OF KANO STATE ENTERPRISE DEVELOPMENT TRAINING INSTITUTES

Muazu Hassan Muazu<sup>1</sup>, Najafi Auwalu Ibrahim<sup>2</sup>

<sup>1</sup>Centre for African Entrepreneurship Research, Dangote Business School, Bayero University, Kano-Nigeria

<sup>2</sup>Othman Yeop Abdullah Graduate School of Business, Universiti Utara, Malaysia

## Abstract

Kano state enterprise development training institutes were established with the expectation to further promote and increase the number of small enterprises owners, improve the sustenance of small businesses, and reduce unemployment in the society. The institutes have graduated many students some of whom have ventured into businesses and others did not start any. Even those that have started hardly sustaining them beyond six months. It is against this backdrop, the study therefore aimed at understanding the effect of entrepreneurship training on the capacity building program with concerns to training quality, trainers competence, and availability and functionality of training facilities in the institutes. A survey research design was used, hence primary data were collected through questionnaire. A sample of 370 respondents were selected using convenient sampling technique. With the use of multiple regression analysis, the results of the study showed that training quality, trainers competence and training facilities have significant effect on capacity building effectiveness. The study thus recommended that the training institutes should standardise the admission process, curricula and improve on post training support activities. They should also determine trainers training needs and should send them for further training. The institutes should provide up-to-date training facilities with effective maintenance mechanism. Also, the study make some recommendations for future studies to in-corporate other effective variables like government political will and funding that could explain the remaining variance in capacity building effectiveness.

**Keywords:** *Capacity-building; Entrepreneurship; Training; Trainers; and Development.*

## INTRODUCTION

Globally, countries are using entrepreneurship development training as a tool in building and improving capacities of their people to take on productive enterprises. It is increasingly becoming a means in the creation of small enterprises as well as employment creation in developing economies. This entrepreneurial drive and the benefits that comes with them, made Nigerian government to develop programs and agencies to promote entrepreneurship training at various levels in the country. According to Davidson et al, (2006) entrepreneurship development is very relevant in the economic development of countries across the world. These productive enterprises can succeed in managing and growing their businesses if they have the appropriate skills and expertise that would enable them carry out their daily business undertakings effectively. The skills and expertise are often learned or acquired through capacity building programmes.

Capacity building is the process whereby individuals, groups, and organisations abilities are enhanced to mobilize and use resources in order to achieve their objectives on a sustainable basis (UNDP, 2002). Capacity building consists of activities designed to increase the

competence and effectiveness of individuals and organisations (Stryk, Damon, & Haddaway, 2011). These activities, such as entrepreneurship training are intended to help participants acquire new skills, methods and capabilities of creating new and growing their existing enterprises.

De Cenzo and Robbins (2007) argued that training is basically a learning experience, which seeks a relatively permanent change in an individual's skills, knowledge, attitudes or social behaviour. Entrepreneurship development training is a personal development through which an enterprise culture can be created into the minds of potential entrepreneurs (ILO/UNDP, 1990; Harper, 1993). It is therefore well-recognised that training opportunities play a key role in cultivating future entrepreneurs and in developing the abilities of existing entrepreneurs to grow their business to greater levels of success (Henry, Hill and Leitch, 2003).

Evidence suggests that capacity building program has several positive effects. For example, the participants in capacity building training experienced, as cited in (OECD, 2014), increased problem-solving and decision-making abilities. Also experienced were improved interpersonal relationships, teamwork, money management, enhanced social psychological development (i.e. self-esteem, ego development, and self-efficacy) and improved creativity. Therefore, entrepreneurship training recognises the importance of multiple intelligences and talents as prerequisites for creativity, innovation and entrepreneurship (OECD, 2014). Entrepreneurship training is often viewed within the framework of lifelong learning.

The notion that entrepreneurs are born, is rather weak, instead it is well recognised now that the entrepreneurs can be created and nurtured (Kuratko, 2003). When these skills are learned through capacity building program, the potential entrepreneurs could display change in personality traits, attitudes, motivations and enterprising tendencies, which will in turn improve the performance of participants' ventures. Very importantly, the effectiveness of the capacity building program should be an area of concern. The effectiveness might be affected or influenced by the whole of the entrepreneurship training process and activities, such as the quality and relevance of the training programme, trainer's competence and capabilities and facilities available in the institutes. Trainings could take the form of apprenticeship, workshops, seminars, schools and or training institutes. Common among the trainings in Nigeria is that of the training institutes, where people are kept for certain period of time to learn and acquire skills necessary for their businesses development.

In view of the need to build the capacities of its people so as to encourage small business development, create employment, reduce poverty level and to improve the economy of the state, as was buttressed by (Tijjani-Alawiye, 2004; Izedonmi, 2009; and Unachukwu, 2009). Kano state government established a number of training institutes in the state within the years of 2011-2013. The Kano state enterprise development institutes offer various programmes and have graduated many people. Although the capacity building programmes covers people with existing businesses and those who may start new enterprises, what is not clear is how effective are the capacity building programmes in developing the desired entrepreneurship skills of the trainees.

Earlier researchers like Rae and Woodier-Harris (2012), highlighted a model for entrepreneurship education and training that considered 'effectiveness' as the key outcome

rather than learning, hence it focused on issues that concerns training design and techniques, trainee mindset, capability and training effectiveness. An elaborate research on effectiveness of entrepreneurship training has been provided by Colette, Hill and Leitch, (2005), they established that there are some difficulties associated with the design of programs, as well as their objectives, content and delivery methods. There is still room to conduct this research with additional variables such as trainers competence and training facilities which were not covered by earlier studies, specifically in Kano state, Nigeria.

This study therefore tries to assess the effect of entrepreneurship training on capacity building run by these institutes with emphasis on the process of the training as was supported by TIER model. It is also aimed at understanding specifically the effects of training quality, trainer's competence and training facilities on capacity building effectiveness. It is therefore hypothesised that the quality and relevance of training program has no significant relationship with capacity building effectiveness; Trainers' professional competence and experience do not have any effect on capacity building effectiveness; and availability and functionality of training facilities in the institutes has no effect on capacity building effectiveness.

## LITERATURE REVIEW

Capacity building is the art of enhancing new and improved entrepreneurship skills. Capacity is a dynamics involving a complex combination of attitudes, resources, strategies and skills, both tangible and intangible (Schacter, 2000). Capacity is more of capabilities of performing certain tasks. Capacity building is a complex notion – it involves individual and organisational learning which builds social capital and trust, develops knowledge, skills and attitudes and when successful creates an organisational culture which enables organisations to set objectives, achieve results, solve problems and create adaptive procedures which enable it to survive in the long term (UNDP, 2002). According to ESRC (2012) capacity building is a process where individuals, groups, networks, and organisations are encouraged and facilitated in enhancing their knowledge and skills so as to increase their ability to perform innovative and high quality social science research. As a process it involves imparting new and improved skills to individuals or group of individuals. Capacity building can be defined narrowly in this context as the act of increasing knowledge and skills for starting and growing enterprises and every other support (financial and enabling environment). The capacities for enterprise development are built through certain activities such as internship and training.

Entrepreneurship development training is a personal development through which an enterprise culture can be created into the minds of entrepreneurs to be (ILO/UNDP, 1990; Harper, 1993). It is therefore well-recognised that training opportunities play a key role in cultivating future entrepreneurs and in developing the abilities of existing entrepreneurs to grow their business to greater levels of success (Henry, Hill and Leitch, 2003). Considering its importance worldwide, entrepreneurship training is often included in national curricula for vocational training in the European Union and other developed countries (CEDEFOP, 2011). Not only Europe, countries like Nigeria had made it a compulsory course of study in all tertiary institutions in the country.

The increasing desire to develop and nurture entrepreneurial attitudes and skills through training necessitated the creation of training institutes and or development centres in many states of Nigeria. According to (Bronte-Tinkew and Redd, 2001; Gibb, 2005) some key

features of entrepreneurship training are interdisciplinary of different settings; development of both soft and hard skills, and particularly the combination of the two; Learning process is embedded in different contexts that are relevant for different disciplines; and, Outcomes seek to foster entrepreneurial behaviours, skills and mind-sets. Entrepreneurship skills such as idea development, problem-solving, network development, resource management, risk management and leadership are often required competences and generally appeal to trainees. At the same time, a more narrow set of skills are increasingly taught to support those trainees to start-up a business. This includes, for example, learning how to draft a business plan, manage the day-to-day operations of a business (e.g. accounting, management, commercial law, and marketing) and complying with legal and regulatory requirements (e.g. business registration, filing taxes) (European Commission, 2009).

The quality of training program comprises of the program structure, training course content and the methods of conducting the training. Program structure comprises of pre-training, training and post training activities. One of the major activities in the pre-training phase is the selection of participants and their respective institutes to be trained in. Once the institutes or centres have been identified to have the capacity for potential trainees, the program coordinator or the institutes undertakes promotional campaign (Nwazor, 2012). Screening and selection of trainees could make training more qualitative because all those selected would have to qualify through which certain traits can be identified and the trainees would therefore choose which profession or trade to be trained in. Training programmes undertaken without adequate promotional campaign fails to evoke much response and this can be a major reason for the failure of EDPs (Sebastian & Awasthi, 1992). This would enable wider reach to potential trainees who may wish to enrol into the program.

Training course content is equally an element of training quality, because it shows necessary skills to be taught in the training program. According to Brown (2000) as cited in the work of Azila-Gbetteor & Harrison, (2013) curriculum has to focus on the features that needed to be conceiving of both business and technical skills. According to (Nwazor, 2012; Sebastian & Awasthi 1992; Singh, 1990) some of the major inputs provided in a training content are; behavioural inputs like achievement motivation training, communication skills, problem solving skills, interpersonal skills, creativity, decision making, etc. The objective of this input is to reinforce the motivation and entrepreneurial traits of the trainees. The other input is to facilitate decision making process to set up a new venture, like business opportunity guidance, information, project planning and technical inputs. Furthermore, Brown (2000) as cited in the work of Azila-Gbetteor & Harrison, (2013) maintain that the curriculum has to focus on the features that needed to be conceiving of and starting a new business and or growing an existing enterprise. The said skills includes technical, management, people skills, sales and marketing skills, time management skills etc.

Another important factor is the training method. Even if the course or training content is perfectly appropriate to the target group in question, the training can be rendered quite ineffective if the delivery methods are not chosen well. To develop entrepreneurial practice requires methods capable of instilling transversal entrepreneurial skills (Mwamisha & Wanjau, 2013). The way and manner to which the training is being conducted is the method of training. Okudan & Rza (2006) posit that effective entrepreneurship training should provide opportunities for participants to practice a combination of all the entrepreneurial leadership components. These components have to do with role play or on the job training for

the participants. According to Brown (2000) entrepreneurship training and education should be viewed in terms of the skills that can be taught and characteristics that can be engendered in trainees in order to help them develop new and innovative plans for their future business endeavours. Romijn, (1989) argued that different EDP seems to indicate that practical training, involving a variety of people who actually deal on a day-to-day basis with the problems of small-scale businesses in different capacities is much more successful than training that relies more on lectures by professional teachers.

Entrepreneurship development training requires a great deal in terms of competence and experience on the part of the trainers. Increasingly, trainers are identified as the most important factor influencing the quality of training (European Commission, 2013). Ideally, different sessions should be conducted by specialists in different areas. According to Romijn, (1989) achievement motivation training for instance requires considerable skills, which can only be offered by a mature trainer with a sound background in psychology and lively interest in people. That is to say a professional trainer with bank of experience makes more contribution to success of capacity building program. Donovan, Bransford & Pellegrino (1999), in their review of training evaluation models from the economic and human resource literature, pointed out that when dealing with the issue of human competence, trainers' expertise is critically important. Good quality entrepreneurship training requires qualified personnel responsible for its conceptualisation and delivery; being qualified as a trainer for entrepreneurial skills means to be in possession of highly developed individual competencies, in terms of personal and professional knowledge, skills, attitudes and values. It also means being able to apply these competencies alone (i.e. autonomously) and in interaction with participants and or other trainers (European Union, 2002).

### The Tier Model of Training Effectiveness Research

In this study the TIER model was used in accepting the basis to which this whole work was conducted. According to Gregory & Thaddeus (2009) the TIER model systematically structures training effectiveness research across four stages. Stages 1 and 2 are components of formative evaluation in which the objectives and processes of training are conceptualized, drafted, and refined. During these stages, researchers explore instructional alternatives to determine which are most appropriate for study. Stages 3 and 4 are components of summative evaluation—a systematic attempt to determine whether the fully developed training intervention is meeting its objectives as planned or desired (Scriven 1967, 1991) as cited in the work of Gregory & Thaddeus (2009). The model therefore means that research could be conducted at any of the four stages outlined in figure 1 below.

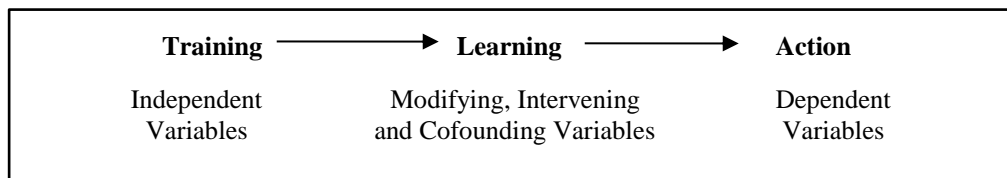
Stage 1	Stage 2	Stage 3	Stage 4
Formative Research	Process Research	Outcome Research	Impact Research

**Figure 1:** Logical and progressive stages for training effectiveness research

### Study Variables Under the Tier Model

The TIER model regards five types of study variables as integral to training effectiveness research: independent, dependent, modifying, intervening, and confounding variables (see

Figure 1). Studies depend on access to measurable data for these variables. This study considered only independent and dependent variables under the TIER model.



**Figure 2** Variables influencing the effectiveness of the training-learning-action continuum

Independent variables are the working variables—that is, the training inputs and activities that are implemented and studied. They are presumed to cause or influence certain training outcomes. Depending on the study, independent variables could include timing, format, and location of training as well as modifications to the training rationale, content, or educational approach under study (Gagné, 1985) as captured and developed in the work of Gregory & Thaddeus (2009). The Dependent variables on the other hand are the intended aims of training, which are expected to result from exposure to the independent variables. As exposure varies, results may differ, allowing effectiveness to be measured. The TIER model differentiates between dependent variables that are immediate effects of training (termed "outcomes") and dependent variables that are later-emerging effects of training (termed "impacts") (Mohr, 1992) as put by Gregory & Thaddeus (2009).

The TIER model was adapted as it positioned this current study on the second stage of the model. At the second stage, the study focussed on the PROCESS stage as put by the model. The process stage study says that training effectiveness study can be conducted on the learning elements such as program structure, training methods and pedagogy, trainer's competence and facilities for training.

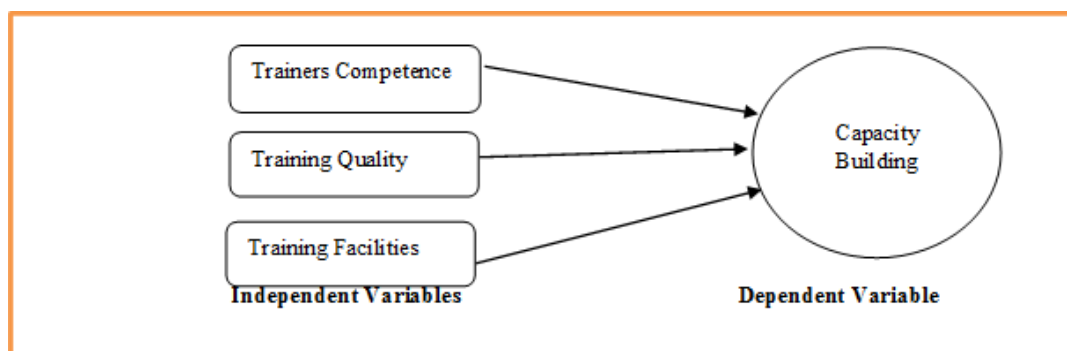
## METHODOLOGY

Survey research design was used in carrying out this study because it involves collecting data in order to test hypothesis or answer research questions. Three variables were identified to include capacity building as the dependent variable and on the other hand, the independent variables are training quality, trainers' competence and experience and training facilities.

*The variables are represented by Y, X1, X2 and X3.*

$$Y = f(X1, X2, X3 + u)$$

$$Y_t = b_0 + b_1X1 + b_2X2 + b_3X3 + u \dots \text{(Linear Form)}$$



**Figure 3:** Research Conceptual Model

The population of the study covers the graduates of the eight (8) entrepreneurship training institutes in Kano State. The number of graduates is up to 10000 people, hence a sample size of three hundred and seventy (370) respondents was chosen based on Krejcie and Morgan (1970). A convenient sampling technique was used in selecting the respondents, where closed- ended questionnaire was used as the instrument, considering 5-point Likert scale interval in measuring the data.

Cronbach's alpha statistics was used in testing the reliability of the instrument. It was measured on the scale Pearson's product moment correlation coefficient that varies between 0 and 1, so the closer the alpha to 1.00 the greater the consistency of questions in the study instrument. Hence, 0.60 Cronbach's alpha was adopted as supported by Hair et al. (2010).

The data analysis, inferential statistics specifically multiple regression was used, using SPSS software to test the dependency of the relationship between the dependent and independent variables and was also used to test the study hypothesis. Pearson's correlation was used to explain the relationship between the independent variables. Therefore, the Cronbach's alpha obtained in this study for the dependent variable (Capacity Building) is 0.621 and for the independent variables are 0.707, 0.749 and 0.731 for training quality, trainers competence and training facilities respectively.

## RESULTS AND FINDINGS

Response rate shows that 197 valid copies of the questionnaire were used for further analysis. Thus, a response rate of 53% was achieved by this study. A response rate of 30% is acceptable for survey studies (Sekaran, 2003; Hair, Black, Babin & Anderson, 2010).

**Table 1:** Inter-correlation among Variables

Constructs	1	2	3	4
Capacity building	1			
Training quality	.502	1		
Trainers competence	.449	.235	1	
Training facilities	.390	.630	.415	1

\*\*. Correlation is significant at the 0.01 level (1-tailed)

The values of Pearson correlation show the relationship between dependent variable (i.e. Capacity building and independent variables (Training quality, Trainers competence & Training facilities). Cooper and Schindler (2003) and Allison (1999) indicated that correlation

of 0.80 or higher are problematic despite the maximum of 0.75 acceptable by the rule of thumb.

Table 1 above, the highest correlation between independent variables was between training quality and training facilities, which was significant at 0.01 level ( $r = 0.630$ ,  $p < 0.01$ ). On the other hand, the lowest correlation was between trainers competence and training facilities significant at 0.01 ( $r = 0.015$ ,  $p < 0.01$ ) this indicates a weaker correlation. The correlation between dependent variable and independent variables were all positive- showing significance at 0.01 for capacity building and training quality ( $r = 0.502$ ,  $p < 0.01$ ), capacity building and trainers competence ( $r = 0.449$ ,  $p < 0.01$ ) and between capacity building and training facilities ( $r = 0.309$ ,  $p < 0.01$ ). Although the correlation shows significance, the coefficients were not large enough to cause collinearity problem as argued by Cooper and Schindler (2003); and Allison (1999). Hence correlation between independent variables and the dependent variable in this study did not go beyond the acceptable range and as such would not cause multicollinearity problem.

To generate an ideal conclusion on the results of regression analysis that would enable application of the model on another population of interest, would require a thorough examination of normality, collinearity, linearity, homoscedasticity and independence of the residual (Hair et al., 2010). The authors put it that, these assumptions are applicable to both dependent and independent variables and their relationship as a whole.

**Table 2. Model Summary<sup>b</sup>**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.616 <sup>a</sup>	.379	.369	1.83496	1.887

a. Predictors: (Constant), TRAININGFACILITY, TRAINERSCOMPETENCE, TRAININGQUALITY

b. Dependent Variable: CAPBUILDING

The results of multiple correlation ( $R$ ), squared multiple correlation ( $R^2$ ) and adjusted squared multiple correlation ( $R^2_{adj}$ ) shows how well the combination of independent variables predicts the dependent variable. This study's  $R^2$  of 0.379 in table 3 above indicates that the variability in Capacity building being the dependent variable was up to 37.9%. This means that the independent variables are good predictors of capacity building effectiveness. The 1.887 Durbin Watson has fallen within the acceptable range of 1.5 – 2.5 as recommended by Norusis (1999).

**Table 3: ANOVA<sup>b</sup>**

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	392.427	3	130.809	38.849	.000 <sup>a</sup>
1 Residual	643.115	191	3.367		
Total	1035.541	194			

a. Predictors: (Constant), TRAININGFACILITY, TRAINERSCOMPETENCE, TRAININGQUALITY

b. Dependent Variable: CAPBUILDING



Regression model is considered significant when it is 0.000 under Anova. Having Sig. F Change value ( $F(3, 191) = 38.849, p < .0005$ ) in table 4 shows that the model used in this study was appropriate as 0.000 significance value was attained.

**Table 4: Coefficients<sup>a</sup>**

Model	Unstandardize		Standardized	t	Sig.	Correlations			Collinearity	
	d Coefficients		Coefficients						Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	6.443	1.037		6.212	.000					
TRAINING QUALITY	.097	.029	.251	3.321	.001	.467	.234	.189	.570	1.754
TRAINERS COMPETENCE	.480	.069	.420	6.963	.000	.483	.450	.397	.895	1.117
TRAINING FACILITY	.184	.075	.180	2.465	.015	.329	.176	.141	.610	1.639

a. Dependent Variable: CAPBUILDING

## Results of Multiple Regression (Hypotheses Testing)

This section presented results of the coefficients, meaning hypotheses testing concerning the relationship between Enterprise development which is the dependent variable and independent variables – training quality, trainers competence and training facility. To establish the actual effect of independent variables on the dependent variable multiple regression analysis was conducted. In testing the hypotheses developed for this study, the choice of  $p < .05$  and  $p < .01$  as level of significance was adopted as put by (Cooper & Schindler, 2003; Hair et al., 2010).

Table 4 above showed that Trainers competence is having the highest Beta value of 0.420 indicating a strong prediction of the dependent variable. With standardized coefficient Beta of 0.420 relative to other predictors, Trainers competence emerged as the strongest predictor. This implies that when all other independent variables are held constant, Trainers competence explains exactly 42 percent variation in the dependent variable of this study. Training Quality appeared to be the second predictor with Beta value of 0.251 relative to other predictors in this study's model. Meaning that, should other dependent variables be held constant, Training Quality explains 25.1 percent of the relationship with Capacity building as the dependent variable of the study.

Additionally, at Beta point 0.180 in the coefficient table above indicated that Training Facilities represent the lowest predictive power among the dependent variables. With 18 percent of the variation in the dependent variable implies that whenever other variables are dropped Training Facilities explains the weakest relationship in this study.

The multiple regression and the hypotheses testing results as indicated in table 4 and the model summary in table 2 above showed that the independent variables were able to explain 37.9 percent of the variance in the dependent variable. Notwithstanding any other independent variables not used in this study, the achieved  $R^2 = 0.379$  is adequate enough to predict variation in Capacity building for enterprise development as the dependent variable of this study.

A detail investigation of the contribution of individual independent variables in the explanation of the dependent variable showed that Training Quality with ( $\beta = 0.251$ ,  $t = 3.321$ ,  $p = 0.001$ ), Trainers Competence ( $\beta = 0.420$ ,  $t = 6.963$ ,  $p = 0.000$ ) with significant contribution and Training Facilities with ( $\beta = 0.180$ ,  $t = 2.465$ ,  $p = 0.015$ ). With positive values of Beta, Sig. and  $t$  in the regression result, therefore shows that all the null hypotheses of the study which states that “The quality and relevance of training program has no significant relationship with capacity building effectiveness”, “Trainers’ professional competence and experience do not have any effect on capacity building effectiveness” and “Availability and functionality of training facilities in the institutes has no effect on capacity building effectiveness” are not supported and therefore considered rejected.

**Table 5: Summary of the Study Hypotheses Testing**

Null Hypothesis	Statement of Null Hypothesis	Remarks
Ho1	Trainers’ professional competence and experience do not have any effect on capacity building effectiveness.	Not Supported
Ho2	The quality and relevance of training program has no significant relationship with capacity building effectiveness.	Not Supported
Ho3	Availability and functionality of training facilities in the institutes has no effect on capacity building effectiveness.	Not Supported

As shown on the summary of findings of the hypothesis of this study, all the null hypotheses are deemed rejected and the statements remain untrue as regards Capacity building effectiveness.

## DISCUSSION OF FINDINGS

The results of this study were earlier presented in the previous section. The result shows clearly that all the three (3) null hypotheses were dropped or rejected. This is because the independent variables were found to be good predictors of capacity building effectiveness. In this section therefore, the discussion on the finding would be based on the study objectives and hypotheses.

One of the objectives was to assess the quality of training programme run by the institutes and its effects on capacity building effectiveness. This study finding is not in consistent with the null hypotheses Ho1, which states that training quality has no significant relationship with capacity building effectiveness. From the finding it shows that there is significant relationship between capacity building and training quality, meaning that the higher the quality of training the better the effectiveness of capacity building. This quality comprises of the manner trainees were selected, the training method used and the post training support and follow-up rendered by the institutes. The more effective these factors are the better the capacity building

effectiveness. This therefore was in consistent with several previous studies like (Romijn, 1989; Mwamisha & Wanjau, 2013; and Azila-Gbettor & Harrison, 2013) where they both established that method and content of training are significant in training effectiveness.

Another objective of the study was to assess the professional competence and experience of the trainers in the training institutes and how it affects capacity building effectiveness. Whereby the corresponding null hypotheses Ho2 states that trainers professional competence and experience do not have any effect on capacity building effectiveness. On the contrary, the result showed that, there is positive relationship between trainers' competence and capacity building, meaning that trainers' competence has great effect on capacity building effectiveness. This is in line with the sayings of Donovan, Bransford & Pellegrino (1999), pointed out that when dealing with the issue of human competence, trainers' expertise is critically important.

The other objective of this study was to examine the availability and functionality of training facilities in the institutes and how it affects capacity building effectiveness. Consequently, the null hypothesis Ho3 states that the availability and functionality of training facilities in the institutes has no effect on capacity building effectiveness. This study's finding was not consistent with the null hypotheses because it indicates that availability of training facilities has positive effect on capacity building effectiveness with  $p < 0.000$ .

## **CONCLUSION**

Although previous studies established positive link between some of the variables and capacity building in different contexts, the linkage was not empirically examined on a sample of 370 respondents who were participants of Kano state enterprise development training institutes. This study was presumably the first of its kind to be conducted in Kano state Nigeria that examines the effect of training quality, trainers competence and training facilities on capacity building effectiveness. The study was able to establish and validated that the higher the quality of training, the more competent the trainers are and availability and functionality of training facilities the more effective a capacity building program would be in the development of micro, small and medium enterprises.

The study findings show clearly that these gaps uncovered from the literature review have been covered. It also laid a foundation for further studies in the near future that would employ other effective variables capable of predicting capacity building effectiveness which were not examined under the current study.

## **RECOMMENDATIONS**

Having discussed the various findings of the current study in previous section, this section presented recommendations based on the findings as well. The recommendations are provided to Kano state entrepreneurship development training institutes, Kano state government, any other training institutes within and outside Nigeria, state governments who may wish to establish these kinds of training institutes in the country and every other stakeholder. Specifically, the recommendation concentrated on the practical and theoretical effects of training quality, trainer's competence and training facilities on capacity building. Again, the

recommendation is concerned with policy formulation that can promote entrepreneurship and enterprise development culture in the society.

- i. Improving the quality of training- based on the result of the study, it was established that training quality had a positive relationship with capacity building effectiveness. Training quality comprised of the pre-training, training (methods and content) and post-training activities. It thus became pertinent for training institutes to provide adequate information through the available and wider reached medium (radio, newspapers, hand bills, television etc.) to prospective trainees for upcoming training program; and trainees should be screened without bias of any kind (political, religious, ethnicity and or gender) and be allowed to choose institute of their desire and trade or profession to be trained upon before admission.

The training method (class room and practical) should be of high standard as obtained in other parts of the world. Similarly, the training content (curriculum) should be rich enough to instil self-dependence through enterprise development into the minds of trainees. The issues of motivation, innovation, small business management, marketing, sources of funding, record keeping, working with others, financial discipline, mentoring etc. should be part of the content of the training.

Post training activities include provision of starting capital/equipment either on soft loan basis or free of charge to participants and post training supervision/follow-up. It is recommended therefore, that the training institutes employ adequate mechanism for follow-up supervision of participants established enterprises. The starting capital be it cash, equipment or machineries be splitted into two folds; half would be a grant and the other half be a soft loan that would be issued at developmental stages of the enterprise. This would go a long way in controlling or reducing problems of beneficiaries selling off the equipment for their selfish interest. Also, supervisory mechanism has to be employed to help check and correct the activities of graduates of the capacity building programs.

- ii. Building on trainers competence – the result of the regression analysis of this study showed trainers competence having 0.420 (42%) predictive power as the strongest predictor of capacity building effectiveness, hence the need for training institutes to always consider professional competence of trainers before recruitment. Also, the institutes should continuously determine trainers training needs and send them for further trainings and maybe internship, both local and international to upgrade their competences.
- iii. Provision of up-to-date and functional training facilities – even though this variable maintained the least predictive power of capacity building, it still indicated positive relationship with training effectiveness, having up-to 0.180 Beta (18%). It is therefore recommended that the institutes/government to provide up-to-date and adequate facilities like workshop, equipment and machines in the institutes. This would carter for the practical aspect of the training and it will make training very effective.

This study's  $R^2$  of 0.379 indicated that the utilised variables as shown by the model variance did not sufficiently explained capacity building effectiveness, meaning that there are

other effective variables that were not treated in this study. Variables like funding of the institute, affiliations with other institutes, government political will, duration of the capacity building program etc. It is therefore recommended that the above mentioned additional variables be incorporated in future studies which may better explain the remaining 62.1% variance in capacity building.

This study also suggests that further research can be conducted on capacity building assessing the impact of entrepreneurship training on potential entrepreneurs or existing small business owners. Again, a study could be conducted on impact of the training measuring before and after effect on entrepreneurs' business development and growth.

## REFERENCES

- Allison P. D. (1999). *Sociological Methods & Research*, Vol. 28 No. 2, Sage Publications, Inc.
- Azila-Gbetteh, E. M. and Harrison A. P. (2013). Entrepreneurship Training and Capacity Building of Ghanaian Polytechnic Graduates. *International Review of Management and Marketing* Vol. 3, No. 3, 2013, pp.102-111
- Bronte-Tinkew, J. and Z. Redd (2001). Logic Models and Outcomes for Youth Entrepreneurship Programs. D.C. Children and Youth Investment Corporation.
- Brown, C. (2000). Curriculum for Entrepreneurship Education: A Review. Digest number 00-8. (Online).<http://www.celcee.edu/publications/digest/Dig008.html> (accessed 8/10/2012)
- CEDEFOP, (2011). Guidance Supporting Europe's Aspiring Entrepreneurs: Policy and Practice to Harness Future Potential, Luxembourg: Publications Office of the European Union.
- Colette, H., Hill, F. and Leitch, C. (2005). The Effectiveness of Training for New Businesses: A Longitudinal Study. *International Journal for Small businesses*, 4(12). Sage Publication London.
- Cooper, D. R. And Schindler, P. S. (2003). *Business Research Methods*. McGraw-Hill/Irwin.
- Davidson, P., Delmar, F. and Wiklund, J. (2006). Entrepreneurship as Growth: Growth as Entrepreneurship. In P. Davidson, F. Delmar and J. Wiklund (Eds.) *Entrepreneurship and the Growth of Firms* (pp 21- 38). Cheltenham; Edward Elgar Publishers.
- DeCenzo, D. A. and Robbins, S. P. (2007). *Human Resource Management*. New York: John Wiley and Sons, Inc.
- Donovan, S., Bransford, J., and Pellegrino, J. (Eds) (1999). - *How People Learn: Bridging Research and Practice* - National Academy of Sciences.
- ESRC (2012). A Strategic Framework for Capacity Building within the ESRC National Centre for Research Methods (NCRM) (Economic and Social Research Council).
- European Commission, (2009). Entrepreneurship in Vocation Training and Training. Final Report of the Expert Group. Best Procedure Project.
- European Commission (2013). Entrepreneurship Training – A Guide for Educators.
- European Union (2002). Final Report of the Expert Group "Best Procedure" Project on Education and Training for Entrepreneurship. Brussels: European Commission Directorate-General for Enterprise.

- Gibb, A. (2005). Towards the Entrepreneurial University – Entrepreneurship Training as a Lever for Change. NCGE Policy Paper #003.
- Gregory P. L., and Thaddeus F. (2009). A Model for Research on Training Effectiveness. National Institute for Occupational Safety and Health Publications Dissemination 4676 Columbia Parkway Cincinnati, OH 45226-1998.
- Hair, J. F., Black, W. C., Babin, B. J., and Anderson, R.E. (2010). Multivariate Data Analysis (7<sup>th</sup> ed.). Prentice Hall, Upper Saddle River, New Jersey.
- Harper, M. (1993). Selection and Training for Entrepreneurship Development. ILO Geneva.
- Henry, C., Hill, F. and Leitch, C. (2003). Entrepreneurship Education and Training – Ashgate, Aldershot.
- ILO (1990). The Promotion of Small and Medium Sized Enterprises. ILO, Geneva.
- Izedonmi, F.O. I. (2009). Model of wealth creation, Benin City, Mindex Publishing Company
- Krejcie, R. V. and Morgan, D. W. (1970). Determining Sample for Research Activities. *Educational and Psychological Measurement*, 30, 607-610.
- Kuratko D. F. (2003). Entrepreneurship Education: Emerging Trends and Challenges for the 21st Century. Coleman Foundation White Paper Series for the U. S. Association of Small Business and Entrepreneurship. Available at [http://www.usabe.org/pdf/CW\\_2003-kuratko.pdf](http://www.usabe.org/pdf/CW_2003-kuratko.pdf)
- Mwamisha, D. M. and Wanjau, K. (2013). Transforming Implementation of Entrepreneurship Education Programme in Technical Training Institutions in Kenya. *European Journal of Business and Innovation Research* 1 (3):18-27
- Norusis, M. J. (1999). *SPSS Base System User's Guide to Data Analysis*. Prentice Hall, New Jersey.
- Nwazor, J. C. (2012). Capacity Building, Entrepreneurship and Sustainable Development; *Journal of emerging trends in Educational Research and Policy studies (JETERAPS)* 3(1): 51-54)
- OECD, (2014). Supporting Entrepreneurship in the Vocational Training System in Tunisia. Reviews on Skills and Competences for Entrepreneurship.
- Okudan, G. E., and Rzasas, S. E. (2006). A Project Based Approach to Entrepreneurial Leadership Education *Technovation* 26: 195 – 210.
- Rae, D. and Woodier-Harris, N. (2012). International Entrepreneurship Education: Postgraduate Business Student Experiences of Entrepreneurship Education. *Education and Training*, Vol. 54: 8/9.
- Romijn H. A., (1989). Selected Issues in Entrepreneurship Training for Small Business in Developing Countries. A working Paper series No.46.
- Sebastian, J. and D. Awasthi (1992). Entrepreneurship Development Programmes of North Eastern Industrial Consultants: A Status Report, Entrepreneurship Development Institute of India, Ahmedabad.
- Schacter, M. (2000). Capacity Building: A New way of Doing Business for Development Assistance Organisations, Policy Brief #6, Institute on Governance, Ottawa
- Sekaran, U. (2003). *Research Methods for Business: A Skill Building Approach* (2<sup>nd</sup> ed.). New York: John Wiley & Sons, Inc.
- Singh, M. (1990). An Evaluation Study of Entrepreneurship Development Programmes (EDPs) conducted by NITCON, Department of Management Studies, Punjab University, Patiala.

- Stryk, R. J., Damon, M., and Haddaway, S. R. (2011). Evaluating Capacity Building for Policy Research Organisations. *American Journal of Evaluation*, 32(1), 50-69
- Tijani-Alawiye, B. (2004). *Entrepreneurship Processes and Small Business Management*, Ilaro, Nigeria.
- Unachukwu, G. O. (2009). Issues and Challenges in the Development of Entrepreneurship Education in Nigeria.
- UNDP (2002). Capacity Assessment and Development, in a Systems and Strategic Management Context. Technical Advisory Paper 3.

# FACTORS EFFECTING FEMALE MIGRATION: BANGLADESH PERSPECTIVES

Humaira Parvin<sup>1</sup>, Fazle Rabbi<sup>2</sup>

<sup>1</sup>Research Fellow, Australian Institute for Sustainable Development, Lakemba, NSW 2195, Australia

<sup>2</sup>School of Business, The University of Notre Dame Australia, Sydney Campus, NSW 2007, Australia

## Abstract

Migration plays a vital role in the world economy, and female migration constitutes a significant part of the total migration. Despite substantial contributions to the welfare of the society, international female migration is a challenging issue in many developing countries such as Bangladesh. Considering the number of total international migration, female migration ratio is still low in Bangladesh. Various factors such as socio-cultural practices, religion, education, government policy affect this female migration adversely. Female migrants also face different challenges in every sphere of the migration process, which make the situation difficult for them. Addressing these issues is necessary for the economic development and gender empowerment aspects of Bangladesh. Concerted efforts of various government and non-government organisations can change the scenario for the international female migrants of Bangladesh.

**Keywords:** *Female migration, Migration from Bangladesh, Trends of female migration, Remittances, Social factors, Religion, Government migration policy*

## INTRODUCTION

Migration is an age-old phenomenon, and from the time immemorial it is being taken place in various forms and shapes in all over the world. International labour migration is a component of the population movement in almost all countries of the Asian region, which contributes a large percentage of the world migrant workforces. There were around 244 million migrants in the world in 2015 of which 52% were male, and 48% were female (UN Department of Economic and Social Affairs, 2016). Similarly, since 1976 a large number of labour have migrated from Bangladesh to the other regions of the world. But in Bangladesh, the female migration has always been a less significant issue. Unlike the other labour surplus countries, female migrants hold a low percentage of the labour migrants in Bangladesh (Islam, 2012). In 2015, the proportion of female migrants was only 13%, whereas the Southern Asian average was 45% (UN Department of Economic and Social Affairs, 2016). There are various factors which are liable for this low rate of female migration from Bangladesh. Also, female migrants are facing various problems in their migration process, and these problems should be addressed for the betterment of the society.

This paper tries to identify the factors affecting the female migration from Bangladesh adversely after describing the current trend of female migration and government policies on it in Bangladesh. Then it shows various challenges, both internal and external, faced by the female migrants of Bangladesh. Finally, this report suggest some recommendations after analyzing the current female migration scenerio of Bangladesh.

## OBJECTIVE AND METHODOLOGY

Reviewing available data and statistics, it can be found that compared to the other countries of the world with same social, cultural and economic conditions, Bangladesh has a



very poor number of female migrants. So, the primary objective of this paper is to identify the major factors which negatively affect the female migration process of this country based on available literature.

This paper is based solely on the secondary data which are collected from the reports and articles of various government and non-government organisations. Tabular and graphical analysis are done with the collected data in order to achieve the objective of the study.

This paper focuses on the temporary international female migration from Bangladesh. As international female migration has a strong impact on the economic and social spheres of the country, this paper emphasises on that particular subject. According to some studies, in addition to the formal channel, a considerable number of migration take place via the informal channel. Due to the lack of reliable data, discussion on those issues is out of scope of current research. In addition, discussion of some issues are eluded in this study due to discrepancies in similar data in different sources.

## **PATTERN OF BANGLADESH INTERNATIONAL MIGRATION**

Bangladesh has a long history of international migration since its inception in 1971. Without some exceptions, Bangladesh is having an increasing number of migrants each year. According to the Bureau of Manpower Employment and Training (BMET) of Bangladesh, 10.9 million Bangladeshi have gone overseas from 1976 to May 2017 on short term contract work and the highest 350% increase of the migrants relative to the previous year occurred in 2007 (BMET, 2017a). At the same time, the number of overseas employment of female workers during 1991 to May 2017 is 630,157 and the year 2004 reflected the highest 378% rise of them (BMET, 2017b). Apart from this, 7 million long-term Bangladeshi emigrants are living in different countries of the world. And, the number of migrants from Bangladesh has increased from 987,900 to 1,422,800 during 2000 to 2015, while female migrants' share has decreased from 14% to 13% during the same period (UN Department of Economic and Social Affairs, 2016).

## **INTERNATIONAL FEMALE MIGRATION TREND IN BANGLADESH**

Although Bangladesh is a labour surplus country and the male-female ratio in Bangladesh is 100.3:100 (Bangladesh Bureau of Statistics, 2016), the number of female migrants comprise a low proportion of the total migrants. Untill 2004, around 1% of Bangladeshi migrants were female, and this number has increased to about 8% in 2016. But still, women represent a small minority in contrast to the overall Bangladeshi migrant flows (BMET, 2017a).

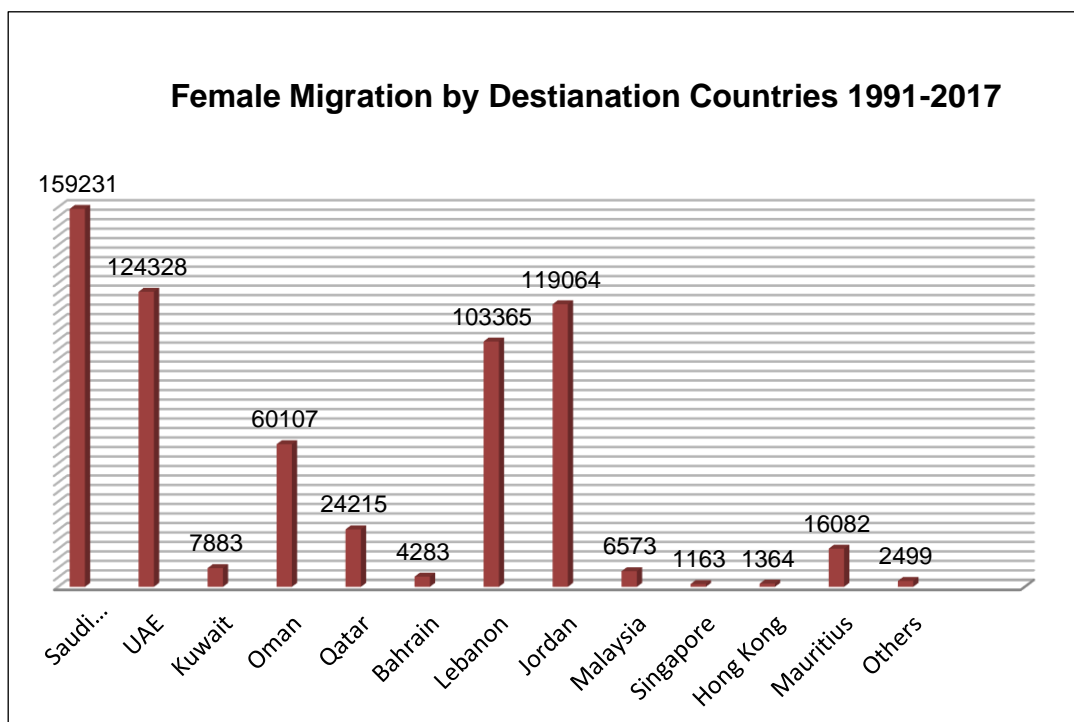
Female migration from Bangladesh is not a very common phenomenon, and there were several restrictions on female migration till 2003. So, female migration was relatively low before 2003, and it has begun to increase after that time and has got momentum in 2004 (Islam, 2012). The following table shows the trend of female migration from Bangladesh during 1991-2010, which depicts that Bangladeshi migrant workers are predominantly male. Female migrants constitute only 148,460 among a total of 6,304,189 migrants from 1991-2010, which is less than 3 percent of the total migrants from Bangladesh.

**Table 1.** Trend of Female Migration from 1991-2016

Year	Number of Total Migrants	Female Migrants	
		Number	Percentage of Total Migrants
1991	147,156	2,189	1.49
1992	188,124	1,907	1.01
1993	244,508	1,793	0.73
1994	186,326	1,995	1.07
1995	187,543	1,612	0.86
1996	211,714	1,994	0.94
1997	231,077	1,762	0.76
1998	267,667	939	0.35
1999	268,182	366	0.14
2000	222,686	454	0.20
2001	189,060	659	0.35
2002	225,256	1,217	0.54
2003	254,190	2,400	0.94
2004	272,958	11,200	4.10
2005	252,702	13,600	5.38
2006	381,516	18,100	4.74
2007	832,609	18,900	2.27
2008	875,055	20,827	2.38
2009	475,278	22,224	4.68
2010	390,702	27,706	7.09
2011	568,062	30,579	5.41
2012	607,798	37,304	6.14
2013	409,253	56,400	13.78
2014	425,684	76,007	17.86
2015	555,881	103,718	18.66
2016	757,731	118,088	15.58
Total	<b>9,628,718</b>	<b>574,075</b>	<b>5.96</b>

Source: (BMET, 2017b).

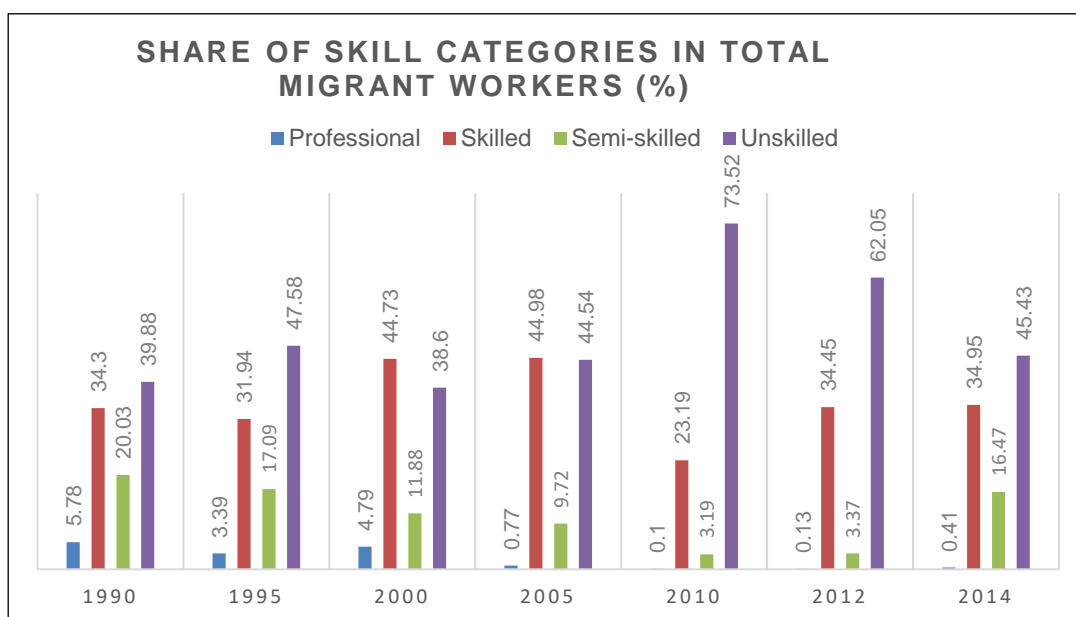
If the female migration pattern by the destination countries is analysed, it can be found from the chart below that Middle Eastern countries have been the main destinations for the female migrants. Upto now, Saudi Arabia is the major destination for the female migrants of Bangladesh.



Source: (BMET, 2017b)

**Figure 1.** Female Migration by Destinations, 1991-2017

From the available data, it can be marked that the percentage of unskilled female workers are much higher than the skilled or professional migrants and among the skilled migrants, the majority of them used to migrate to the Middle Eastern countries (ADB and ILO, 2016). Among the occupation list of the female migrants, house keeping, garment, and other factory working and nursing are the predominants. Though there is a list of 149 different occupations, about 92% of the international female migrants opt for house aide jobs (Islam, 2012).



**Figure 2.** Share of Skill Categories in Total Migrant Workers, 1990-2014, Source: (ADB and ILO, 2016)

## GOVERNMENT POLICY ON FEMALE MIGRATION FROM BANGLADESH

In the early 1970s, the Government of Bangladesh (GoB) did not have any specific policy on the international female migration. Nevertheless, Bangladeshi female workers, started to seek jobs in the global labour market, specially in the Middle-Eastern countries by their own initiatives. Besides this, during the 1980s Bangladeshi female migrants used to migrate in skilled labour category such as doctors, nurses, teachers, etc. In early 1981, restriction over semi-skilled and unskilled women workers was imposed by a Presidential Order on the ground of protecting their dignity. According to the order, except the professional and skilled labours, female migrants were not be permitted to go abroad without a legal male guardian. This restriction was imposed in response to a demand from the association of the Kuwait migrants for some incidents of repeated women abuse in Kuwait (Siddiqui, 2001). Although in 1988, little change was brought in the order, but this was not completely in favor of the female migrants (Siddiqui, 2008).

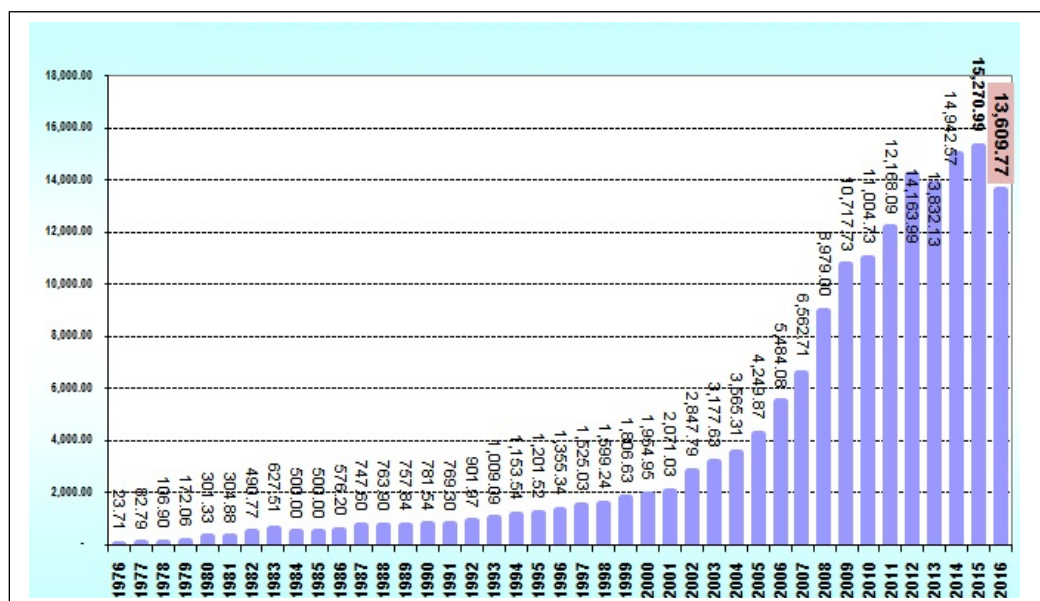
In 1997, a complete ban was imposed on semi-skilled and unskilled labour according to a government decision, which followed by an inter-ministerial meeting among the Ministry of Foreign Affairs, Ministry of Finance, Ministry of labour and the Cabinet Division of the Bangladesh Government. This prohibition excluded only the highly skilled and professional women such as doctors, engineers, and teachers. This decision was considered to be one of the most discriminatory policy against women and received heavy criticism from different groups of the civil society such as female rights group, labour organisations, human rights workers and so on. The government rationalized this policy as a pro-active measure to protect the dignity of the women (Migration Forum Asia, 2011; Siddiqui, 2008).

In 2003, the ban was relaxed by mentioning that semi-skilled and unskilled workers of certain ages can go abroad under special permission. The GoB's Overseas Employment Policy

of 2006 recognized the equal rights of men and women to migrate overseas for employment. These policy changes caused a shift in the numbers of women migrating for work. Before the lift of the ban, the female migration represented less than 1% of all migration (between 1991-2003). Since changes to the policy on female migration in 2003, this number has steadily increased (Migration Forum Asia, 2011).

## REMITTANCE SCENERIO

In spite of having certain challenges, the Bangladeshi workers managed to keep regularity in the remittance flows of the country. This increased flows of remittance are not only improving the economic condition at the household level but also helping to boost up the national economy.



**Figure 3.** Year-wise Remittances Earned from 1976 to 2016 in Million USD, Source: (BMET, 2017b).

From different studies, it has been seen that despite having a poor number and getting less salary than their male colleagues, the female migrants remit more comparing to that of the male migrants of Bangladesh. On an average, the females remit 72% of their income to home countries, whereas the percentage of male remittance is 45% to 50% of their total income (Das, 2012). Furthermore, the females remit more consistently and regularly. In a survey finding by Rahman (2013), it was revealed that most of the females use the formal channel for sending remittances. According to that study, all the females who took part in the survey use formal channels without the exception of 2% females who used both formal and informal channels. At the same time, 67% of male use informal channels, 15% formal channels and 18% used both formal and informal channels for sending remittances to home. Moreover, the females spend their remittances for family consumption, education, medical purposes, while male use remittances for land purchase and small business ventures (Rahman, 2013).

## **FACTORS AFFECTING THE INTERNATIONAL FEMALE MIGRATION FROM BANGLADESH**

For more than 50 years, the international immigration issue has gained attention to the social scientists in both developed and developing nations. For years, the immigrant receiving countries has shifted their demands of the labour force from one region to another region, transforming the developed nations into multi-cultural and multi-ethnic societies. There have been several attempts to explain why people migrate from developing to developed countries. It is not possible to completely explain why the pattern of migration is like this. There are numerous theoretical models and approaches which explain the migration process by using various assumptions and frameworks (Ali, Mujahid, Rashid, & Shahbaz, 2015). The 'Neo-Classical Theory' expresses that wage differentials and employment conditions are major causes of migration and admits that these are the decisions of the individuals for income maximization. Contrast to that the 'New Economics of Migration' focusses on the larger units, typically family or household decisions, rather than individuals' decisions as the condition for migration. While the 'Dual Labour Theory' and the 'World System Theory' emphasize on the macro level forces aggregation such as the structural requirements of modern industrial economies and natural consequences of economic globalization as the causes of migration (Massey et al., 1993). None of these theories can explain the female migration completely, rather they support the scenario partially (Oishi, 2002).

There have been numerous researches in the field of migration, and there is a general agreement among the researchers that migration is a complex process. Situations created by both the macro and micro level economic, social and catalytic factors make individual or a group of people decide to migrate. Hence, the factors may depend on a country's geo-political location, destination countries, social structure, cultural attributes, political condition (Siddiqui, 2004). For Bangladesh, five factors have been listed as the deciding factors in the migration process of Bangladesh, which are: economic, environmental, social, demographic and political (Martin et al., 2013). Several forms of climate conditions like flood, cyclone, river erosion and so on act as important push factors for migration (Farhana, Rahman, & Rahman, 2012; Ranjan, 2016).

In 2013, the male-female workforce composition in Bangladesh was 42.5 and 18.2 million respectively. This pattern is common in both the rural and urban areas (Bangladesh Bureau of Statistics, 2016). So, 'what makes the female workforces' share comparatively low both in the home and abroad' is a crucial question. Similarly, although both male and female share almost same economic, environmental and political reality, what makes the male population migrate more than their female counterpart? Different studies identified varied factors which may affect both negatively and positively the male migration, but the existing literature suggests that the social factors play the decisive role in the case of female migration. Ullah (2007) finds 12 structural factors in his study which are largely affecting the female migration. Among them, religion, education, and language capacity are the most important (Ullah, 2007). Among various factors, the followings have been much discussed issues:

### **Socio-Cultural Practices**

Since gender attributes are largely determined by the social and cultural values, the migration decisions of the females vastly depend on them. Because of the flexible gender

role, in the Philippines, Sri Lanka, and Thailand, a large number of female migration occurs every year (Omelaneuk, 2005). On the contrary, the Bangladeshi patriarchal family patterns make the migration decisions to come from the male members of the family. So in this context, it is really difficult for a woman, especially who are unmarried, to go abroad to work at her own will in spite of having her every potential to do good in abroad. However, the married women enjoy a certain amount of decision making power. In a study, it was found that the majority of the female migrants are above the age of 40 and married (Rahman, 2013).

## Religion

According to Ullah (2007), religion is the most vital factor which creates hindrance in the Bangladeshi women's journey to the overseas. As the Muslim family prefers to keep their female members in 'purdah', very often they are reluctant to let them go outside the border (Ullah, 2007). But religion has not been an issue in female migration in other Muslim countries such as Indonesia, which has a higher percentage of female migrants. In the year 2015, Indonesia's female migrant's percentage was 42% of the total migrants, whereas Bangladesh had only 13% (UN Department of Economic and Social Affairs, 2016). This may be the result of the more conservative version of religious practices in Bangladesh. As Omelaneuk (2005) finds that the more religious or cultural restriction imposed upon the female, the less emigration occurs. For example, in the Indian state Kerala, the proportion of Muslim migrants are lowest comparing to the other sections of the society (Zachariah, Mathew, & Rajan, 2001).

## Education

Education is the most vital factor on the way to women empowerment. In order to equip the women population to integrate into the development process of the country, education is one of the most important factors (Villualluz, 2000). Literacy rate among the Bangladeshi women is much lower compared to men and other countries' females. The literacy rate is even lower in rural areas of Bangladesh. In the year 2015, the overall literacy rate for both sexes were 63.6%, where the male and female shares were 65.6% and 61.6% respectively. Among them, the literacy rate of women in the rural area was 55.1%, whereas in the urban area it was 71.2% (Bangladesh Bureau of Statistics, 2016). So, it can be observed that the females of the rural areas have the lowest literacy rate. Due to the poor education, the rural women have less employment opportunity and have less knowledge of the changing world context. Moreover, for the same reason, they have limited access to the information and little knowledge of the contemporary world (Ullah, 2007). Apparently, the less educated group has fewer opportunity to migrate overseas.

## Government Migration Policy

In every country of the world, government policy plays a decisive role in encouraging or discouraging the migration process. For Asian countries, this reality is much more visible, and Sri Lanka is one of the major examples of this. In 1970, the government of Sri Lanka formulated policy encouraging female migrants and took some pro-active initiatives understanding the demand of the labour markets of the Gulf countries. As a result, by 1980s, 90% of its international labour force was female in the Gulf region (Siddiqui, Migration and Gender in Asia, 2008). Contrast to that, the Bangladesh Government policy was very much

unfavourable to the female migration, which subsequently leads to the poor female workforce in the international labour markets and the present policy also has nothing encouraging for female migration.

## **CHALLENGES FACED BY THE FEMALE MIGRANTS**

Women face different sorts of problems in the migration process. According to Sijapati (2015), the phases of problems can be divided into the following four categories:

### **Pre-migration Stage**

#### *Restrictive Social and Gender Norms*

Like other Asian countries, in Bangladesh, the gender norms are very strict, and women have very limited decision-making power. This results in difficulties for women who wish to migrate resulting in lower female migration rate (UN Women, 2013). Oishi (2002) reports that countries with higher levels of female autonomy in the household have higher rates of female migration. So, women face difficulties in persuading the male members of their families. This culture affects negatively on the female migration, as most of the time the males are reluctant to let them go abroad.

#### *Trafficking*

Due to the limited access to information and illiteracy, women are vulnerable to the trafficking. It is often found that the females are trafficked and being sold to the brothels in both internal and external migration cases. Mostly in rural areas, females are offered lucrative jobs with high salaries by brokers or middlemen, who are usually known to their families. And, afterwards, they send the females to the bordering countries, who would end up working in the sex industries. In the South Asia, Bangladesh and Nepal are the two most vulnerable countries of origin, from where women and girls are trafficked to the bordering countries. Every year around 10,000 to 20,000 women and girls are trafficked to India, Pakistan, Bahrain, Kuwait and the United Arab Emirates from the other South Asian countries (Rahaman, 2015).

#### *High Cost of Migration*

In spite of several formal instruments working in the migration process, around 55 to 60 percent recruitments take place through individual initiatives and personal connections (Siddiqui, 2004). Very often these formalities are done via sub-agents or brokers, which result in increased migration cost than usual causing several forms of harassments and distresses to the migrants (Barakat, Hossain, & Haque, 2014). Since the females have limited options to go abroad and less information, they become easy victims of these brokers and pay high migration cost.



### *Difficulties in Managing Migration Costs*

As women in Bangladesh lack necessary access to the resources and opportunities, they face difficulties in managing high migration cost (Caritus Internationalis, 2010). For this, they borrow money from the NGOs or the 'mahajans' of their locality at high interests and becomes indebted for the long term. Later, the lion's share of their earning is used to repay the debts (Sijapati, 2015).

### **In the Transit**

Due to the lack of communication skills and education, the female migrants very often face difficulties during travelling, especially those who are not regular travellers, face harassments and hostilities at the exit and entry points (Hear, Brubaker, & Bessa, 2009). If the migrants are transported through the illegal channel, they become victims of physical exploitations by the transporters, fellow male travellers or border security guards during travel time (Jolly & Reeves, 2005).

### **At the Destination**

#### *Payments, Working Hours and Service Benefits*

The complaints regarding payments of salary are the most common suffering for almost all the female migrants around the world. Even signing a contract does not guarantee them about timely and proper payments from their employers (Siddiqui, 2008). The domestic workers frequently suffer than the workers of the formal sectors. For the female workers, working experiences in the Middle East are the worst than the experiences of other parts of the world. According to a study, the Bangladeshi female migrants receive at least 20% less salary to that was mentioned in the contract. They are also deprived of other job benefits such as bonus increments, overtime and holidays. The complains of the Bangladeshi garment workers working in the UAE garment sector about the irregular payments of 'over time' duties they perform, is much common. Long working hours is another common complaint of the female migrant workers. Heavy work for 15-20 hours in a row is not unusual among the migrant workers of both domestic and formal sectors in the Middle East (Barakat & Ahasan, 2014).

#### *Physical, Mental and Emotional Abuses*

The Middle Eastern countries, especially the Saudi Arabia and the UAE have been the popular destinations for the female workers. Around 30.28% of women workers work there as domestic workers who are at the risk of physical and mental abuses mostly including rape, confinement, poor wages or no wage. They suffer most as they have very limited scope to contact outside (Barakat & Ahasan, 2014). Virtually the conditions of those migrants are like slaves. They are reportedly beaten and sexually abused when they ask for their salaries. Other countries like Thailand and Malaysia, where a considerable number of female workers go, incidents of mental and physical abuses are also not very uncommon. In the Asian countries, where very often the females are trafficked or illegally entered anyway, they are handed over to the Police after being exploited and then kept in detained for illegal entry to the country (Ranjan, 2016).

### *Workplace Conditions*

The skilled labours working abroad, enjoy much better conditions in the working environment, but the working and living conditions of the majority of the semi-skilled and unskilled workers are extremely poor. A section of the workers is accommodated within the factory premises. They rent their own accommodation and live with other migrants from Bangladesh. In a typical situation, a large group of people is accommodated in a small room, with little or no privacy and the extremely unhygienic environment. Most of the female garment workers complained about the environment being intolerably hot to them. Very often they are devoid of drinking water and sanitary facilities. Moreover, the conditions of their working places are often very hazardous also. They work there with minimum security measures (Siddiqui, 2004; 2008).

### **Re-integration**

Social stigma is the main problems for returnee migrants. In spite of remarkable contributions to both the family and the social level, the returnee female migrants are not accepted very whole-heartedly by their families and societies. Most of the time they are suspected and misjudged of their sexual misconduct and other sorts of criminal activities by their families and friends. Very often they are kept detached from their children by their husbands on the ground of protecting the children from being spoiled. Some studies reveal that even the returned migrants who become a victim of sexual harassment abroad, confront violence at the hands of husbands or in-laws upon coming back home (Sijapati, 2015). Apart from this, the returnee female migrants find it almost impossible to have an easy access in the society than their male colleagues (Migration Forum Asia, 2011).

### **CONCLUSION AND RECOMMENDATIONS**

Although the female members comprise almost 50% of the total population of Bangladesh, still the number of female migrants does not represent the real picture of women participation. It is true that the women in Bangladesh have a very low voice not only in the family decision making process but also in everywhere. Even though it is quiet surprising that the participation of female in every sphere in Bangladesh is quiet encouraging. Even in some services such as military, police, which is traditionally considered as male service, the percentage of female participation is increasing there day by day at a good pace. In the case of overseas migration, also the female number is increasing, but not in that way as it should be. The female migration contributes to the significant development of the household, society and the nation as a whole, but still, the issue has been less addressed by the government. In order to encourage more female to migrate, proper initiatives should be taken by the government. At the same time, the society also has to play a good role in this regard.

Considering the scenerio of the international female migration from Bangladesh the following recommendations are made to improve the situation.

- Bangladesh Overseas Employment Policy (2006) and all other current existing laws are not enough to address the female migration issues (Migration Forum Asia, 2011). So, programs and legal amendments should be brought to address the complex issues, especially the social factors relating to the female migrants.

- Though the gender inequality has been removed from primary education with women's enrolments at 55% compared to 45% of their male counterparts, women's enrolments in the vocational and technical education still remain poor (Migration Forum Asia, 2011). This is a major cause for the less number of females working under skilled migrants criterion. In order to increase the skilled female migrant, the government should establish more specialized training institutes and set priority to train the female migrants in order to compete with other labour exporting countries like the Philippines, India, Indonesia, etc.
- It has been found that the female migrants face severe problems with re-integration with their families and societies. So, the government should take proper steps to establish an appropriate mechanism for re-integration of the female workers such as awareness building programs among the common people, especially in the rural areas to lessen the existing negative views towards women employment.
- Bangladesh very recently signed Memorandum of Understanding (MoU) for sending 200,000 workers to Malaysia and Hong Kong by the year 2013, which will also include female migrants (Bureau of Manpower Employment and Training, 2015). But it is noteworthy that there is no reservation for female quotas in these treaties. So, in order to decrease gender disparity, specific quota should be introduced for female, at least for a certain period of time.
- Since female workers face very tough conditions while working overseas, the government should initiate more MoUs, bilateral and multilateral agreements with the countries, which are the major destinations for female workers.

## REFERENCE

- ADB and ILO. (2016). *Overseas Employment of Bangladeshi Workers: Trends, Prospects, and Challenges*. Manila: Asian Development Bank (ADB) and International Labour Organisation (ILO).
- Ali, A., Mujahid, N., Rashid, Y., & Shahbaz, M. (2015). Human Capital Outflow and Economic Misery: Fresh Evidence for Pakistan. *Social Indicator Research*, 124(3), 747-764. doi:10.1007/s11205-014-0821-5
- Bangladesh Bureau of Statistics. (2016). *Report on Bangladesh Sample Vital Statistics 2015*. Dhaka: Bangladesh Bureau of Statistics (BBS), Government of Bangladesh.
- Bangladesh Bureau of Statistics. (2016). *Statistical Pocket Book of Bangladesh 2015*. Dhaka: Ministry of Planning, Government of Bangladesh.
- Barakat, A., & Ahasan, M. (2014). *Gender and Migration from Bangladesh*. Dhaka. Retrieved from [http://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/---ilo-dhaka/documents/publication/wcms\\_310411.pdf](http://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/---ilo-dhaka/documents/publication/wcms_310411.pdf)
- Barakat, A., Hossain, M. I., & Haque, E. (2014). *The Cost: Causes of Potential Redress for High Recruitment and Migration Costs in Bangladesh*. Dhaka: International Labour Organisation.
- BMET. (2017a). *Overseas Employment and Remittances from 1976 to 2017*. Retrieved from Bureau of Manpower Employment and Training (BMET), Bangladesh: <http://www.bmet.org.bd/BMET/viewStatReport.action?reportnumber=17>
- BMET. (2017b). *Overseas Employment of Female Workers from 1991 to 2017*. Retrieved from Bureau of Manpower Employment and Training (BMET), Bangladesh: <http://www.bmet.org.bd/BMET/viewStatReport.action?reportnumber=28>
- Bureau of Manpower Employment and Training. (2015). *Skills for the international labour market: Bangladesh Country Report*. Dhaka.

- Caritus Internationalis. (2010). *The Female Face of Migration*. Vatican City: Caritas Internationalis. Retrieved from <http://www.caritas.org/includes/pdf/backgroundmigration.pdf>
- Das, U. K. (2012). Female Migrant Workers' Remittances and Contribution to the National Economy: An Exploratory Research. Dhaka.
- Farhana, K. M., Rahman, S. A., & Rahman, M. (2012). Factors of Migration in Urban Bangladesh: An Empirical Study of Poor Migrants in Rajshahi City. *Bangladesh e-journal of Sociology*, 9(1), 105-117.
- Fleury, A. (2016). *Understanding women and migration: A literature review*. Global Knowledge Partnership on. Retrieved from [http://www.knomad.org/docs/gender/KNOMAD%20Working%20Paper%208%20final\\_Formatted.pdf](http://www.knomad.org/docs/gender/KNOMAD%20Working%20Paper%208%20final_Formatted.pdf)
- Hear, N. V., Brubaker, R., & Bessa, T. (2009). *Managing Mobility for Human Development: The Growing Silence of Mixed Migration*. Oxford: United Nations Development Program.
- ILO, Labour Migration Branch. (2015). *ILO Global Estimates on Migrant Workers: Results and Methodology*. Geneva: International Labour Organisation (ILO).
- Islam, M. N. (2012). *Study on Women Migrants Situation*. Retrieved from Bureau Manpower, Employment and Training (BMET): <http://www.bmet.org.bd/BMET/resources/Static%20PDF%20and%20DOC/publication/Survey%20on%20Female%20migrant.pdf>
- Jolly, S., & Reeves, H. (2005). *Gender and Migration: Overview Report*. Brighton: Bridge Institute of Development Studies.
- Khandaker Mursheda Farhana, S. A. (2012). Factors of Migration in Urban Bangladesh: An Empirical Study of Poor Migrants in Rajshahi City. *Bangladesh e-Journal of Sociology*, 9(1), 105-117. Retrieved from <http://bangladeshsociology.org/Factors%20of%20Migration%20in%20Urban%20Bangladesh%20An%20Empirical.pdf>
- Martin, M., Kang, Y. h., Billah, M., Siddiqui, T., Black, R., & Kniveton, D. (2013). Policy Analysis: Climate Change and Migration Bangladesh. Refugee and Migratory Movement Research Unit: Sussex Centre for Migration Research. Retrieved from <http://migratingoutofpoverty.dfid.gov.uk/files/file.php?name=wp4-ccrm-b-policy.pdf&site=354>
- Massey, D. S., Arango, J., Hugo, G., Kouaouchi, A., Pellegrino, A., & Taylor, J. E. (1993). Theories of International Migration: A Review and Appraisal. *Population and Development Review*, 19(3), 431-466. Retrieved from <http://www.jstor.org/stable/2938462>
- Migration Forum Asia. (2011). *CEDAW and the Female Labour Migrants of Bangladesh*. Dhaka. Retrieved from [http://tbinternet.ohchr.org/Treaties/CEDAW/Shared%20Documents/BGD/INT\\_CEDAW\\_NGO\\_BGD\\_48\\_8124\\_E.pdf](http://tbinternet.ohchr.org/Treaties/CEDAW/Shared%20Documents/BGD/INT_CEDAW_NGO_BGD_48_8124_E.pdf)
- Nicholas Van Hear, R. B. (2009). *Managing Mobility for Human Development: The Growing Silence of Mixed Migration*. Oxford: United Nations Development Program.
- Oishi, N. (2002). *Gender and Migration: An Integrative Approach*. California: Centre for Comparative Immigration Studies. Retrieved from <https://escholarship.org/uc/item/0s04g29f>
- Omelaneuk, I. (2005). *Gender, Poverty Reduction and Migration*. Haifa.

- Rahaman, M. R. (2015). Human Trafficking in South Asia (Special preferences on Bangladesh, India and Nepal): A Human Rights perspective. *IOSR Journal Of Humanities And Social Science (IOSR-JHSS)*, 20(3), 1-8. doi:DOI: 10.9790/0837-20330108
- Rahman, M. M. (2013). Gendering Migrant Remittances: Evidence from Bangladesh and the United Arab Emirates. *International Migration*, 51, 160-178. doi:10.1111/j.1468-2435.2012.00763.x
- Ranjan, A. (2016). Migration from Bangladesh: Impulses, Risks and Exploitations. *The Round Table: The Commonwealth Journal of International Affairs*. doi:10.1080/00358533.2016.1181409
- Siddiqui, T. (2001). *Transcending Boundaries: Labour Migration of Women from Bangladesh*. Dhaka: University Press Limited.
- Siddiqui, T. (2004). Bangladesh: The Complexities and Management of Out-Migration. (P.-S. Ahn, & P.-S. Ahn, Eds.) *Migrant Workers and Human Rights :Out Migration from South Asia*, pp. 19-55.
- Siddiqui, T. (2008). *Migration and Gender in Asia*. Bangkok.
- Sijapati, B. (2015). Women's labour migration from Asia and the Pacific: Opportunities and Challenges. *IOM Issue in brief*, 1-16.
- Ullah, A. A. (2007). The State of Female Migration Flow in International Labour Market: How is Bangladesh doing?
- UN Department of Economic and Social Affairs. (2016). *International Migration Report 2015: Highlights*. New York: United Nations.
- UN Women. (2013). *Managing Labour Migration in ASEAN: Concerns for Women Migrant Workers*. Bangkok: UN Women.
- Villualluz, S. E. (2000). *Women Around the World Fact Sheet: A Quarterly Fact Sheet*. Dhaka: Centre for Legislative Development.
- Zachariah, K. C., Mathew, E. T., & Rajan, S. I. (2001). Socio-Economic and demographic consequences of migration in Kerala. *International Migration*, 39(2).

# CRITICAL SUCCESS FACTORS (CSF) OF ERP IMPLEMENTATION: A STUDY WITH TRIZ PERCEPTION MAPPING

**Lim Teck Loon, Kow Mee Yee, Akbariah Mahdzir, Nooh Abu Bakar**

*Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Malaysia,*

## **Abstract**

Manufacturing solution like Enterprise Resources Planning (ERP) is designed for the manufacturing organisation to streamline business operation by offering a suite of software modules for business and process improvement. Literatures showed that the success rate of the ERP projects was lesser than half because the ERP implementation process was rather complex and related to the issues that were difficult to address like people, process and methodology. There was not much specific finding on the relationship of the critical success factors (CSFs) and strategic intervention on people, process, methodology, technology and infrastructure as the best approaches. Hundreds of CSFs were identified however it was difficult to find literatures on specific CSFs that were indicated as the “most critical success factors” to address. In this paper, the authors employed content analysis on literatures to identify CSFs of ERP implementation based on research articles published between years 2005-2016. The constant comparative methodology was then used to harmonize the 332 identified CSFs to 90 CSFs. TRIZ perception mapping technique was then used to narrow down the search for the “most critical CSFs”. The results showed the most critical CSFs of ERP implementation were “benchmark implementation progress on clear milestone and performance metrics”, “project champion”, “competence project team”, “ERP system capability” and “user acceptance”. The research findings also showed TRIZ perception mapping could help to improve the quality of the research output on CSFs studies.

**Keywords:** *TRIZ Perception Mapping (PMap), Critical Success Factors (CSFs), Enterprise Resources Planning (ERP) Implementation*

## **INTRODUCTION**

Enterprise Resources Planning (ERP) is the manufacturing solution that is used by the manufacturing enterprise for business and process improvement. In an effort to remain competitive, there has been an increasing need in organisations to connect the information supplied by each department into a common entity (Nwankpa, 2015; Ram, Corkindale, & Wu, 2014). ERP systems are designed for the manufacturing organisation to address the problem of information fragmentation as they integrate and streamline internal processes by providing a suite of software modules that cover all functional areas of a business (Wei & Ma, 2014). However, increasingly we hear of the failures of ERP implementations, or the complete abandonment of the system (Elragal & Haddara, 2013; Poon & Yu, 2010). Resultantly, there has been expanded research focusing on the implementation process and its critical success factors (CSFs) (Al-Mashari, Al-Mudimigh, & Zairi, 2003; Amid, Moalagh, & Zare Ravasan, 2012; Ijaz, Lodhi, & Irfan, 2014; Ngai, Law, & Wat, 2008a).

There are CSFs compilation, classification and taxonomy made available and they are intended to be used as good reference guide for ERP projects implementation (Dezdar & Sulaiman, 2009). CSFs shall enhance the probability of achieving higher success levels and, resultantly in timesaving, cost savings, quality and efficiency in their ERP system implementation (Finney & Corbett, 2007). However, the compilation of CSFs listing is

typically long and there are not many specific findings on the relationship of the CSFs and its strategic intervention on people, process and methodology as the best approaches. There was none of the CSFs specifically indicated as the “most critical factors to address” (Ram & Corkindale, 2014). Some of the CSFs case studies also found out there was no specific resolution given to attend the CSFs (Saade & Nijher, 2016). This has resulted in raised of the research question: *“Out of so many CSFs identified through literatures, which CSFs are the most critical ones and should be putting highest attention in ERP implementation?”*

This aim of this study was indented to find the answers for the research question in order to identify the most critical CSFs of the ERP implementation that would be more understandable and helpful to the practitioners in the industry. Our research work presented in this paper entailed two methodologies: the first involved the literature review study on CSFs; and the second related to the analysis and synthesis for the most critical CSFs. The results of the findings on the most critical CSFs were summarized in the last section of the article.

## LITERATURE REVIEW

Researches in earlier 80's had indicated CSFs were those few things that must go well and must be given special and continual attention by a manager or an organisation to bring about high performance to ensure success (Boynton & Zmud, 1986). CSFs definition by Rorster & Rockart was “the limited number of areas in which results, if they are satisfactory, will ensure competitive performance for the organisation” (Forster & Rockart, 1989). For a management team, a CSF processed a clear, explicit, and shared understanding of the organisation's business environment and the actions which were necessary (Forster & Rockart, 1989). The CSFs concept promised a systematic way of identifying the key areas, or signposts, that required the constant and careful attention of management in order to achieve performance goals (Ram & Corkindale, 2014).

The success rate of the ERP system implementation was low even though companies did not show the failure of their implementation. The literatures showed there were different factors influence either **positively** or **negatively** on the successful implementation of the ERP, and CSFs were the reasons that determined the successful implementation (Ijaz et al., 2014; Rajan & Baral, 2015). There were 3 stages of ERP implementation as indicated: **pre-implementation**, **implementation** and **post-implementation** and the CSFs occurred in all implementation phase stated above (Ijaz et al., 2014). ERP solution implementation was complex and hence CFSs system processes were related to system selection process, project management process, implementation strategy, and success measure process (Bansal & Agarwal, 2015). Since the ERP system was used by the end users, CSFs were associated with users, project team, top management, consultants and vendors (Lech, 2016). Different set of CSFs could be categorized under different classification to suite ERP projects lifecycle for different industry either SMEs or large organisation, CSFs taxonomy were compiled the for ease of reference and providing good guideline for practitioners (Dezdar & Sulaiman, 2009)

A comprehensive search through the relevant literatures for the past 12 years ranging from 2005 to 2016 for the articles from journals and conference proceedings found numbers of research articles that discussing on CSFs compilation, classification and taxonomy. Research conducted by Finney & Corbett (2007) over hundreds of journals using key terms search

identified 45 CSFs articles. CSF constructs were then identified using content analysis methodology and inductive coding technique to identify 9 strategic CSFs and 17 tactical CSFs with total of 26 CSFs (Finney & Corbett, 2007). Ngai et al. (2008) conducted similar search for relevant literatures for 10 countries/regions and identified 18 CSFs from the 48 related articles, and ‘top management support’ and ‘training and education’ were found the most frequently cited as the critical factors (Ngai, Law, & Wat, 2008b). Dezdar and Sulaiman (2009) reviewed 95 articles and identified 17 taxonomy of CSFs through the literature review (Dezdar & Sulaiman, 2009). Ahmad *et al* (2013) presented the results of a study to identify and analyse the interrelationships of the critical issues involved in the implementation of ERP in small and medium sized enterprises (SMEs) (Ahmad & Pinedo Cuenca, 2013). In their findings, the CSFs were mainly contributed by 18 organisation factors, 2 neutral factors, and 12 operational factors with total of 33 CSFs. Ram and Corkindale (2014) search through 236 articles and found out 15 CSFs for the post implementation that associated with post-implementation performance improvements. Their study showed that still remained many proposed CSFs that needed to be robustly empirically tested for their actual influence on some aspect of ERP success (Ram, Corkindale, & Wu, 2013). Saade and Nijher (2016) searched for 37 case studies and extracted 64 CSFs from literature and subsequent detailed analysis found a total of 22 factors that were distinct. The proposed CSFs can be used by practitioners in five ways: assess implementation of an ERP; ex-ante assessment; comparative analysis with other implementation experiences; utilize CSFs from model as part of key performance indicators; and utilize the model to establish a concise strategy to project management process for the ERP implementation (Saade & Nijher, 2016).

**Table 1.** Literature Review Papers on CSFs

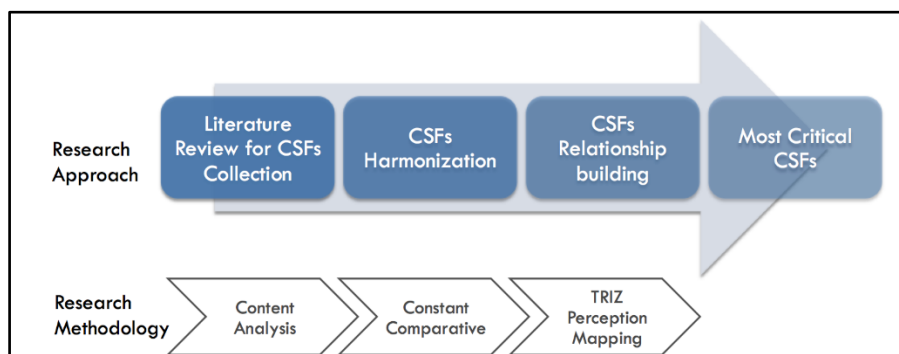
Authors	R. Saade, H. Nijher	J.Ram, D.Corkindale	M.Ahmad. R.Pinedo	S.Dezdar, A.Sulaiman	E.Ngai, C.Law, F.Wat	S.Finney, M.Corbett
Year Published	2016	2014	2013	2009	2008	2007
CSFs Articles Year-Range	1999-2013	1998-2010	1999-2013	1999-2008	2006-2007	1983-2000
Number of CSFs Related Articles	341	236	50	95	48	45
Number of CSFs Identified	64	46	33	54	80	55
Number of Distinct CSFs	22	15	10	17	18	26

The authors of this paper hardly discovered the most critical CSFs indicated specifically from all literatures mentioned above. However, the articles had provided a good source of “raw CSFs” because the respective articles compiled the CSFs from the search on thousands of articles from journals, thesis and other form of publications. With regards to all the literature findings, the final results presented were merely CSFs taxonomy or categorization as distinct CSFs. In this research, the authors of this paper did not use the distinct CSFs but instead using the “raw” identified CSFs for analysis.



## RESEARCH METHODOLOGY

The research approach and research methodology of this research is illustrated in Figure 1 below.



**Figure 1.** Research Approach and Research Methodology

### CSFs collection and harmonization

This study was indented to find out the most critical CSFs for the ERP implementation. Given that the purpose of this study was to achieve a depth of understanding of the various CSFs already identified by other researchers, “content analysis” was a proper analysis approach. Patton (1990) declared that content analysis was the process of “identifying, coding and categorizing” the primary pattern in the data; and Cavana et al. (2001) suggested the similar for conducting “content analysis” using the “constant comparative method” (Dezdar & Sulaiman, 2009). Content analysis was employed in this research where researchers performed the theme coding manually and highlighted each theme as CSF as it occurred in the raw data being perused. In this research, the 332 identified CSFs were used instead of the distinct CSFs because those identified CSFs were considered “raw” CSFs.

The following steps were used to analyse the CSFs in the published articles. The first step of content analysis was “data collection” that needs to determine which CSFs words or phrases will be selected as themes and the search was within the compiled related CSFs from the literatures. The second step was “open coding” where the raw data was coded to theme that allows first attempt of compressing the mass of data into categories. This stage of the coding process involved determining whether to code for a specific pre-determined set of CSFs or to permit for a more interactive coding approach. In this part of the analysis, emphasis was placed on the words or phrase themselves and not on the meaning of the words. The third step was “axial coding” that needed to work around the central axis of the CSFs until where it was necessary to decide whether CSFs were to be coded exactly as they appeared, or if they could be recorded in some changed to achieve the level of generalization. The forth step was “selective coding” that needed to look for facts that illustrated or justified CSFs and then made a comparison and identifies contrasts between sub CSFs and CSFs to allow the researchers to investigate the relationships across categories. The end of this process would produce a list of harmonized CSFs to be used in next step to search for the most critical CSFs using TRIZ perception mapping.

## TRIZ Perception Mapping (PMap)

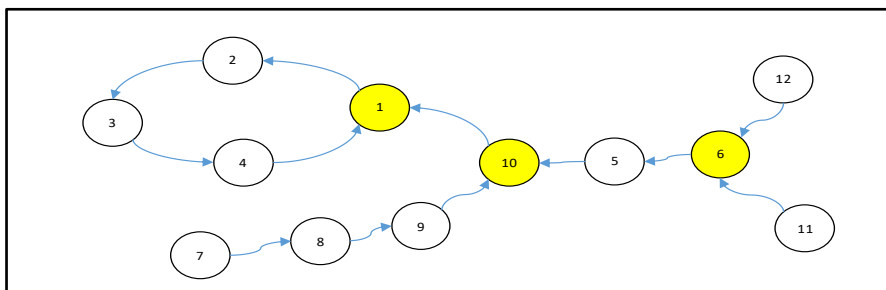
The roots of the perception Mapping tool derives from the work on ‘flow-scaping’ done by Edward de Bono (Bono, 1995). The tool is a simple yet powerful way of making sense of the relationships between the different attributes of problem (Mann, 2004). Perception Mapping technique offers a systematic approach to manage the emotional and perceptual complexities present in business problem situations involving people. The tool uses the way human brain works in order to develop the lists of our perceptions about the situation under evaluation, and then progresses to examine how each of these connects to the others. (Nagendra & Prakasan, 2007)

The first step to do in TRIZ perception mapping was to identify and listing down and the identified CSFs as possible most critical CSFs from the content analysis. The most possible critical CSFs were then tabulated and indexed with a running number as illustrated in Table 2. The next process was building the relation of the potential critical CSFs by pairing them. By starting from the first CSF in the list, ask the question “what this will lead to?” and looked for the most possible of another potential CSF, then indicated the “lead to” CSF number at the end column in the table. The process continued with the second CSF and decided what it will lead to another potential CSF. The “lead to” CSF could be any other CSFs or same as the previous step. The process continued until the last potential CSF in the table list. All potential critical CSFs must have a “lead to” pair in the “lead-to” table, as illustrated in Figure 2.

**Table 2.** Perception Mapping Lead-To Table

CSF#	CSF Description	LEAD TO
1	CSF#1	2
2	CSF#2	3
3	CSF#3	4
4	CSF#4	1
5	CSF#5	10
6	CSF#6	5
7	CSF#7	8
8	CSF#8	9
9	CSF#9	10
10	CSF#10	1
11	CSF#11	6
12	CSF#12	6

Since it was difficult to visualize the linkages between each of the most possible critical CSFs, next step was to perform a graphical perception mapping by drawing each CSF with an arrow sign for each “lead to” pairs. The resulting perception map showed a system map of one attribute-pair leads to another, leads to another and so on until one led back to the initial pair. The process was continued until the last CSF was drawn in the perception map. Figure 3 illustrates the graphical view of the CSFs analysis with perception mapping for Table 2.



**Figure 2.** Graphical Perception Mapping of CSFs

There were 2 significant points to be observed in the perception map. Firstly, the system in map might contain at least one closed loop and all these closed-loops were significant (item #1, #2, #3, #4 in Figure 2). Secondly, there were possibilities that several root cause pairs of the “lead-to” could be pointing to a same connection point in the perception map, these were called the “**collector points**”, as indicated as item #1, #6, #10 in Figure 2. Those CSFs collector points would be the most possible critical CSFs that we were searching for. Collector points could be the potential most critical CSFs as the other CSFs were merely perception and ultimately lead to the most critical CSFs (Yeoh, 2014).

## DATA COLLECTION, ANALYSIS AND RESULTS

### Data collection

The data collection was based on the journal articles that focused on the CSFs compilation through literature reviews. The research papers that searched through were the research articles published from 2005 to 2016. After the detail reviews, the chosen articles were publication from S.Finney & M.Corbett (2007) (Finney & Corbett, 2007), E.Ngai, and C.Law & Wat (2008) (Ngai et al., 2008b), S.Dezdar & A.Sulaiman (2009) (Dezdar & Sulaiman, 2009), M.Ahmad & R.Pinedo (2013) (Ahmad & Pinedo Cuenca, 2013), J.Ram et al. (2013) (Ram et al., 2013), and R. Saade & H. Nijher (2016) (Saade & Nijher, 2016). Total of 332 CSFs were identified in the first stage of data collection.

### Data analysis

With the collected raw “CSFs”, constant comparison analysis was performed. After details analysis and harmonization, a total of 90 CSFs were harmonized as listed in Table 3.

**Table 3.** Perception Mapping Table of CSFs

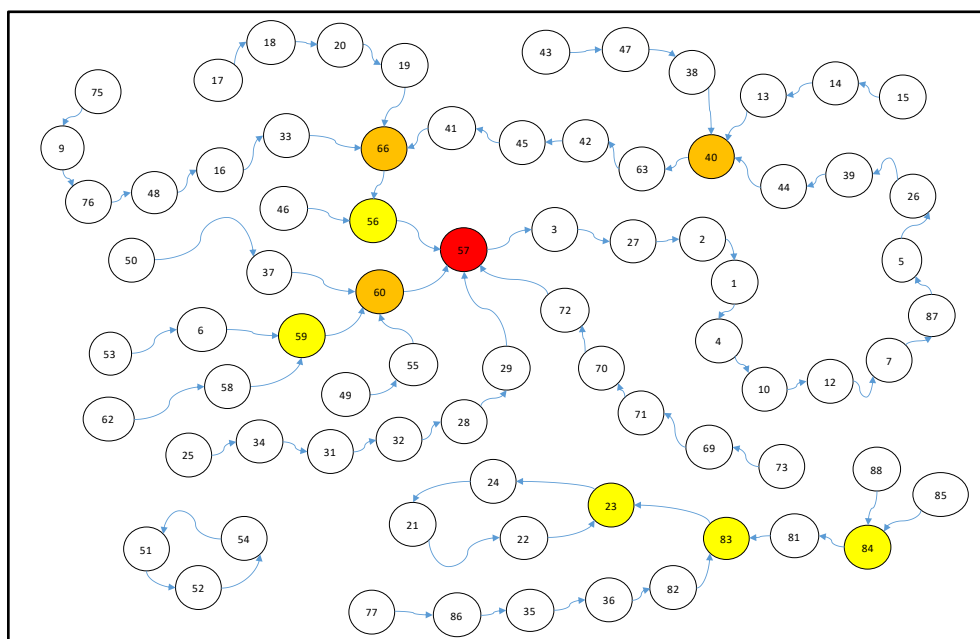
NO	Critical Success Factors (CSFs)	Lead To	NO	Critical Success Factors (CSFs)	Lead To
1	Appropriate business and IT legacy systems	4	46	Managing consultants	56
2	Business plan/vision/goals/justification	1	47	Staff retention	38
3	Justify the project based upon factors of cost and economic scale	27	48	Full-time team members	16
4	Business process/rules are well understood	10	49	Employee/personnel relations	55
5	Business process reengineering	26	50	Sparing use of consultants	37
6	Minimal customization	59	51	ERP vendor	52

NO	Critical Success Factors (CSFs)	Lead To	NO	Critical Success Factors (CSFs)	Lead To
7	Change management culture and programme	87	52	Vendor-customer partnerships	54
8	Change management	5	53	Use of vendors' customization tools	6
9	User involvement	76	54	Vendor support	51
10	Organisational culture and political structures	12	55	Kept suppliers/customers informed	60
11	Commitment to change	8	56	Monitoring and evaluation of performance	57
12	Understanding corporate culture	7	57	Benchmarked implementation progress against clear milestones or performance metrics	3
13	Re-train IT workforce in new skills	40	58	Focused performance measures	59
14	Training and education	13	59	Client acceptance	60
15	Developed clear education and training strategy	14	60	Monitoring and feedback	57
16	Education on new business process	33	61	Organisational characteristics	62
17	Communication	18	62	Had technology/infrastructure in place	58
18	Inter-departmental communication	20	63	Organisational experience of IT or organisational change projects of a similar scale	42
19	Communicated regularly with all who would be affected	66	64	Company-wide commitment	61
20	Open and honest communication	19	65	Implementation of ERP was not due to competitive pressure	64
21	Data management	22	66	Project champion	56
22	Data analysis and conversion	23	67	Project management	68
23	Data accuracy	24	68	Clear and defined project plan (goals, objectives, strategy, scope, schedule) Smaller scope	73
24	Data quality control	21	69	Avoid scope creep	71
25	ERP strategy and implementation methodology	34	70	Implementation costs	72
26	Regard as a technological, business, and organisational project	39	71	Realistic deadlines for implementation are set	70
27	Alignment between business strategy and IT strategy	2	72	Realistic expectations with regard to ROI and reduced IT/IS costs exist	57
28	Begin process changes first	29	73	Management of expectations	69
29	Strategic alignment of exercise	57	74	Total-quality management	75
30	ERP is treated as a programme not a project	25	75	Interdepartmental cooperation	9
31	Phased vs. Big Bang	32	76	Dedicated resources	48
32	Use accelerated implementation strategy	28	77	"To-be concept" as project guideline	86
33	Deep understanding of the key issues relating to ERP implementations	66	78	Knowledge management	15
34	Select a good methodology	31	79	Managing conflicts in ERP projects	66
35	Careful selection of appropriate package	36	80	Clear and simple project organisation	39
36	Suitability of software and hardware	82	81	Software development, testing, and troubleshooting	83
37	Decision-making process/style	60	82	Defining the choices of architecture	83

NO	Critical Success Factors (CSFs)	Lead To	NO	Critical Success Factors (CSFs)	Lead To
38	ERP teamwork and composition (Personnel)	40	83	System Integration	23
39	Steering committee	44	84	Software configuration	81
40	Project team competence	63	85	Troubleshooting	84
41	Empowered decision makers	66	86	Functional requirements are clearly defined before selecting an ERP product Perceived complexity	35
42	Selecting the right employees	45	87	Top management support	5
43	Employee morale (incentives)	47	88	Fit between ERP and business/process	84
44	Business and technical knowledge of team members and consultants	40	89	National culture	90
45	Balanced or cross-functional implementation team	41	90	Country-related functional requirements	10

The next stage of data analysis was to perform perception mapping to find out the most critical CSFs. These activities were carried out together with 3 industry experts. The first expert was a solutions consultant (IExp#1) with over 20 years of experience in implementing enterprise solutions including ERP, Product Lifecycle Management (PLM), turnkey ICT software development and ICT system infrastructure. The second expert was a Project Manager (IExp#2) with 12 years of experience in engineering solution implementation in CAD/CAM, ERP and PLM implementation for the manufacturing companies. The third expert was an industry consultant (IExp#3) from a government agency that having 15 years of experience in providing solution advisory and consultancy in product and process innovation to the local manufacturing enterprises. He has experience in conducting training on Manufacturing Management Course at university and industry. These industry experts were fully involved in the processing of perception mapping and had provided unbiased opinions and expert views to make the “lead to” decision. When there was different opinion occurred, the team would discuss and brainstorm for the best lead-to CSF decisions. The outcome of this exercise provided full lead-to results as shown in Table 3.

The graphical perception mapping was then produced and as indicated in Figure 3 below.



**Figure 3.** Graphical Perception Mapping of CSFs

## Results

Referring to the graphical perception mapping in Figure 3, there are 3 closed-loops and 9 collector points are identified. The first closed-loop is the largest closed-loop, centring to CSF#57 (red colour) with 5 connecting joints, then CSF#60 and CSF#66 (brown colour) with 4 connecting joints, and CSF#56 (yellow colour) with connecting 3 joints. Nearby there is CSF#59 that leading to CSF#60.

The second closed-loop consists of CSF#21, CSF#22, CSF#23 and CSF#24; and connecting to CSF#83. CSF#83 and CSF#84 (yellow colour) are collector points that come with 3 connecting joints respectively.

The third closed-loop is a small closed-loop consists of CSF#51, CSF#52 and CSF#54 that all linked together in a closed circle. There is no collector point found in this loop.

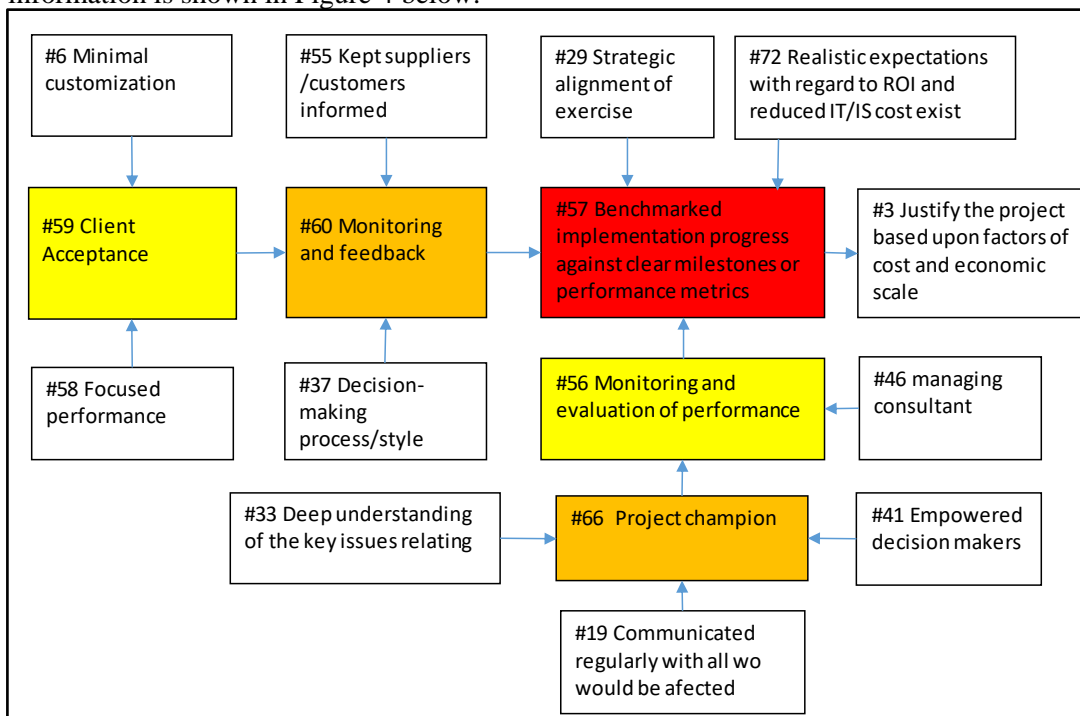
The ranking of the most critical CSFs shall be determined from the CSFs that come with most connection points found in the graphical perception mapping. Hence, the most critical CSFs discovered in this research are:-

- (i) CSF#57 Benchmarked implementation progress against clear milestones or performance metrics
- (ii) CSF#66 Project Champion
- (iii) CSF#40 Project Team Competence
- (iv) CSF#56 Monitoring and evaluation of performance
- (v) CSF#60 Monitoring and feedback
- (vi) CSF#59 Client acceptance
- (vii) CSF#84 Software configuration,

- (viii) CSF#83 System integration
- (ix) CSF#23 Data accuracy

## DISCUSSION

For first closed-loop, the graphical perception mapping that comes with full descriptive information is shown in Figure 4 below:



**Figure 4.** Perception Mapping of First Closed-loop

Referring to Figure 4, CSF#57 is the most critical CSF because it is the central for the other CSFs that leading to. Yeoh (2014) has indicated the central of the root cause will have the most connecting joints because that's the cause of the problems are leading to (Yeoh, 2014). With respect to that, IExp#1 and IExp#2 supported that fact that it is very crucial to always benchmark the implementation progress against the clear milestone and performance metrics, because that shall be the measuring point whether the project is successfully completed and achieving the desired performance and productivity. This is aligned to Boynton & Zmud (1986) indicated that the critical things that must go well and must be given special and continual attention from a manager or an organisation to benchmark against high performance to ensure implementation success (Boynton & Zmud, 1986). It is critical to pay high attention to benchmarking to the performance metric and milestone as that's the measure to avoid the project cost overrun and ensure it can bring high return of the investment (ROI) with the desired results.

CSF#66 is critical because IExp#1, IExp#2 and IExp#3 fully supported the fact to appoint a project champion in position to carry out the ERP project implementation is very critical. Project champion should have deep understanding on the key issues related to the project requirements. Project champion should be empowered to make-decision (CSF#41) and having

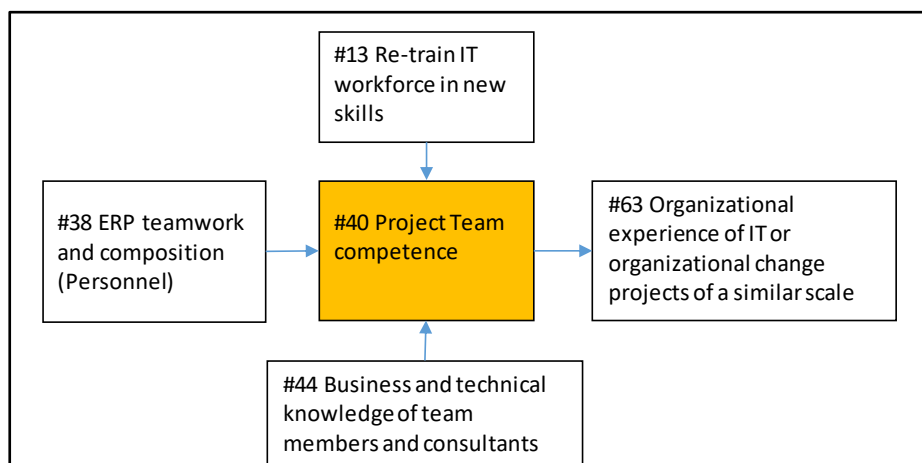
ability to communicate with all level of people in the project (CSF#19). The finding of criticality to have a Project Champion is align to the findings by (Yeh & Xu (2013) that indicated choosing the right full time project manager, training of personnel, and the presence of a champion could be related to project success (Yeh & Xu, 2013)

CSF#56 shows criticality in monitoring and evaluation the performance of the project implementation is crucial and it shall be the responsibility of the project champion (CSF#66) and consultant (CSF#46). This is matching to the research findings by Trkman (2010) that technology-task should monitor to fit between IT and business processes for the standardization of processes, information, automation, training and empowerment of employees (Trkman, 2010).

CSF#60 indicates another aspect of monitoring and feedback on the system users and suppliers. Continue monitoring and feedback from all related party shall facilitate decision-making process and to determine the better action to be adopted for improvement. With respect to this, the fact supported by Tsai et al. (2011) who had conducted investigation of the impacts of internal/external facilitators on the project success of ERP. The results reveal a significant causal relationship by monitoring system providers, implementation consultants and project team and users (Tsai et al., 2011).

CSF#59 shows the criticality to have the client acceptance on the system. Both IExp#1 and IExp#2 pointed out it is always a challenge to get user acceptance and sign-off the system. With regards to this, user must “buy-in” and accepting the fact that the system has helped them to increase their productivity. Rajan & Baral (2015) claimed that in order to achieve this there are many factors including the computer self-efficacy, getting organisational support, giving them training will have a positive influence on ERP usage which in turn has significant influence on panoptic empowerment and individual performance (Rajan & Baral, 2015).

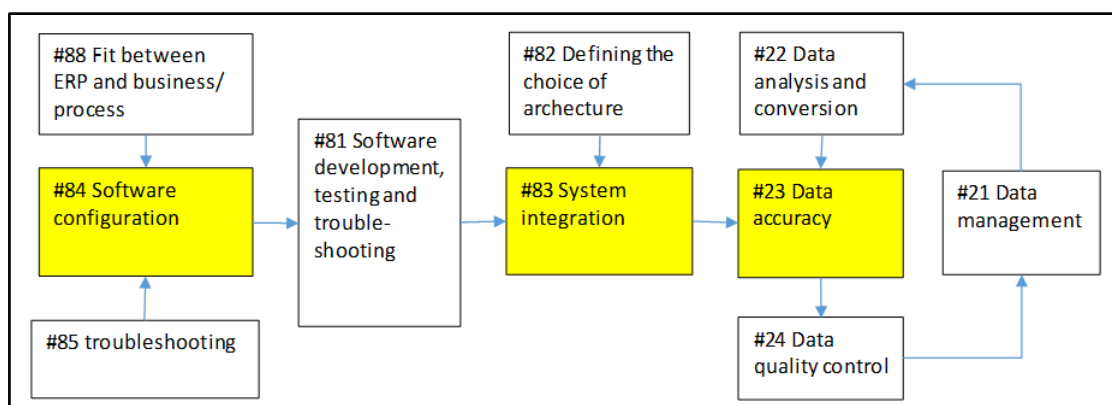
This group of CSF#57, CSF#66, CSF#56, CSF#60, CSF#50 are very much related to the organisation internal issues that related to people, monitoring project and implementation methodology.



**Figure 5.** Perception Mapping on Project Team Competence



In Figure 5, it shows that CSF#40 (project team competence) resides in the first big closed-loop. CSF#40 is the collector points from CSF#38 (ERP teamwork and composition), CSF#13 (re-train IT workforce in new skills) and CSF#44 (business and technical knowledge of team members and consultant). It has indicated that the project team competence can lead to organisation change through the experience gained. Empirical study from Kerimoglu et al (2008) did reveal that organisational adoption can only be accomplished if the satisfaction with the ERP system was achieved by competency and flexibility of the technology along with the special efforts of project management during project implementation (Kerimoglu, Basoglu, & Daim, 2008). With regards to this, both IExp#1 and IExp#2 shared their past experiences that it is critical to form a competent project team and impart the team with the relevant industry knowledge and further trained them with the software usage skills. If this is carried out properly, it would be able to help to execute the project implementation successfully.



**Figure 6.** Perception Mapping on Second Closed-loop

Figure 6 shows another separate group of CSFs showing 3 collector points on CSF#84, CSF#83 and CSF#23. It is interesting that the perception mapping on CSF#83 lead-to a closed-loop of CSF#23, CSF#24, CSF#21 and CSF#22. This group of CSFs is mostly ERP technology functions that related to the capability of the ERP system, the flexibility of the system and the integration need to link the ERP system to other system. Similar results were presented by Kerimoglu (2008) that all of these factors are determined at the very beginning of the project when the ERP product is being selected by the organisation (Kerimoglu et al., 2008). CSF#84 shows the need to tune the system to match to the business processes requirement for the organisation. CSF#83 indicates the need to integrate the system with the other related enterprise solution or system. Either the system is having configuration or integration, CSF#23 reveals it is critical to ensure the Data Accuracy because the usefulness of the system rely on the ability to generate the accurate reports to the management for decision making. IExp#3 indicated organisations always try to find the most suitable ERP packages in the market through details requirement study, and system demonstration were just to ensure there is a perfect match between the ERP system and their specific business industry and requirements. ERP system selection is difficult especially the organisation business operation and process is very complex and dynamic (Aslan, Stevenson, & Hendry, 2015).

A PMap loop can be considered a vicious cycle especially when one root cause worsen, it leads to another root cause to worsen too, which the results in a spiral down to chaos (Yeoh,

2014). Therefore, the CSF#23 Data accuracy loop may cause chaotic if the ERP system is not able to provide good quality of data and the proper data management.

Finally, there is a small closed-loop of CSF#51 (ERP vendor), CSF#52 (Vendor-customer partnerships) and CSF#54 (Vendor support) reside independently outside the two main circles. Even though there is no collector point in this closed-loop, whole closed-loop may consider as a critical factor too. This could be explained the ERP vendor could be outside the organisation but they are the external entity that could affect the ERP implementation success. If an organisation selects an inadequate ERP to fit their needs, the project will most likely destined to fail. Research and practice have provided several cases of ERP project failures because of a faulty selection process (Haddara, 2014). Therefore, the supplier selection criteria shall include their market position, training given by the supplier and the technical support and experience because the supplier service quality is critical to the project success (Tsai, Lee, Shen, & Lin, 2012).

## CONCLUSIONS

The initial research in this study has given a good overview about the CSFs, CSFs taxonomy, CSFs categories and its classifications. This research has achieved its objective that identified 9 most critical CSFs from the 90 shortlisted CSFs candidates filtered through the literature reviews. The first phase of the research compiled the CSFs through literature review on the articles that had searched hundreds of researches articles on CSFs from research publications. This has given 332 raw CSFs and had provided sufficient sampling of data for analysis. The subsequent harmonization using constant comparative methodology had filtered down to 90 CSFs for further investigation. The second phase of the research using TRIZ Perception mapping had allowed the study on the relationship of the CSFs that could further helping us to narrow down the search for the most critical CSFs.

Based on the outcome of the study, the 9 most critical CSFs can be further consolidated to 5 most critical CSFs as followings. This shall answer the research question of this research.

- #1 **Benchmark implementation progress on clear milestone and performance metrics** – A close monitoring of performance review and evaluation on ERP systems implementation can in turn lead to the achievement of all the business desired goal and objectives.
- #2 **Project Champion** – appoint a dedicated project champion to lead the ERP implementation. Project champion should have deep understanding of operation of the organisation and the key issues related to the project requirements. Project champion shall be empowered to make-decision and have ability to communicate with all level of people. Project champion shall conduct regular evaluation and monitoring the performance.
- #3 **Competence project team** – setup of competence project team can lead to the success of ERP implementation that can be resulted organisation change. Hence the project team shall consist of a pool of competent members that has been given sufficient training and knowledge transfer to implement the ERP software.
- #4 **User Acceptance** – End user must “buy-in” to accepting the system and “hands-on” to use the system to improve their productivity. Project team shall continue to monitor their satisfaction level and give positive influence on the usage to the others.

**#5 ERP System Capability** – try to get a right and perfect match for the most suitable ERP system. The ERP system shall be easy to learn up, easy to configure, tune or customize to bridge-up the business requirement gap, and to generate accurate reports for decision-making. Select a vendor with track records to provide a capable system to suite the organisation is very crucial.

The limitations of this study comprise the difficulty to conduct generalizations on the CSFs compiled from the literature articles and the process of making decision on the CSF lead-to in perception mapping. Therefore, the industry experts were invited to participate in the data analysis in order to get some expert views in the decision making process.

The novelty of this research is using TRIZ perception mapping is new in CSFs study and this research shows the methodology could help to narrowing down the search to improve the quality of the search output for CSFs in ERP implementation. The approach can be used for the researches that come with similar requirements in future.

## REFERENCES

- Ahmad, M. M., & Pinedo Cuenca, R. (2013). Critical success factors for ERP implementation in SMEs. *Robotics and Computer-Integrated Manufacturing*, 29(3), 104–111.
- Al-Mashari, M., Al-Mudimigh, A., & Zairi, M. (2003). Enterprise resource planning: A taxonomy of critical factors. *European Journal of Operational Research*, 146(2), 352–364.
- Amid, A., Moalagh, M., & Zare Ravasan, A. (2012). Identification and classification of ERP critical failure factors in Iranian industries. *Information Systems*, 37(3), 227–237.
- Aslan, B., Stevenson, M., & Hendry, L. C. (2015). The applicability and impact of Enterprise Resource Planning (ERP) systems: Results from a mixed method study on Make-To-Order (MTO) companies. *Computers in Industry*, 70(0), 127–143.
- Bansal, V., & Agarwal, A. (2015). Enterprise resource planning: identifying relationships among critical success factors. *Business Process Management Journal*, 21(6), 1337–1352.
- Bono, E. de. (1995). Serious creativity. *The Journal for Quality and Participation*, 18(5), 12. Retrieved from [http://teaching.ust.hk/~mark329/Papers/serious creativity.pdf](http://teaching.ust.hk/~mark329/Papers/serious%20creativity.pdf)
- Boynton, A. C., & Zmud, R. W. (1986). An Assessment of Critical Success Factors. *Sloan Management Review*, 25(4), 17-.
- Dezdar, S., & Sulaiman, A. (2009). Successful enterprise resource planning implementation: Taxonomy of critical factors. *Industrial Management & Data Systems*, 109(8), 1037–1052.
- Elragal, A., & Haddara, M. (2013). The Impact of ERP Partnership Formation Regulations on the Failure of ERP Implementations. *Procedia Technology*, 9(0), 527–535.
- Finney, S., & Corbett, M. (2007). ERP implementation: a compilation and analysis of critical success factors. *Business Process Management Journal*, 13(3), 329–347.
- Forster, N. S., & Rockart, J. F. (1989). Critical Success Factors: An annotated bibliography. *MIT Sloan Review*, (191), 3041–3089.

- Haddara, M. (2014). ERP Selection: The SMART Way. *Procedia Technology*, 16(0), 394–403.
- Ijaz, A., Lodhi, R. N., & Irfan, S. M. (2014). A Qualitative Study of the Critical Success Factors of ERP System - A Case Study Approach. In *Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management Bali, Indonesia, January 7 – 9, 2014 A* (pp. 2556–2566).
- Kerimoglu, O., Basoglu, N., & Daim, T. (2008). Organisational adoption of information technologies: Case of enterprise resource planning systems. *The Journal of High Technology Management Research*, 19(1), 21–35.
- Lech, P. (2016). Causes and remedies for the dominant risk factors in Enterprise System implementation projects: the consultants' perspective. *SpringerPlus*, 5(1), 1–12.
- Mann, D. (2004). Common Ground - Synergies Between TRIZ, Perception Mapping and Kansei Engineering, 44(1275). Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.559.526&rep=rep1&type=pdf>
- Nagendra, B. S., & Prakasan, K. (2007). Balancing customer satisfaction and strategic organisational development activities - An application of TRIZ techniques. *TRIZCON 2007*. Retrieved from <http://www.aitriz.org/documents/TRIZCON/Proceedings/Nagendra-Kappoth-Balancing-customer-satisfaction-and-strategic-organisational-development-activities.pdf>
- Ngai, E. W. T., Law, C. C. H., & Wat, F. K. T. (2008a). Examining the critical success factors in the adoption of enterprise resource planning. *Computers in Industry*, 59(6), 548–564.
- Ngai, E. W. T., Law, C. C. H., & Wat, F. K. T. (2008b). Examining the critical success factors in the adoption of enterprise resource planning. *Computers in Industry*, 59(6), 548–564.
- Nwankpa, J. K. (2015). ERP system usage and benefit: A model of antecedents and outcomes. *Computers in Human Behavior*, 45(0), 335–344.
- Poon, P.-L., & Yu, Y. T. (2010). Investigating ERP systems procurement practice: Hong Kong and Australian experiences. *Information and Software Technology*, 52(10), 1011–1022.
- Rajan, C. A., & Baral, R. (2015). Adoption of ERP system: An empirical study of factors influencing the usage of ERP and its impact on end user. *IIMB Management Review*, 27(2), 105–117.
- Ram, J., & Corkindale, D. (2014). How “critical” are the critical success factors (CSFs)? *Business Process Management Journal*, 20(1), 151–174.
- Ram, J., Corkindale, D., & Wu, M.-L. (2013). Implementation critical success factors (CSFs) for ERP: Do they contribute to implementation success and post-implementation performance? *International Journal of Production Economics*, 144(1), 157–174.
- Ram, J., Corkindale, D., & Wu, M.-L. (2014). ERP adoption and the value creation: Examining the contributions of antecedents. *Journal of Engineering and Technology Management*, 33(0), 113–133.
- Saade, R. G., & Nijher, H. (2016). Critical success factors in enterprise resource planning systems - A review of case studies. *Journal of Enterprise Information Management*, 1, 72–96.

- Trkman, P. (2010). The critical success factors of business process management. *International Journal of Information Management*, 30(2), 125–134.
- Tsai, W.-H., Lee, P.-L., Shen, Y.-S., & Lin, H.-L. (2012). A comprehensive study of the relationship between enterprise resource planning selection criteria and enterprise resource planning system success. *Information & Management*, 49(1), 36–46.
- Tsai, W.-H., Shaw, M. J., Fan, Y.-W., Liu, J.-Y., Lee, K.-C., & Chen, H.-C. (2011). An empirical investigation of the impacts of internal/external facilitators on the project success of ERP: A structural equation model. *Decision Support Systems*, 50(2), 480–490.
- Wei, J., & Ma, Y.-S. (2014). Design of a feature-based order acceptance and scheduling module in an ERP system. *Computers in Industry*, 65(1), 64–78.
- Yeh, C.-H., & Xu, Y. (2013). Managing critical success strategies for an enterprise resource planning project. *European Journal of Operational Research*, 230(3), 604–614.
- Yeoh, T. S. (2014). Perception Mapping. In *Systematic Innovation in Business & Management* (p. 38). First Fruits Sdn. Bhd.

# PROBLEM SOLVING PROCESS IN MALAYSIA AUTOMOTIVE MANUFACTURING

**Mohd Yusri Mohd Yusof , Hiroshi Nakanishi**

*Department of Management of Technology, Malaysia-Japan International Institute of Technology,  
Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, 54100 Kuala Lumpur, Malaysia*

## **Abstract**

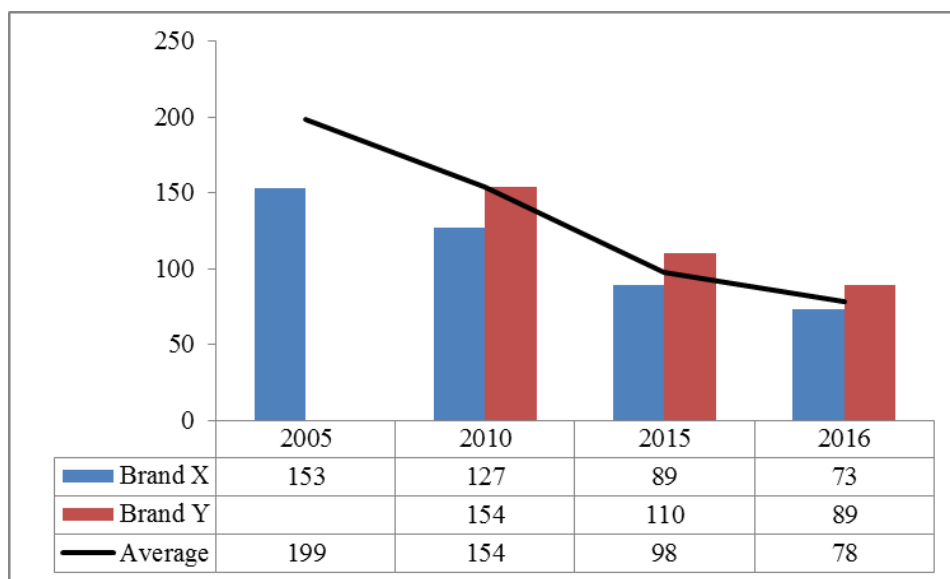
Purpose of this research is to investigate the problem-solving process between selected automotive first-tier suppliers and its carmaker. The investigation is to determine the differentiation between problem solving process managed by automotive manufacturer and the A3 Methodology problem solving process practiced by Japanese manufacturing practitioner. The research areas are focus on the requirements of control of non-conformance product (hereafter known as defect) as stated in ISO 9001 Quality Management System (hereafter known as QMS) requirements and problem-solving approach between first-tier suppliers and its carmaker, and the A3 Methodology which contains six steps of problem solving process. There were ten tier-1 suppliers and one Malaysian carmaker located in Rawang are selected in this investigation. The data were collected from the carmaker's defect claim reports and tier-1 suppliers' corrective action reports. The analysis was conducted to define the process of managing defect in carmaker organisation and determine the process of problem solving in tier-1 supplier organisation based on the defect claim reports received from carmaker. The research found (i) the carmaker and its tier-1 suppliers were managing the defect according to ISO 9001 QMS requirement, (ii) the problem-solving process between automotive manufacturers and A3 Methodology have differences and similarities. The other findings are discussed as an opportunity for improvement among industrial practitioners. As a conclusion, the implementation problem solving process have different approach between Malaysian manufacturer and Japanese practitioners.

**Keyword** - *Problem solving process, A3 Methodology, Root Cause Analysis (RCA), Containment Action, Corrective action*

## **QUALITY OF MALAYSIAN CARMAKER**

The revolution in Malaysia automotive industry has changed the consumer perception on the quality of the product made by carmakers. The competition among carmakers gives more options to consumer either to retain the car brand or change to the other car brand. Thus, the carmaker should take immediate action if consumer facing unpleasant experience especially repetitive car defects to prevent it from scattering around mainly through social media. For the carmaker which has less defect or problem experience faced by consumer would have advantage to convince the consumer to remain with the car brand. There is study made by J.D Power Asia Pacific on the measures of the problems experienced by new-car owners during the first two to six months of ownership. The study is called as Initial Quality Study (in following sections will be written as IQS).

The IQS by J.D. Power Asia Pacific on car brands in Malaysia since year 2002 is to examine more than 200 problem symptoms covering eight categories: car exterior; driving experience; features/ controls/ displays; audio/ entertainment/ navigation; seats; HVAC; car interior; and engine/ transmission. All problems are summarized as the number of problems per 100 vehicles (PP100). Lower PP100 scores indicate a lower rate of problem incidence and, therefore, higher initial quality. The IQS result between two Malaysian car brands from year 2005 and 2016 is shown in Figure 1.



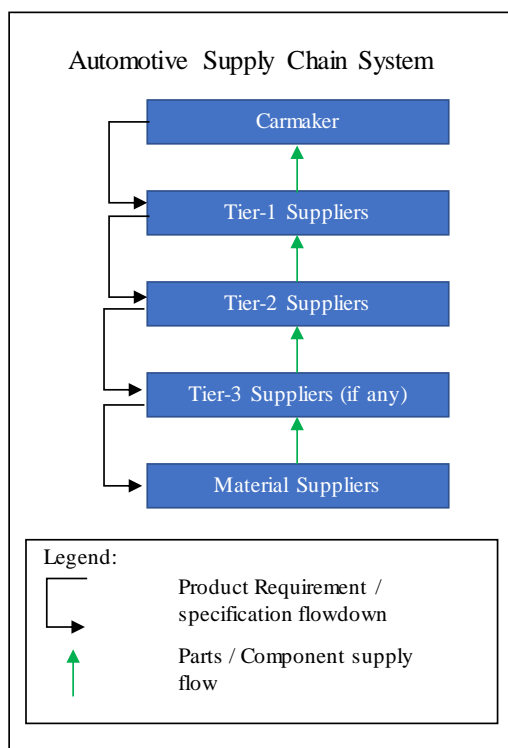
(Source: www.jdpower.com)

**Figure 1.** IQS result of two Malaysian car brands from 2005 to 2016

From the Figure 1 above, Malaysian carmaker Brand X shows the level of its quality is below than the average IQS score in year 2005. It means the quality of Brand X is better than other car brand in the market. While in year 2010, Brand Y has shortlisted together with Brand X which both brands show good quality compared to the average IQS score. In 2015 and 2016, Brand X and Brand Y shows better score compared to the average IQS score and the average IQS score is getting smaller compared to 2005. It shows the level of Malaysian car quality is improving even though there were some defects or problem occurred after consumer purchased the car. How the Malaysian carmaker Brand X improve the level of its quality in line with the average score of IQS?

Based on this phenomenon, the formal research to investigate the factors that make Brand X problem solving process succeed is essential for industrial practitioners or other scholars even though the story have been discussed among Malaysia since last ten years ago. Generally, the defects found are coming from the carmaker or its suppliers manufacturing process. In following section, the automotive manufacturing process and its defects is explained.

## Automotive Manufacturing Process



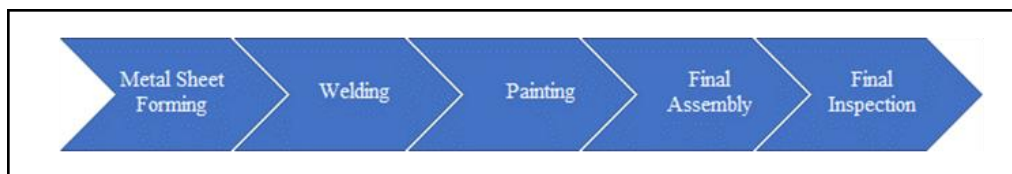
Source: This research

**Figure 2.** Automotive Supply Chain System

The automotive manufacturing process consists of the supply chain system and the production system in carmaker organisation. The automotive supply chain system comprises of carmaker, suppliers and material provider. The system is designed to ensure the carmaker requirements and specification are flowing down to all suppliers and material providers and control the parts supply to carmaker from suppliers. Figure 2 shows the generic automotive supply chain system. In this automotive supply chain system, all suppliers and material providers are bonded with the contract provided by carmaker. The purpose of the supply chain contract is to ensure the suppliers deliver the purchased parts or component according to carmaker requirements and plan.

According to ISO 9001 requirements, any organisation or companies should establish and implement the inspection or other activities necessary for ensuring that purchased parts meets specified purchase requirements. In this case, carmaker and its supplier should have a process to assure the quality of parts fit to use for car production. In the following sub-section, the process of car production is explained.





(Source: This research)

**Figure 3.** Car production system

Figure 3 above shows the car production system obtained from carmaker Brand X in last factory visit. The car production in carmaker begin with metal sheet forming and followed by welding process to build a car body. The quality of car body is determined by the accuracy of assembly process and appearance of the metal sheet after forming process. The process treatment and painting of car body is the subsequent of automotive production process in carmaker facilities. The paint process parameter, colour matching, paint peel and other surface control items are the quality requirements need to be conform to the product specification. There are other important criteria in treatment and painting process, it is called sealant application. The purpose of sealant application is to conform the Noise, Vibration and Hazardous (in following sections will be written as NVH) level meets the product requirements. The installation process of interior, chassis, harness and engine management system parts are the last process of car production prior final inspection by quality inspectors.

The discrepancy of product or process from the specification or requirements can create defects on the product and cause production stoppage. When there are high percentage of defects occurred in manufacturing or production processes, managing defect is crucial to ensure the defect would not disseminate to the following processes.

## Product Defect in Manufacturing Process

**Table 1.** Type of Manufacturing Process Defects

Manufacturing Process	Type of Defective Product
Plastic Injection Moulding	White mark, Shrinkage, Short shot, Dimension error
Metal pressing	Burr, Seizure, Scratch, Wrinkle, Dimension error
Welding	Nut weld miss, pin hole, weld crack, detached
Assembly	Part missing, part malfunction, appearance defect, misprocess

(Source: A Textbook of Manufacturing Technology: Manufacturing Processes, R.K Rajput 2007)

In manufacturing processes, 'defect' is one of the threats that leads to poor business performance in term of quality, cost and delivery. According to R. Rajput (2007), the product defect depends on the type of manufacturing processes as shown in Table 1. Thus, the respective suppliers should take appropriate action to eliminate the defects and prevent recurrence. In many cases, defective products are caused by 'mistakes' and there are several types of mistake that frequently happened; (i) omitted process (ii) processing mistake (iii) mistake in setting up workpiece, (iv) missing part (v) wrong part (vi) processing the wrong

workpiece (vii) mis-operation (viii) adjustment mistake (ix) equipment not set up properly, and (x) tools and jigs improperly prepared (C. M. Hinckley 2003).

In the event of defect out flow from supplier to carmaker or from carmaker to consumer, the investigation of the root cause of the problem and implementation of corrective action is required. According to ISO 9001 Quality Management System Requirements – Section 8.3 Control of non-conformance product (includes defective product), the organisation shall ensure that product which does not conform to product requirements is identified and controlled to prevent its unintended use or delivery. The elaboration of ISO 9001 Quality Management System (in following sections will be written as QMS) Requirements – Section 8.3 Control of non-conformance product is written in following sub-section.

### **ISO 9001 Quality Management System Requirements – Section 8.3 Control of Non-Conformance Product**

ISO 9001 QMS Requirements for any organisation which produce the products or services. The Section 8.3 Control of non-conformance product (includes defective product) required a documented procedure to define the authorities and responsibilities to control and dealing with non-conforming product by one or more of the following ways:

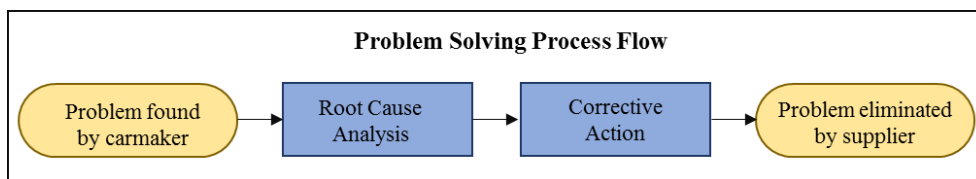
- i. by taking action to eliminate the defects;  
The company or organisation should identify the affected production batch and contain the defective product. If any escapement to carmaker or consumer, the company should inform in proper manner to fix the problem. The company is responsible to analyse the root cause of the defects and establish corrective action to eliminate the problem.
- ii. by authorizing its use, release or acceptance under concession by a relevant authority (includes carmaker);  
The company or organisation should establish a team (also known as Material Review Board, MRB Committee) to review and provide the disposition of the defects through concession to accept the condition of defect with carmaker or authorize body approval.
- iii. by acting to preclude its original intended use;  
If the defect can affect to the consumer safety or product functionality, the company should scrap it to avoid unintended use in future.

Based on the guidance given by ISO 9001, the supplier and carmaker should have an agreement to manage the defects or problem by establishing standard problem-solving process or procedure which includes all aspects. The following section is explained the elements of problem solving process from the perspective of Total Quality Management (TQM).

### **PROBLEM SOLVING PROCESS**

The result of poor control leads to delivery of defective product to customers. The establishment of manufacturing process control plan before the start of production is important to suppliers to define the appropriate process control method and re-action plan. Re-action plan means action to be taken if product or process cannot be controlled. In case

of defective product discovered, the suppliers need to re-act and use the right quality tools and techniques to eliminate the defect phenomenon (Saux, 2006).



Source: This research

**Figure 4.** Problem Solving Process Flow

With respect to problem solving process as shown in Figure 4, response to the defective product is most important for containment action. Containment action is defined as immediate action to address the phenomenon of defective product. Containment action taken must be dedicated, short-term, extraordinary and remain until effective corrective action implemented (Dan R, 2013). In the problem-solving process, exercising the right quality tools in determining the correct root cause is important to ensure right corrective action plan. (McQuater, Scurr, Dale, & Hillman, 1995). There are four (4) important lessons to achieve the objective of problem solving process (Rajput, 2007)(Mcquater, Dale, Wilcox, & Boaden, 1994) which are listed as

- i. Consistently using quality tools for quality improvement
- ii. Eliminate the defective products by analysing the data from quality tools
- iii. Deploy the corrective action plan from the result of analysis
- iv. All staff within the supply chain to exercise the quality tools.

Effective root cause analysis is discovering three main questions (Dan R, 2013), which are listed as

- a. Why did the defective product reach the customer?
- b. Why did the defect occur?
- c. Why did the system fail to detect?

In some cases, the root cause analysis requires creativity and innovative thinking to get the specific corrective action (Motschman & Moore, 1999). According to (Tari & Sabater, 2004), the most important factors in the successful implementation of the corrective action are full management support and commitment and giving the correct problem solving process training to the right staff at the right time. The other factor is quality tools that been used to solve the problem. Tari & Sabater (2004) found only 46.20% companies are implementing problem solving methodology in their organisation and very small percentage of companies implement basic quality tool in their quality management. Table 2 shows the percentage of companies implemented quality control techniques and tools in their organisation.

**Table 2.** Implementation of Quality tools and Problem-Solving Methodology among the suppliers

Quality Control Techniques and tools	
	Percentage of firms Implemented
Scatter diagram	16%
Cause and effect diagrams	21.70%
Pareto diagram	23.60%
Failure Mode Effective Analysis	25.40%
Histogram	35.80%
Quality Cost Analysis	45.20%
<b>Problem Solving methodology</b>	<b>46.20%</b>
Statistical Process Control	51.90%
Internal audits	100%

Source: Quality tools and techniques: Are they necessary for quality management?, J.J Tari (2004)

For those suppliers or carmaker which is obtained the ISO 9001 Quality Management System certification, the internal audit is one of mandatory techniques to verify the effectiveness of quality system in the organisation. While statistical process control implementation is more to monitor the moving data such as temperature, dimensional, and volume. It means, for the company have no requirement to monitor their process, statistical process control may not relevant. However, the companies that implemented quality measures as part of their KPI, the quality cost analysis is one of the tool to analyse the scrap and rework cost over the total production cost. For the problem-solving methodology, there were common techniques such as 8D Methodology, PDCA, Six Sigma and A3 Methodology. As mentioned early, this research has chosen A3 Methodology because from the researcher experience in industry, A3 report is most popular method used by Malaysian carmaker Brand X to record the quality corrective action reported by its suppliers. Therefore, in the following sub-section, the A3 Methodology as one of problem solving techniques is elaborated.

### The A3 Methodology Problem Solving

The A3 Methodology is a sequential thinking process adapted in Toyota to derive the Plan – Do – Check – Action (PDCA) cycle in process improvement (Sobek & Art, 2011). The thinking process started with Plan stage which the team members need to fully understand the background of the problem or project (Maruta, 2012). At this stage, team members have to define also the status of the problem and the objective of future goal. The team requires approval from management level to start with the next stage of Do and followed by stage of Check (Maruta, 2012). The corrective action plan of A3 Methodology encourages to implement lean activity such as 5S, Total Preventive Maintenance, Jidouka and Heijunka (Margerison, 1988). The verification of corrective action effectiveness is required to ensure the problem of defective products is successfully executed. Only if the corrective action plan is successfully implemented, new standard will change the current operating procedures. After the change is made, the stage of Act is completed to close the PDCA cycle as a loop (Maruta, 2012). Otherwise, the process begins from other new Plan stage (Sobek & Art, 2011).

Once the PDCA cycle is successfully completed, the practitioners will establish the A3 report for record purposes. The term "A3" derives from the paper size used for the report,

which is the metric equivalent to 11" x 17" (or B-sized) paper. The A3 report for problem solving consist of six steps (Mohd Saad, 2013) (Sobek & Art, 2011) as listed in Table 3.

**Table 3.** The A3 Methodology Problem Solving

Step	Title	Descriptions
Step 1	Theme and Background	The themes indicate the problem(s) being addressed to and they are descriptive.
Step 2	Current condition	The current problematic processes highlighted on the diagram and future goal.
Step 3	Root cause analysis	The analysis is using QC tools to define the root cause such as Why-Why Analysis.
Step 4	Countermeasure proposals / plan	The corrective action proposals to eliminate the root cause of defective product.
Step 5	Countermeasure execution plan	The schedule to execute the corrective action.
Step 6	Follow up plan	The verification of corrective action execution.

Source: Mohd Saad (2013) and Sobek & Art (2011)

As a conclusion, the analysis of PDCA in problem solving process is adequate for A3 Methodology application. The following section highlights the problem-solving process in Malaysian automotive manufacturing industry.

## RESEARCH METHODOLOGY AND DATA COLLECTION

The research on the application of problem solving process in automotive manufacturing industry was conducted in Malaysian carmaker Brand X as mentioned in previous section. The carmaker is joint venture between Malaysian company and Japanese automotive maker. The researcher has given opportunity to review the carmaker defect claim reports and its suppliers' corrective action reports for the period of January 2015 until March 2015. As a result, ten suppliers which are Malaysian owned companies operating more than 10 years in the plastic product within automotive supply chain have been chosen. Each of the suppliers may have one or more plastic product manufacturing process types which are injection moulding, blow moulding and thermoforming.

**Table 4.** Defective product summary of 10 suppliers

Company	No. of claims	Type of defect	Root cause
A	2	Short-shot	Start-up sample mix part
		Dented	Start-up sample mix part
B	3	Part broken	Customer false
		Surface Un-even (wavy)	Start-up sample mix part
		Sink mark	Start-up sample mix part
C	2	Short-shot	Start-up sample mix part
		Sink mark	Start-up sample mix part
D	1	Weld line	Irregular parameter setting
E	2	Sink mark	Start-up sample mix part
		Part broken	Irregular parameter setting
F	3	Warping	Irregular parameter setting
		Dimensional error	Mould worn out

Company	No. of claims	Type of defect	Root cause
		Excessive material	Mould worn out
<b>G</b>	2	Dimensional error	Irregular parameter setting
		Short shot	Start-up sample mix part
<b>H</b>	3	Short-shot	Start-up sample mix part
		Dimensional error	Start-up sample mix part
		Dented	Irregular parameter setting
<b>I</b>	2	Dimensional error	Mould worn out
		Part broken	Mould worn out
<b>J</b>	1	Excessive material	Irregular parameter setting
<b>Total</b>	<b>21</b>		

Source: This research

A total of 21 defect claim reports have been reviewed from all ten suppliers and the summary of defective claim reports as shown in Table 4 above. The suppliers' problem-solving process proceeded after received carmaker's defect claim reports.

### The carmaker Brand X defect claim report

The Malaysian carmaker Brand X defect claim reports is called Troubleshooting and Information Action Report divided to three sections (i) problem description, (ii) problem verification and investigation, (iii) supplier investigation if related. In problem description section, the detail of problem background is recorded such as type of problem, occurrence time and date, occurrence area, part number, part name, quantity and report running number. The detail structure of defect claim report is written in Appendix 1.

In section of problem verification and investigation, the quality investigator will record the problem phenomenon such as pictures or sketches of product, comparison between defects and good part, detail of defect parts information, production disruption information, and result of containment action in production and logistic.

In final section, if the problem is due to supplier escapement, the information or claim report will convey to supplier representative. The supplier engineer from carmaker will request the supplier to review defect occurrence and perform immediate containment action prior the meeting. The investigator also records the supplier process control method for defective product(s), suspected root cause(s) and follow up plan respectively. The suppliers are required to give feedback, by submitting Quality Problem Investigation Report (carmaker report template) to carmaker's investigator within the time given.

Once the QPIR submitted, the Brand X supplier engineer will verify the corrective action on site to verify the effectiveness of corrective action implementation. Depends on severity of the defect or problems, it can be series of follow-up action made by carmaker to confirm the problem is eliminated.

## **Suppliers' Quality Problem Investigation Report**

The carmaker supplier's Quality Problem Investigation Report (hereafter known as QPIR) as shown in Appendix 2 contains defective product description and supplier's name. The report is divided into nine sections which are (i) problem descriptions, (ii) returned part investigation, (iii) mechanism of failure, (iv) trial/simulation/re-occurrence tests (if applicable), (v) trial for detection (if applicable) (vi) causes of occurrence and outflow, (vii) corrective actions taken, (viii) suspected affected range, and (ix) conclusion. The suppliers' QPIR format is provided by Brand X carmaker.

Section 1 of the QPIR describe the defective product description. For examples product name, product number, car model, defect type, quantity of defective product and result of sorting activity. The supplier's findings between defective product and good product are presented at Section 2 and the supplier states the conclusion of the investigation. Section 3 of the QPIR, where suppliers are highlighted the effected manufacturing process of defective product. The supplier will focus on the highlighted process as source of possible root cause.

In the QPIR Section 4 and Section 5, the suppliers are encouraged to simulate the problem occurrence and detection. The purpose is to confirm the problem phenomenon. Section 6 of QPIR is showing the supplier's analysis of problem root cause and the quality tool why-why analysis has been used to determine the possible cause of defect and outflow. From the result of root cause analysis, the supplier table out the corrective action proposals and announce the due date to complete the corrective actions execution in Section 7. In this section, supplier will state the status and responsible staff of corrective action execution. The supplier presented the process standardization in this section after the corrective action taken is successful. Section 8 is for supplier to indicate the other process that effected to the corrective action.

Finally, the supplier will write the conclusion of the effectiveness of problem root cause and the corrective action taken. From the research result, the data analysis is conducted and the research findings are discussed in following section.

## **THE DATA ANALYSIS AND DISCUSSION**

In this section, the analysis data is made by making comparison between the supplier quality problem investigation report (QPIR) and A3 Methodology. While the other research findings are discussed to determine the success factors of carmaker Brand X problem solving process to eliminate the defects. After the data analysis and discussion completed, the research result is concluded in following section.

The comparison between supplier QPIR and the A3 Methodology is summarized in Table 5.

**Table 5.** Comparison between A3 and QPIR Methodology

<b>A3 Methodology</b>	<b>Brand X Supplier QPIR Methodology</b>
Theme and Background - The themes indicate the problem(s) being addressed to and they are descriptive.	Problem description - For examples part name, car model, defect type, quantity of defective product and result of sorting activity.
Current condition - The current problematic processes highlighted on the diagram and future goal.	Returned part investigation - The investigation between actual defect and requirements
Not applicable	Mechanism of failure - To verify the occurrence of problem
Not applicable	Trial / Simulation test - To determine the direct cause of problem
Not applicable	Trial for detection - To determine the direct cause of problem
Root cause analysis - Analysis by any QC tools	Cause of occurrence and outflow - Why-why analysis
Countermeasure proposals / plan - The corrective action proposals to eliminate the root cause of defective product.	Countermeasure taken - The corrective action proposals to eliminate the root cause of defective product - The schedule to execute the corrective action.
Countermeasure execution plan - The schedule to execute the corrective action.	
Follow up plan - The verification of corrective action execution	Not applicable
Not applicable	Suspected affected range - Quantity of defect outflow to carmaker
Not applicable	Conclusion - Lesson learnt from the problem

Source: This research

From the Table 5 above, the A3 Methodology have six sections compared to supplier QPIR methodology have nine sections to complete the problem-solving process. The supplier QPIR used different approaches to determine the root cause of the problem compared to A3 Methodology. In the Brand X problem process, the follow up plan is conducted by the Brand X supplier engineer instead of supplier. The following paragraph, discussion of Brand X problem solving process is written.

The problem reviews between carmaker and its suppliers are the process of ‘problem know-how’ which can be categorized as an initial step in problem solving process towards root cause analysis. It can be defined as Plan stage of A3 Methodology process. The outputs of problem review between carmaker and its suppliers will provide the information of problem background, current conditions and future goals for improvement. The information is recorded as Step 1 and Step 2 in A3 report. As mentioned in the problem-solving report of A3 Methodology, the root cause analysis categorized as Plan stage of A3 Methodology and mentioned as Step 3 in A3 report. The research data shows the root cause analysis begins with two steps as listed below;



- (i) recognizing the effected manufacturing process and
- (ii) eliminating the not-possible causes.

Within these steps, the suppliers are encouraged to use two quality tools which are identified as *process flow diagram* to recognize the effected manufacturing process and *why-why analysis* to eliminate the not possible causes. From the research observations, the suppliers are also required to make simulation of defect phenomena which A3 Methodology is not required.

Other research observations also found that the analysis of other manufacturing process data has not been mentioned in QPIR. The example of manufacturing process data are process check sheets, inspection check sheets, production reports, statistical process control sheets and material certifications. Step 4 and Step 5 in A3 report is supplier's corrective action plan and execution schedule which categorized as Do and Check stages in A3 Methodology. In this step, the researcher found that suppliers provided the corrective action plan to improve the defect occurrence and outflow. The suppliers' corrective action plan also indicates the responsible staff, due date and status of the executions.

The other finding from this research, carmaker investigator verification on supplier corrective action have been conducted and it was recorded separately in minute of meeting. At the end of the problem-solving stage, the researcher found that suppliers have made a few changes in their operation standardization such as Work Instruction, Inspection Check sheet, Process Flow, and fool proof as permanent corrective action.

There are several recommendations discuss in section below for future researchers or industrial practitioners to improve the A3 Methodology application in problem solving process.

## CONCLUSION AND RECOMMENDATION

The problem-solving methodology in automotive manufacturing process has differences compared to A3 Methodology even though the report format in A3 paper is same. The Malaysian carmaker Brand X has implemented the problem-solving technique which suits with Malaysian automotive supplier background so that the determination of root cause and implementation of corrective action is accurate and effective. The closure of problem-solving methodology of Malaysian carmaker Brand X is identical compared to A3 Methodology. Both methodology are practicing "follow-up action plan" to verify the effectiveness of implemented corrective action in the supplier production processes and ensure the problem will not occurs again. The lesson learnt from this research to automotive suppliers is to consider the availability of current resources and capability to execute the corrective action plan accordingly as recommended by Macot (2003). For future research, it is recommended to the other researcher to explore the effectiveness of root cause analysis and corrective action in problem-solving process and suggested the solution of the finding to industrial practitioners.

## REFERENCES

- Dan R, R. (2013). Corrective Action Challenge - How to construct a robust problem solving process. *Quality Progress ASQ*.
- Margerison, C. J. (1988). Team Management Problem Solving. *Industrial Management & Data Systems*, 88(5/6), 12–14.
- Maruta, Ri. (2012). Maximizing Knowledge Work Productivity: A Time Constrained and Activity Visualized PDCA Cycle. *Knowledge and Process Management*, 19(4), 203–214.
- Mcquater, R. E., Dale, B. G., Wilcox, M., & Boaden, R. J. (1994). The Effectiveness of Quality Management Techniques and Tools in the Continuous Improvement Process: An Examination. In *Factory 2000 - Advanced Factory Automation* (pp. 574–580).
- McQuater, R. E., Scurr, C. H., Dale, B. G., & Hillman, P. G. (1995). Using quality tools and techniques successfully. *The TQM Magazine*, 7(6), 37–42. <https://doi.org/10.1108/09544789510103761>
- Mohd Saad, N. (2013). *A3 Thinking Approach to Support Lean Product and Process Development*. Cranfield University.
- Motschman, T. L., & Moore, S. B. (1999). Corrective and preventive action. *Transfusion Science*, 21(2), 163–178. [https://doi.org/10.1016/S0955-3886\(99\)00088-0](https://doi.org/10.1016/S0955-3886(99)00088-0)
- Organisation, I. S. Quality Management System - Requirement ISO 9001, 2008 § (2008).
- Rajput, R. (2007). *A Textbook of Manufacturing Technology: Manufacturing Process*. Firewall Media.
- Saux, D. Le. (2006). The Effective Use of Process Control Plans and Process Failure Mode Effects Analysis in a GaAs Semiconductor Manufacturing Environment. In *CS MANTECH Conference* (pp. 31–34). Vancouver.
- Sobek, D. K., & Art, S. (2011). *Understanding A3 Thinking: A Critical Component of Toyota's PDCA Management System*. CRC Press.
- Tarí, J. J., & Sabater, V. (2004). Quality tools and techniques: Are they necessary for quality management? *International Journal of Production Economics*, 92(3), 267–280. <https://doi.org/10.1016/j.ijpe.2003.10.018>

## Appendix 1 – Carmaker Brand X defect claim report

<b>BRAND X</b>	<b>TROUBLESHOOTING AND INFORMATION ACTION REPORT</b>				Report no.: _____																																											
					DOWNTIME VALIDITY	PART PROBLEM																																										
<b>PROBLEM</b>  <b>SUSPECTED CAUSE</b>				MODEL	LINE	DATE	SHIFT	CHECKED	PREPARED																																							
				CATEGORY <input type="checkbox"/> Downtime <input type="checkbox"/> Line Reject <input type="checkbox"/> Others																																												
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F) Troubleshooter Comment

Appendix 2 – Carmaker Brand X Quality Problem Investigation Report

QUALITY PROBLEM INVESTIGATION REPORT																																	
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<div>3.0 Mechanism of Failure</div> <div>Process flow in P2</div> <div>Process flow in supplier</div>		<div>5.0 Trial for detection</div>																															
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# THE LINKAGE OF POTENTIAL HAZARDS WITH POTENTIAL HAZARDS WITH SAFETY IMPACT: A VIEW FROM FLOATING STORAGE FACILITY IN MALAYSIA

Rosmaini Tasmin<sup>1</sup>, Salehuddin Md Fadzil<sup>2</sup>, Muhammad Shafiq<sup>3</sup>

<sup>1</sup>Department of Production and Operation Management, Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia.

<sup>2</sup>Hess E&P Malaysia BV, Hess Corporation, Pasir Gudang, Johor, Malaysia.

<sup>3</sup>COMSATS Institute Of Information Technology, Wah Cantt, Pakistan.

## Abstract

Floating storage facility offers one unique and innovative solution for new installation in offshore crude oil industry. However, the system will easily contribute to potential hazards or risks that are difficult to quantify due to shortness of experience. This article gives an overview of the potential hazards during normal activity and relevant safety impact to personnel, asset and environment. The study applied Risk Assessment approach to measure potential hazard levels. Survey on 157 employees of 4 floating oil storage facilities were analysed with methodological tools of ANOVA One Way, T-Test and Pearson Correlation to evince linkage between potential hazard and safety impact. The result showed that there is significant and yet low level of relationship between potential hazards and safety impact. The findings from the collected experience-based and research survey data can be applied to facilitate the development of rationalized approaches for top management in decision-making on the safety guideline, policy making and investment towards the floating storage facility.

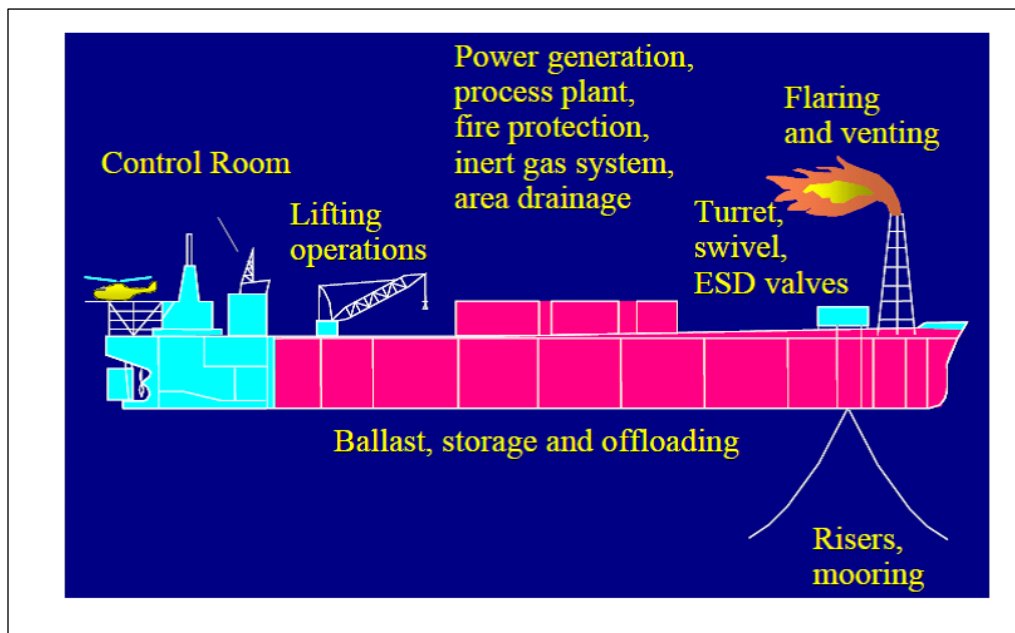
**Keywords** *Potential hazards, Floating storage facility, Safety impact, Occupational accidents*

## INTRODUCTION

Prices for crude oil have been plunging since the late 2008 and this seems barely increasing significantly in the past five years. As such, oil industry seeks better economic solutions to its new challenges for business sustainability. Business operation has always been encountering economic challenges and trying unique methods for sustaining competitive advantage, especially through process efficiency (Tasmin et al., 2016). Hence, floating storage and offloading (FSO) crude oil facilities nowadays are becoming one preferred and efficient solution for new installation of oil and gas fields. Wilne (1998) reported that such facilities are suited for both small marginal fields and large deep-water reserves. Due to cost reasons and practical advantages if compared to fixed installation, floating facility is the most commonly used as crude oil storage systems. According to Alford (1997), with the straight forward mechanism of building and conversion basing on the existing ship building technology, the expensive offshore works can be kept to minimum as most of the construction, hook-up and commissioning can be completed onshore, with significantly less cost. The floating facility is a comprehensive system, it subsequently contributes to the potential hazard or risk that is surmountable to quantify due to lacking of experience, when compared to conventional shipping industry. It is reported that global shipping industry has been largely having a safe track record, even though when an incident happens it is expectedly disastrous (Hetherington et al., 2006). As such, there is a typical

similarity in terms of potential hazards and safety risks in maritime shipping and floating crude oil storage facilities.

For the construction of floating storage facility, two options can be considered. First option is the conversion of an existing shipping vessel. With the condition of the vessel and approval by the Classification Society, the selected tanker is converted to become floating storage and offloading facility. Related transferring equipment is installed to suite for the facility to receive oil and gas from designated oil well via subsea pipeline. Another option for oil storage is by building a new purposely built floating facility. The concept of this huge oil storage is rather similar with the converted vessel. Such storage facilities are expected to remain on a designated location for up to 20 years with all the environmental conditions taken into system design consideration (Ericson, 2016). Some of the facilities are designed to suite the process of keeping hydrocarbon which is located on top of the vessel. The floating facilities are designed to avoid any dry docking as compared to the practice of conventional sailing vessel. This poses new challenges as on-site repairing can become very difficult and equipment failure may have adverse consequences for vessel safety (Wilne, 1998).



**Figure 1:** FPSO compartmentalizing of the ship

Figure 1 shows the example of Floating Production Storage and Offloading (FPSO) compartmentalizing of the ship, according to Gilbert and Ward (2001). It classified floating crude oil storage vessel in 7 areas, namely control room, lifting operation, ballast-storage-offloading, risers-mooring, flaring-venting, turret-swivel-ESD and power-generation, process plant, fire protection, inert gas system plus drainage areas. Risers and mooring is located at the front part of the vessel, as it is linked to the storage compartments and

offloading. Flaring and venting is placed high above at the front part of the facility. Such systematic design has been vital for operational safety and employee safety compliance.

## LITERATURE REVIEW

Smith-Crowe et al. (2003) stated strong and positive correlation between safety knowledge and safety performance, mediated by organisational climate, especially at highly safety guarded facility such as nuclear waste site. As such, studies on safety hazards at acutely safety sensitive venues have been impacting many oil and gas facilities, including floating oil storage terminal vessel. The floating storage structure has been used widely and reliably throughout the oil industry for many decades. The floating storage facility was primarily installed as for storage and offloading activity. Nowadays, with modern technology, the facility becomes offshore producing installation, storage facility and offloading terminal; all rolled into one single unit. Moan et al. (2002) described that the floating storage and production unit is a vessel that receives oil and gas from subsea wells through flow lines known as risers. The vessels can be a purpose-built ship or semi-submersible, or a converted shipping line tanker. This facility is commonly known as floating, production, storage and offloading (FPSO). The vessel without production system is termed as floating, storage and offloading (FSO).

Vinnem (2000) explained from the operational safety perspective of FPSOs: based on initial summary report, although the facilities are becoming more common, operational safety performance may still be considered somewhat unproven, especially when compared to fixed installations. Furthermore, floating installations are more dependent on continued operation of some of the marine control systems, during a critical situation. There is accordingly a need to understand the aspects of operational safety for the facilities, in order to enable a proactive approach to safety, particularly in the following areas:

- Turret operations and flexible risers,
- Simultaneous marine and production activities,
- Vessel movement/weather exposure, and
- Production, ballasting and offloading.

Hazard identification is a formal activity to examine all aspects of the operation under consideration using a pro-forma approach. It depends on the quality of the input data available and is typically performed as a table-top exercise lead by an experienced facilitator and the participation by representatives covering the full range of design and operational expertise for the system under consideration (Spires, 2001). The author stated that the hazard identification has considered a total of eleven different hazard categories that exists during the production phase of development. Biasotto and Rouhan (2004) explained that each identified hazard is analysed in terms of its functional failure, failure mode, consequences (including the possible different scenarios), existing barriers, control methods and repair strategies. The identified hazards are qualitatively classified on the basis of the likelihood and the related consequences regarding risks to personnel, to environment and to asset and production (Biasotto and Rouhan, 2004).

In the records of history, there have been a number of catastrophic accidents on offshore facility and causes of such accidents have become lessons-to-learn to operators and this has shed more light on the subject matter. While such accidents are undesirable and should be avoided at all costs, the world has benefited in no small measure from these experiences (Omogoroye and Oke, 2007). Chang and Lin (2005) reported that fire which led to explosion account for 85% of the onshore incidents involving petroleum refineries, oil storage and terminals, in the case of 242 oil storage accidents in the last four decades.

Human-related factor, such as manpower and its associated behaviour, has been identified as one influential element contributing to fragility of many safety-sensitive industries. Fugas et al. (2012) reported that working peers' habitual safety norms and attitudes mediated the relationship between workplace safety climate and proactive safety behaviours, among more than 300 workers in transportation industry. In addition, Hetherington et al. (2006) emphasized that monitoring, managing, controlling and modifying the human factors issues of maritime workers could contribute significantly and positively towards safety performance in shipping industry. In February 1986, at Thessaloniki, Greece, cutting torch sparks ignited a tank spill fuel from a dike of a fuel storage tank. As a result, the fire quickly spread to neighbouring petrochemical storage areas and causing the destruction of almost all 12 crude oil tanks. Whilst in December, 1985 at Naples, Italy, 24 tanks of marine petroleum products terminal were destroyed by fire that was caused by tank overfill. Fire and explosion totally destroyed the main terminal buildings, neighbouring industrial facility and residential homes (Chang and Lin, 2005). Obviously, there are far many more oil storage accidents on the main land, in comparison to the focus of this study which is on floating oil storages in the open sea (offshore).

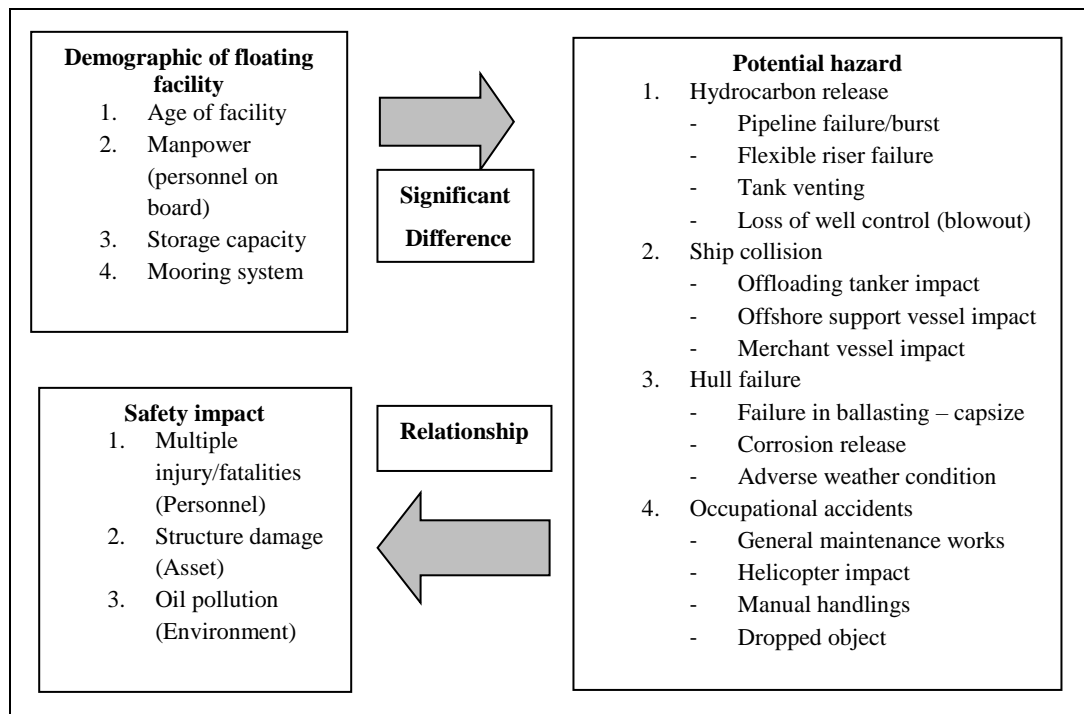
The major hazard to the offshore oil and gas facility is not much different from others as described in lesson learn of the onshore accidents. They are clearly categorized as: loss of well control or blowout, fire from the process plant, explosion from the process plant, H<sub>2</sub>S and naturally occurring radioactive materials from reservoir, extreme weather, ship collision, seismic events and helicopter or other aircraft impact (Galbraith and Terry, 2008). For the past few years, the major accidents happen involving multiples fatalities, equipment damage and environment impact that require high cost to overcome the situation. Khan et al. (2004) also pointed out that the main hazards on offshore installation are the processed fluids and processing operations, the sea environment and the process links between the reservoir and other installations. The lesson-learned is part of the process to identify the hazards and mitigate them to as minimum as possible. These unfortunate events have happened to 'Alexander L Kjelland – structure failure during adverse weather condition', 'Ocean Ranger – capsized due to ballasting', 'Piper Alpha – hydrocarbon release' and 'Super Puma Helicopter crash at Cormorant', as described in "The Offshore Industry – Learning from Accidents" by Galbraith and Terry (2008). Due to these incidents, the industry has managed to be sufficiently innovative in coming up with relevant solutions to overcome the challenges (Tasmin and Woods, 2007). Though those unfortunate events happened at oil rigs, such mishaps may have also occurred at floating oil storage facilities due to its similar nature of offshore operations.



The floating storage and offloading facility has the ability to handle changes of oil reservoir and process, as well as offering storage and offloading of the treated crude to other export tankers. With this significant and comprehensiveness of the system, it will easily contribute to the potential hazard or risk which is difficult to quantify due to FPSO's limited experience if compared to long time spanning of shipping industry. The hazard is defined as a situation with a potential source of harm that are causing human injury, damage to the environment, damage to property or any combination of such event (BS EN ISO 17776:2002). It may be a physical situation (such as a shuttle tanker is a hazard because it may collide with the production installation), an activity (such as crane operations are a hazard because the load might drop) or a material (such as fuel oil is a hazard because it may catch fire). The essence of a hazard is that it has a potential for causing harm, regardless of how likely or unlikely such occurrence might be.

## **DATA AND METHODOLOGY**

This research study focused on floating storage facilities that have currently been operating in Malaysian waters. Basically, there are 4 field owners operated the floating oil facilities, namely Petronas, Murphy Oil, Talisman and Petrofac. These 4 facilities are selected for data survey which represents the field owner and their facility in Malaysia. The total number of Personnel on Board (POB) for these 4 facilities is 258 people. According to Krejcie and Morgan (1970), the total number of sample should be 154 respondents, in the survey which had been done via stratified random sampling method. In the overall survey, a total of 157 correspondences have been taken as fully usable. This study demonstrated the level of potential hazards, significant differences between the demographic of facility towards the potential hazards and the relationship between potential hazards with safety impact. As such, it described the potential hazards from normal activities that should be considered at the floating oil storage facility. This is essential in order to achieve an overall safety and reliable design to personnel, asset and environment, as shown by the research conceptual diagram in Figure 2.



**Figure 2:** The research conceptual relationship diagram

This research applies the Det Norske Veritas (DNV) risk assessment approach, which is a step in a risk management procedure. It's a process of gathering data and synthesizing information to develop an understanding of the risk of a particular activity. Guldenmund (2000) stated that the safety climate assessment could be viewed as an indicator for organisational safety performance. Hence, the main purpose of risk assessment is to identify and rank the hazard risks so that they can be adequately managed. The use of risk assessment techniques in major hazard industries has grown significantly in recent years. This is particularly true in the offshore industry in the UK, where many aspects are subjected to full hazard risk assessment (DNV, 2001). Ericson (2016) defined hazard risk management is a discipline that is embedded into system development which is to identify and contain hazards, in order to avoid or alleviate the potential risk. Hazard risk is an assessment metric to forecast the probability and severity of possible incident or accident that will happen. This assessment provides among others, authorities and stakeholders with a sound basis for creating awareness about existing and potential hazards and risks, hence making positive decisions related to how they can prioritize and plan expenditures on risk reduction (Funnemark and Engebo, 2005).

There are two methods used as a tool for the study. The risk matrix and analytical tools are used to measure the level of potential hazard, the significance difference of demographic facility towards potential hazards and the relationship of the potential hazards towards safety impact of the facility. The first method of risk matrix is applied to measure the level of potential hazard whether it is 'low', 'medium' or 'high', based on ISO 17776 Risk Matrix approach. The risk matrix is a convenient method of ranking and presenting the assessment

result. The second analytical tools are by applying ANOVA One Way, T-Test and Pearson Correlation, based on SPSS software.

Having set the problem background, literature and research methodology, below are the three research questions to be pursued in this study.

RQ1. What are the hazard levels of hydrocarbon release, ship collision, hull failure and occupational accidents at the floating storage facility?

RQ2. What are the significant differences between the elements of demographic facility towards the element of potential hazards?

RQ3. Is there any relationship between potential hazards and the safety impact of the facility?

## **ANALYSES AND RESULTS**

In this section, the findings from the methodology are discussed and simultaneously, answering the research questions developed for the study. The first research question seeks to determine the hazard levels of hydrocarbon release, ship collision, hull failure and occupational accidents at the floating storage facility; the second seeks to determine the significant differences between the elements of demographic facility towards the potential hazards, while the third intends to determine the relationship between potential hazards and the safety impact of the facility.

### **RQ1. Level of potential hazards**

Table 1 shows the result on each potential hazard to personnel, asset and environment. Tool from ISO 17776 Risk Matrix (DNV, 2001) is applied to study the level of risk rating on each of the potential hazards. The cross reference from consequences and frequency show the risk rating for low, medium and high on each element of potential hazards towards personnel, asset and environment. From the table, it shows the levels of only low and medium risk rating towards the personnel, asset and environment. Fortunately, there is no high risk rating for the element of potential hazards. The level for low and medium level can be applied for ensuring the business continuity of the floating storage operation. If high risk rating appears, few safety steps are taken into consideration to minimize the risk or accident onboard the facility. The new risk reduction measures are implemented and the risk evaluation is repeated. In this particular case, the risk evaluation is defined as risk assessment and to be performed on every task on board facility. The risk reduction or control measures include both those to prevent incidents and to mitigate chronic aftermath of the incidents.

**Table 1:** Level of potential hazard for Malaysian floating storage facility according to Risk matrix

Potential Hazards	Sub section of potential hazards	Impact to Personnel	Impact to Asset	Impact to Environment
<b>Hydrocarbon release</b>	Pipeline failure/burst	Medium	Medium	Medium
	Failure of riser	Low	Low	Medium
	Cargo Tank venting	Medium	Low	Low
	Loss of well control (blowout)	Medium	Medium	Medium
<b>Ship collision</b>	Offloading tanker impact	Low	Low	Low
	OSV impact	Medium	Medium	Medium
	Merchant vessel impact	Low	Low	Low
<b>Hull failure</b>	Ballasting & capsize	Low	Low	Low
	Corrosion release	Low	Medium	Low
	Adverse weather	Low	Low	Low
<b>Occupational accidents</b>	General maintenance	Medium	Low	Low
	Helicopter impact	Medium	Medium	Low
	Manual handling	Low	Low	Low
	Dropped object	Medium	Low	Low

Table 2 evinces that the hazards are at higher risk probability when it comes to the hydrocarbon releases toward the personnel, the asset and the environment onboard. This is depicted by the sums of 8 mediums and 4 lows, as shown by the first row of Table 2 hazards' ranking. It is generally acknowledged that hydrocarbon release is one lethal issue in FPSO/FSO operation, since it is the most probable antecedent that may spark fire ignition onboard. Hence, the facility's top management has to pay higher attention on any eventuality towards issues related to hydrocarbon release. The hydrocarbon release is the first top priority, since this is the most detrimental issue among the four hazards, in relation to the whole safety of the FPSO/FSO facilities. The least potential hazard (ranking fourth) is hull failure, in which the respondents felt that it is the safest hazard issue. This is so because most hulls are double-layered, complemented with safety compartments which are equipped with safety valves and sensors to prevent failures. Furthermore, ship hulls and their coatings are designed to be in operation for very long time, approximately within 20 years.

**Table 2:** The ranking of 4 potential hazards toward safety impact

Ranking	Potential hazards	Mediums	Lows
First	Hydrocarbon release	8	4
Second	Occupational accident	4	8
Third	Ship collision	3	6
Fourth	Hull failure	1	8

## RQ2. Significant difference for demographic facility towards potential hazard

Table 3 shows the summary of significant differences between demographic of floating facility and potential hazards by using analytical tools of the Anova One Way and T-Test. The age of facility, manpower and storage capacity are applying the Anova One Way due to ordinal data type being collected ranging from 1 to 5 respectively. The mooring system using tool from T-Test due to nominal data collected for turret system and spread moored only. The result shows that the age of facility having significant difference for ship collision since 'f' probability is  $\leq 0.05$ . However, manpower and storage capacity are not showing any significant difference towards the potential hazards. The average age of the facilities in this study is below 15 years old and the ship collision is possibly giving an impact to the potential hazards, such as offloading tanker impact, OSV (Offshore Support Vessel) impact and merchant vessel impact. From the experience at the offshore, the OSV is the biggest threat due to the vessel is always at the alongside of the floating storage facility. The impact from the OSV can cause dented damage at the facility hull or worst oil spill to the sea. The sea environment factors, such as wind, swell, wave, and current, could also contribute to the incident, even though the facility have been operating for long period of time.

**Table 3:** The summary of significant differences between demographic of floating facility and potential hazards by using Anova One Way and T-Test.

Demographic of floating facility	Potential hazards			
	Hydrocarbon release	Ship collision	Hull failure	Occupational accidents
Age of facility	f=0.329 Not sig.	<b>f=0.043 Sig.</b>	f=0.819 Not sig.	P=0.762 Not sig.
Manpower	f=0.401 Not sig.	f=0.259 Not sig.	f=0.189 Not sig.	P=0.275 Not sig.
Storage capacity	f=0.121 Not sig.	f=0.161 Not sig.	f=0.133 Not sig.	P=0.581 Not sig.
Mooring system	p=0.547 Not sig.	p=0.469 Not sig.	<b>p=0.001 Sig.</b>	p=0.630 Not sig.

Anova One Way for ordinal data type: significant at 'f' probability  $\leq 0.05$

T-Test for nominal data type: significant at  $p \leq 0.05$

The definition of ageing of facility is about its condition and how that is changing over time. Ageing is that effect whereby a component suffers some form of material deterioration and damage with an increasing likelihood of failure over the lifetime (Horrocks et al., 2009). The significance of deterioration and damage releases will potential effect on the equipment's functionality, availability, reliability and safety. Overall, ageing facility is facility which is, or may be, no longer considered fully fit for purpose due to deterioration or obsolescence in its integrity or functional performance. Ageing is not directly related to chronological age. There are many example of very old facility remaining fully fit for purpose and of recent facility showing evidence of accelerated or early ageing, e.g. due to corrosion, fatigue or erosion failures. It is important to recognize that many features which may be subject to ageing, can contribute to health, safety and environmental performance of the facility or could compromise the performance were they to fail or collapse. In this study, the ageing of system and structure should be brought into attention for the potential impact of ship collision to the facility.

The results are also showing mooring system having significant difference for hull failure and it is significant at  $p \leq 0.05$ . As described by Stiff et al., (2003), some differences between mooring system failure scenarios were identified but many of these scenarios were considered to be low likelihood. The slight differences in risk were driven by the redundancy of the two systems. Since the spread moored system has more mooring lines, which are arranged in closely spread groups, the likelihood of loss of one or more adjacent line escalating to, for example riser damage was considered to be slightly lower than for the turret moored system. However, the close proximity for the mooring lines in relation to the risers was considered a factor influencing the likelihood of mooring failure potentially escalating to riser failure for the turret moored facility. The consequences related to health and safety was also considered to be higher for the turret system because of the more congested and confined area around the turret which can influence the intensity of an explosion as well as the potential for escalation if a gas leak occurs.

### RQ3. Relationship of potential hazards towards safety impact

**Table 4:** The summary for relationship of potential hazards towards safety impact by using Pearson Correlation

Safety Impact	Potential Hazard		
	Correlation Value ( <i>rs</i> )	Significant value ( <i>p</i> )	Relationship
Personnel	0.385**	0.000	Low
Asset	0.401**	0.000	Low
Environment	0.334**	0.000	Low

\*\*Correlation is significant at the 0.01 level (1 tailed)

Table 4 shows the summary for relationship of potential hazards toward safety impact by using Pearson Correlation. Correlation coefficient values show that the influence is at lower level, even though they are really significant. As such, there is a low-level impact of potential hazard on safety impact to personnel, asset and environment, and such impact is very significant ( $p=0.000$ ). This significance means that the potential hazards could severely lower on safety impact towards personnel, asset and environment. From the result, it shows that the asset having higher correlation value (0.401) if compared to personnel (0.385) and environment (0.334) respectively. This finding is relatively acceptable and making sense, as the physical structure of FPSO/FSO is typically huge (big asset). Generally, it is more exposed to the structural effects of potential hazards when compared to personnel and the environment. This finding is in accordance with Gershon et al. (2000) who reported the significant relationship, with  $P < .05$ , between organisational working safety climate and employee compliance with safe work practices (lower workplace exposure incidents). Furthermore, Singer et al. (2009) evinced that among 91 American hospitals with better safety climate had lower reported relative incidence of Patient Safety Indicators (PSIs). These supportive findings signify that excellent safety working environment leads to workers' compliance towards safe working practices.

## CONCLUSION

In Malaysia, the crude oil floating storage is rather quite similar from one to another, except for production unit that is attached to the facility itself. The size of facility and mooring system are depending upon the client/asset owner requirement. From the size of the

facility, it will indicate the manpower requirement for the operation and maintenance. The study has shown that the ageing of the facility gives significant difference to the ship collision as a potential hazard. In general, the ageing process will reduce the performance and efficiency of the facility but the management is always taking efforts to maintain the integrity of the facility. The study also has indicated that the mooring system having significant difference to the potential hazard in relation to hull failure. Majority of the floating storages in Malaysia are using turret moored rather than spread moored system. Turret moored system can be weather vanned according to sea current condition. Due to the facility is always exposed to the sea environment and exposed harsh condition, this will be resulting in high chances of corrosion.

The conclusion of overall study has shown that the influence is at lower level even though they are really significant. As such, there is a low-level impact of potential hazard on safety impact to personnel, asset and environment. All levels in the organisation, from managers to operational staffs, are responsible towards the safety of the facility. They are and have always been in constant need to effectively control the risks and preventing harm at their facilities and environment. This can be worked out by strict operation and safety regulation and making sure that the personnel involved are giving priority to the work of controlling the risk by effective prevention and control through well-established safety management system and positive working culture.

## REFERENCES

- Alford, G. (1997), FPSO Classification – Accounting for the variables. Article reproduced with permission of Lloyd's Register Technical Association.
- Biasotto, P. & Rouhan, A. (2004) Survey and inspection management for FPSOs. 23rd International Conference on Offshore Mechanics and Arctic Engineering, June 20-25, Vancouver, British Columbia, Canada.
- BS EN ISO 17776. (2002) Petroleum and natural gas industries – Offshore petroleum installations - Guidelines on tools and techniques for hazard identification and risk assessment.
- Chang, J.I. & Lin, C.C. (2005) A study of storage tank accidents. *Journal of Loss Prevention in the Process Industries*, 19: 51–59. DOI:10.1016/j.jlp.2005.05.015
- DNV. Marine risk assessment. Offshore Technology Report, 2001/063, HSE Books, ISBN 07176 22 31 2, <http://www.hse.uk/research/otohtm/2001/oto01063.htm>
- Ericson, C.A. (2016), Hazard analysis techniques for system safety. John Wiley & Sons, New Jersey. ISBN 978-1-118-94038-9.
- Fugas, C.S., Silva, S.A. & Meliá, J.L. (2012) Another look at safety climate and safety behavior: Deepening the cognitive and social mediator mechanisms. *Accident Analysis & Prevention*, 45: 468–477. DOI:10.1016/j.aap.2011.08.013.
- Funnemark, E. & Engebo, A. (2005) Development of Tools for risk assessment and risk communication for hydrogen applications. DNV Consulting and DNV Research, Det Norske Veritas AS, Norway.

- Galbraith, D. & Terry, E. (2008) The Offshore Industry – Learning from accidents. Offshore Technology International, 2.
- Gershon, R.R, Karkashian, C.D., Grosch, J.W., Murphy, L.R., Escamilla-Cejudo, A., Flanagan, P.A., Bernacki, E., Kasting, C. & Martin, L. (2000). Hospital safety climate and its relationship with safe work practices and workplace exposure incidents. *American Journal of Infection Control*, 28(3): 211–21. DOI: <http://dx.doi.org/10.1067/mic.2000.105288>.
- Gilbert, R.B. & Ward, E.G. (2001) Comparative Risk Analysis for Deepwater Production System. Final Project Report by Offshore Technology Research Centre.
- Guldenmund, F.W. (2000) The nature of safety culture: a review of theory and research. *Safety Science*, 34: 215-257. Pergamon-Elsevier Science Ltd.
- Hetherington, C., Flin, R. & Mearns, K. (2006) *Journal of Safety Research*, 37: 401–411. Pergamon-Elsevier Ltd. DOI:10.1016/j.jsr.
- Horrocks, P., Mansfield, D., Parker, K., Thomson, J., Atkinson, T. & Worsley, J. (2009) Managing Ageing Plant: A Summary Guide. Report for Health, Safety and Environment, HSE UK.
- Khan, F.I., Veitch, B. & Amyotte, P.R. (2004) Evaluation of inherent safety potential in offshore oil and gas activities. 23rd International Conference on Offshore Mechanics and Arctic Engineering, June 20-25, Vancouver, British Columbia, Canada.
- Krejcie, R.V. & Morgan, D.W. (1970) Determining sample size for research, *Educational and Psychological Measurement*, 30: 607-610.
- Moan, T., Amdahl, J., Wang, X & Spencer, J. (2002) Risk Assessment of FPSOs, with Emphasis on Collision. Originally presented at Society of Naval Architects and Marine Engineers (SNAME), Boston, September 24-27.
- Omogoroye, O.O. & Oke, S.A. A (2007) Safety control model for an offshore oil platform. *Disaster Prevention and Management*, 16(4).
- Singer, S., Lin, S., Falwell, A., Gaba, D. & Baker, L. (2009) Relationship of Safety Climate and Safety Performance in Hospitals. Health Research and Educational Trust, DOI: 10.1111/j.1475-6773.2008.00918.x
- Spires, J.B. (2001) Frequency Analysis of Accidental Oil Releases from FPSO Operations in the Gulf of Mexico. Final Report for Det Norske Veritas, Inc, Houston, Texas.
- Smith-Crowe, K., Burke, M.J. & Landis, R.S. (2003) Organisational Climate as a Moderator of Safety Knowledge-Safety Performance Relationships. *Journal of Organisational Behavior*, 24, 861-876. DOI: 10.1002/job.217
- Stiff, J., Ferrari, J., Ku, A. and Spong, R. (2003) Comparative Risk Analysis of Two FPSO Mooring Configurations. Offshore Technology Conference, OTC 15377. Houston, Texas.
- Tasmin, R. and Woods, P. (2007) Relationship between corporate knowledge management and the firm's innovation capability. *International Journal of Services Technology and Management*, 8(1): 62-79.



- Tasmin, R., Takala, J., Abu Bakr, A.A., Shylina, D., Nizialek, I. & Che Rusuli, M.S. (2016) Sustainable Competitive Advantage (SCA) Analysis of Furniture Manufacturers in Malaysia: Normalized Scaled Critical Factor Index (NSCFI) Approach, *Management and Production Engineering Review*, 7(2): 73-85.
- Vinnem, J.E. (2000) Operational safety of FPSOs: Initial summary report. Prepared by Norwegian University of Science and Technology (NTNU) for the Health and Safety Executive.
- Wilne, T. (1998) FPSO: Reliability for long term operation. Global Maritime's, Rotterdam Office.

# OVERCOMING MAINTENANCE COMPETENCY DEFICIENCY – THE AVIATION MAINTENANCE INDUSTRY PERSPECTIVE AND STRUCTURED ON JOB TRAINING (S-OJT)

**Liew Chee Leong, Mohammad Ali Tareq**

Department of Management of Technology, Malaysia-Japan International Institute of Technology,  
Universiti Teknologi Malaysia Kuala Lumpur

## **Abstract**

Competency (knowledge, skills and abilities) deficiency of employees in an engineering organisation is a critical issue as competency deficiency leads to organisational inefficiencies and ineffectiveness. This results in financial losses and organisational failure. For individuals, competency deficiency means incapability and degraded performance. This may result in inability to meet performance targets and eventually affects one's promotion and career development. While many organisations attempt to address the employees competency deficiency issues, not everyone's efforts were fruitful. This is true when an organisation require specialized knowledge, skills and abilities. Besides, there could be specific issues in overcoming the deficiency that may not be fully understood. If competency deficiencies is critical to both organisations and individuals, and if the organisations and individuals experience difficulty in overcoming this issue, then the know how to overcome these competency deficiencies is a must. The purpose of this paper is to describe a process that may be adopted in overcoming competency deficiencies within an organisation in an engineering sector such as aircraft maintenance, repair and overhaul facility.

**Key words:** *Competency, structured on job training, organisational performance*

## **INTRODUCTION**

One of the critical issues faced by managers today in an organisation is ensuring that its employees have the competency to fulfil existing and future work requirements (Jacobs & Bu-rahmah, 2012). Harvard (2016), defined competency as “things” that individual must demonstrate to be effective in a job, role, function, task or duty. It includes the behaviour, motivation and technical knowledge and skills. For organisations, competency deficiency leads to organisational inefficiencies and ineffectiveness. This results in financial losses, organisational failure and sometimes catastrophe. For individuals, competency deficiency means incapability and degraded performance which increases incident and accident risk. This may result in inability to meet performance targets and eventually affects one promotion and career development.

From the context of aviation maintenance industry, competency of the maintenance personnel is extremely crucial to ensure that the airworthiness and safe operation of the aircraft is maintained at all times. Federal Aviation Administrator (2016), uses the term airworthiness to define the state of an aircraft where the aircraft conforms to its type design and is in a condition for safe operation. In order to achieve the airworthiness of the aircraft to an acceptable level, the aircraft needs to be maintained in accordance to the manufacturer and authority requirements.

Kinnison & Siddiqui (2013), described one of the key purpose of maintenance is to ensure that the airworthiness of the aircraft are maintained to meet the manufacturer's and regulatory requirements. Therefore, it is important that the maintenance personnel receive the appropriate training to have the right competency.

According to Chandler (1998), the maintenance of aircraft has become more and more complex. Technology advancement has caused the aircraft to become more and more sophisticated. The development of integrated avionics systems and composite material structural construction has been increasingly adopted. While new aircrafts continue to be developed, there are still many airlines which continue to operate the older fleet due to their familiarization of the models and existing infrastructure set up. As the world moves into the new global economy era, the aviation business competitiveness and economic factors requires the aviation companies to minimize the grounding time of aircrafts. These factors have dictated the need for higher competency aircraft maintenance personnel.

Kinnison & Siddiqui (2013), states that the most common aviation authority question when investigating an incident or accident was "was the mechanic properly trained?". This question arises as the authority needs to know the competency level of the personnel working in the system involved before the incident or accident. This shows what competency deficiency could lead to.

Moe et al, (2015) studies has shown that improving skills through training, will improve faster problem solving and reduce bottlenecks. This implies that to work effectively and ensure that the airworthiness of an aircraft is maintained, right training is necessary. Conchuir et al, (2009) implies that work experience is a factor influencing the performance of aviation industry, the experience workers are less dependent on the seniors, they are able to gain autonomy and estimate project timeline. In aircraft maintenance, the defect is usually handled by individual or a very small team due to limited space to work on aircraft. Therefore, a properly trained individual becomes critical.

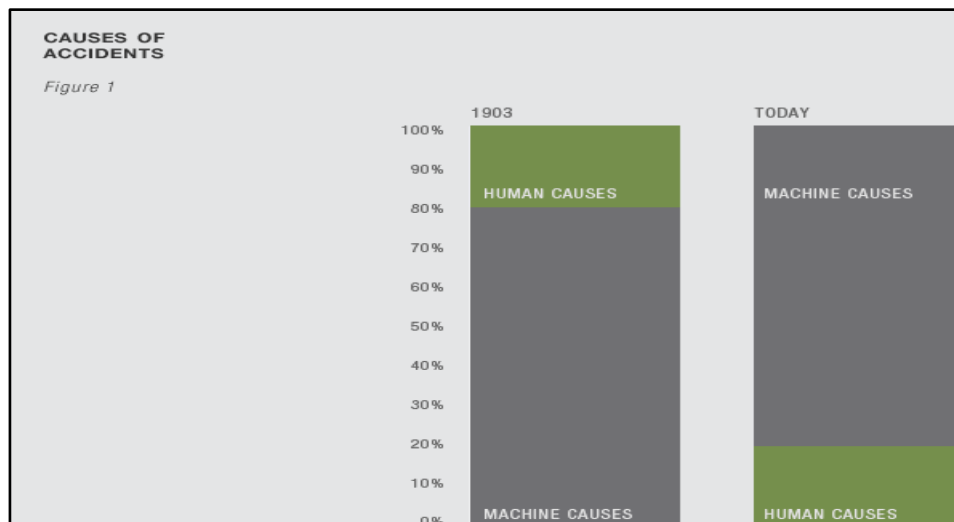
Having a big team may not always be beneficial in the maintenance of aircraft just as Magpili & Pazos (2017) research suggests that when a team member is lack of the necessary skills one tend to become defensive to protect their job and reputation with have low expectations. This indirectly affects the quality of the work output and airworthiness of the aircraft.

The 2003 International Air Transport Association (IATA) Safety Report found that in 24 of 93 accidents (26 percent), a maintenance-caused event started the accident chain. Overall, humans are the largest cause of all airplane accidents (see fig. 1). Maintenance errors can also have a significant effect on airline operating costs. It is estimated that maintenance errors cause:

- 20 to 30 percent of engine in-flight shutdowns at a cost of US\$500,000 per shutdown.
- 50 percent of flight delays due to engine problems at a cost of US\$9,000 per hour.

- 50 percent of flight cancellations due to engine problems at a cost of US\$66,000 per cancellation.

In the early days of flight, approximately 80 percent of accidents were caused by the machine and 20 percent were caused by human error. Today that statistic has reversed. Approximately 80 percent of airplane accidents are due to human error (pilots, air traffic controllers, mechanics, etc.) and 20 percent are due to machine (equipment) failures.



Source: [http://www.boeing.com/commercial/aeromagazine/articles/qtr\\_2\\_07/article\\_03\\_2.html](http://www.boeing.com/commercial/aeromagazine/articles/qtr_2_07/article_03_2.html)

**Figure 1** Causes of Aircraft Accidents

## AVIATION MAINTENANCE COMPETENCY REQUIREMENTS

While many organisations attempted to address the employees' competency deficiency issues, not all efforts were fruitful. This is especially so when an organisation require knowledge, skills and abilities which may be very specialize. Furthermore, there could be specific issues in overcoming the deficiency that may not be fully understood.

Though much effort has been initiated to look into human factors such as training to overcome the competency deficiency issue, the statistics above continues to show that there could be some gap involved. There are rules that has been set out by aviation authority (Faagov, 2017) detailing the process of qualifying personnel to be competent maintenance personnel. In addition, training facility or institution needs to be certified under FAA Title 14 Code of Federal Regulations Part 147 (Gpogov, 2017).

In aircraft maintenance, the complicated system of an aircraft require individual to be equipped with right competencies to face challenging situations. (Srikanth & Jomon, 2015) highlighted that when individuals are exposed or faced with unique and challenging circumstances that requires fast solution, they are forced to make decisions that are risky and uncertain. For this reason it will induce individuals to exert extra effort in dealing with it.

This challenging circumstances will make individuals move away from their comfort zones and enhance their existing capabilities. With the right training, they will also acquire relevant competencies and make a positive impact on their work environment. McCall, Lombardo & Morrison, (1988), McCauley et al. (1994) research studies shows challenging situation handling improves when there is on the job learning.

Aviation maintenance training is driven by three factors (Chandler, 1998), as elaborated below. It is a combination of working environment and the attributes required of a maintenance personnel.

WORKING ENVIRONMENT			
Public safety	Complex Equipment		High workload
In-depth knowledge	Complex mental processing abilities	Skilful use of information	Advanced manual skills
MAINTENANCE PERSONNEL COMPETENCY			

**Figure 2** Aviation Maintenance Personnel Competency Perspective

The table above indicates the demand of the skills and knowledge required in aviation maintenance training. In order to obtain a qualification of an aircraft maintenance license it requires a minimum of 30 months of working experience on aircraft airframes and engines (Gpogov (2), 2017) which is part of the training requirement. Although the training requirement has been clearly stated but yet, (Boyd & Stolzer, 2015) research found that there are indeed maintenance that had also been performed by incompetent personnel describing them as unauthorized individual.

Therefore, these indications shows that there are gaps that need to be addressed to overcome these competency deficiencies. Wu, (2013) claims that to ensure the success of a training program, five factors have been identified as success factors in competency based training processes;

1. Alignment with the organisation's strategic goal and plans
2. Based on a high-performance system
3. Competency model development
4. Individual competency gap
5. Training on the gap

Wu (2013), further warned that ignoring the factors above, the training may result failure or impair success in the training process. In order to achieve a competency standard, the training should focus on the development of the skills, knowledge and attitudes required. It needs to be aligned with the organisation's strategic goal and plans and also based on a high-performance system. Each learner will be measured to see whether they reach the competency standard. They will also be assessed to find the gap between the skills they have and the skills they need, this called the competency gap. Hence a training system is required to be developed to help them acquire the skills therefore closing the gap.

In addition to the above, Sackett & Walmsley (2014), posit that wide array of attributes such as dependability, resilience and cooperation are some personal attributes that plays a role in the competency deficiency. It determines the employee ability to work independently, deal with stress and be able to interact positively with co-workers. Sackett & Walmsley (2014), further question if the employees are able to use their acquired education knowledge, problem solving skills into the workforce, how capable will they apply their soft skills successfully. All these is required to ensure the right competency is addressed appropriately.

## **BASIC AVIATION MAINTENANCE TRAINING PRINCIPLE**

Due to the continuous report of incidents and accidents, the level of effectiveness of training laid down by CFR has been criticized. According to Spencer & Schurman, (1995) studies, regular On Job Training (OJT) may not the most effective training in the field due to the variety of multiple skills required by today aviation maintenance personnel. One of the criticism of the current OJT practices is that it tends to be lax as well as unstructured (Chandler, 1998). In addition, training on the field or maintenance facility tend to be carried out on the job without a formal and well structure set up. When a junior aircraft maintenance technician is attached to a senior technician for unscheduled OJT which is non-systematic, it may be difficult to ensure whether the teaching process is sufficient and whether knowledge and skill were successfully transferred to the junior (Vipond,1990).

Basic training concepts that are generally being adopted by the society has also been applied to aviation maintenance training. Basic training concepts consist of theory in classrooms setting followed by video or demo presentation (Pama, 1992). The effectiveness of training is influenced by the format, content and delivery mode that is able to match the trainees need.

Salvendy & Pilitsis, (1980), advocated an approach known as systems approach. This approach claims to be an efficient training where the knowledge and skills required are delivered at the correct amount at the appropriate time to the learner. Trainers are expected to understand the maintenance task that the learners are expected to learn and later perform correctly. This appear primarily in the classroom setting. There is doubt of the level competency that can be achieved with this classroom approach especially in aircraft maintenance competency.

Jacobs (2017), opined that in order to perform tasks, trainees need to have knowledge and skills, education and training are considered fundamental in order to perform knowledge based tasks. In a sense, education and training are important for trainees to gain knowledge and skills required to perform the task. Formal education and degree programs serve as theoretical foundations of the work for them. However, it is in an actual work environment the trainees will undertake an array of more focused workplace learning and development opportunities. Therefore, a more suitable approach is required to address the competency deficiency issue in aircraft maintenance.

## STRUCTURED ON-JOB –TRAINING APPROACH

Jacobs (2003), posited that in a work environment, the structured-on job training (S-OJT) is effective for learning complex task. This approach is suitable in the setting of aircraft maintenance environment as aircraft maintenance involves multiple interfacing system even for a simple task such as servicing an aircraft tire. However, one key element on S-OJT is that on completion of S-OJT, it is important to continuously practice what was learned.

Jacobs (2017), writes that in the education and training opportunities, the trainees should have the opportunity to practice the knowledge gain through their work situations and receive feedback and coaching. Through practice trainees learn from the hands-on opportunity in their work, acquire deeper knowledge by putting theory to actual situations, not just read textbooks and memorize facts. S-OJT also uses activity logs to document what the trainees have learned and to show how they practice their newly acquire knowledge. A mentor will review and discusses the information in the log and will determine the readiness of the trainees for the next task. This is critical as experience is one of the key factor to determining the right maintenance actions required by aircraft maintenance personnel.

When a trainee performs complex work it is not just about completing the task but thinking about the actions taken to perform the complex work and after the task is completed (Jacobs, 2017). Reflective learning is about reflections of their experiences and as a base on how to respond to similar situations in the future. Jacobs & Bu-rahmah, (2012) claims that the use of activity logs is one method to provide reflection. Based on the activity log an experienced technician will debrief about what was done and discuss or suggest what can be done differently.

Martin & Kolomitro (2014), reminds organisations and individuals that to be competitive, there must be a means to gain knowledge continuously. This implicates that there is a necessity for an effective training system to be developed. The competitiveness from the perspective of right competency becomes crucial in aircraft maintenance. In addition, Sheikh (2008), opined that this process is a critical source of competitive advantage to an organisation albeit, training is a costly investment. It is an indication that for organisation to sustain, it is important to invest in training. However, organisations need to find a suitable approach to keep the training cost as low as possible. The challenge is what is the most suitable approach that also maintains the cost low?

Martin & Kolomitro (2014), further states that since there is no single perfect method to deliver training, trainers need search for the best method. With technology advancement there are many options than ever before. However, this means that an organisation needs to establish its own process to identify how an organisation training may be set up. An organisation's ability to identify the right training method is critical as it is a method to convey information, experience or knowledge to the trainers which may lead them to change their work behaviour and attitude according to the course objectives of attaining the right competency.

There is an increasing number of organisations seeking for the right approaches to develop the competency of employees (Jacobs, 2003). The approach that is proposed is the structured-on job training (S-OJT) (Jacobs & Bu-rahmah, 2012), S-OJT is being defined as a planned process by having experienced technicians to train new technicians on units of task in actual work setting. The approach appeared to be suitable for the aviation maintenance training due to the fact that an operating aircraft and its environment is the avenue where competency will be applied.

According to Jacobs & Bu-rahmah (2012), majority of the training programs in organisation are being set in classroom. In reality, employees such as aircraft maintenance technicians learns the most skills and knowledge in a work setting while actually performing their task. Though majority of training institution have good facilities for training, there is still a vast difference between training facility and actual work setting. As the S-OJT utilizes the workplace as the training and learning setting, this presents a closest learning condition for a learner.

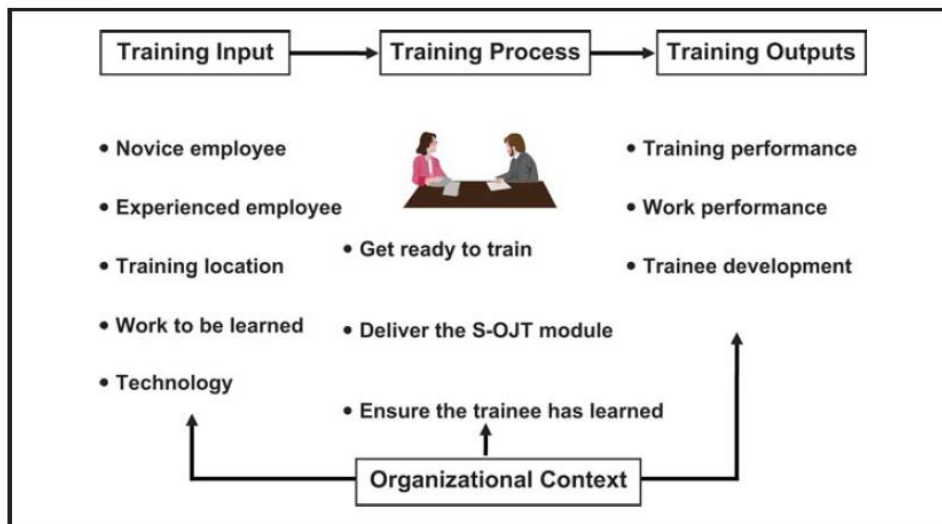
Due to proximity of this this approach to the actual working environment, the level of predictability of training effectiveness improves as it is being conducted by mostly senior technician in a working facility. S-OJT has a flexibility where the training approach can be initiated as and when the need arises with minimal demand on special arrangement within an organisation.

As S-OJT is being conducted in an actual working environment (aircraft maintenance facility), supervisors and managers may serve as trainers who is able to emphasize the specific skills and knowledge thereby effectively transferring the core knowledge and skills that is essential for the task. This directly address the competency areas that is crucial for the task or work. Generally, this process involves the actual work setting, learner (new technicians) and trainers (manager, supervisor and senior technicians).

The process (Jacobs, 2003) covers getting the trainer ready, learner ready, training events during delivery of the training and means used including periodic feedback, follow-up observations and performance rating with the objectives that the learner has been able to pick up the content of the training. The S-OJT ends with a results of achieving the objectives of the training, impact on work and individual self-development progress. Eventually, the organisation is able to ensure that its competency are available as it continues to sustain and move forward.

The basic principle of S-OJT system is displayed in figure 1 below. S-OJT research is an emerging trend especially in the Malaysian aviation industry to attain its aviation maintenance competencies.





Source: Jacobs & Bu-Rahmah

**Figure 3** Display of the S-OJT System

Justification to S-OJT approach to develop competencies can be supported by Torraco (2016), records that during and after World War II, there was a dramatic increase of demand for trained workers. They were brought on due to the expansion of wartime economy and technology innovation. This indicates that human capital itself has the ability to be trained to the right level. Torraco (2016), further opined that training within industry (TWI) was a nationwide partnership between industry and U.S War Manpower Commission to produce military hardware and train millions of workers needed for the enormous transformation to a wartime economy. TWI helped to establish technical training programs in 16,511 manufacturing plants nationwide and when it closed down in 1945, 23,000 were trained to trainers and certified 1,759,650 productions supervisors. Though this approach may not be the same with S-OJT, it does shows that this approach can be utilized to support the growth and economy of an organisation. However, it is important to note that this ability should not only occur during the war time, but also during the current socio-economy status of organisations. The TWI need to be improved to finer details and S-OJT is the improved systems.

In addition, Glass (2013), insist that the rise of US Labour movement also contributed to the growth of employee training and development. Additional labour movements invariably leads to additional training in a growing economy. Without which the economic growth on an organisation sustainability will be affected. One of the key to support an organisation sustainability is through having a effective training system such as the S-OJT approach.

According to Torraco (2016), when peace returned to the economy, training has reduced in size but it remained as a permanent fixture to most organisation. It is clear that overcoming competency deficiency, training through S-OJT approach is necessary for an aircraft maintenance organisation. For an organisation which provide aircraft maintenance services

to ensure high airworthiness condition of the aircraft, S-OJT training approach ensure this objective are achievable.

## CONCLUSION

Though competency is an issue within an organisation as well as its employees, S-OJT approach can be adopted to address this competency issue. The main area of focus of S-OJT is the training efficiency and training effectiveness. Training efficiency includes the reduced time for the training session while achieving the knowledge and skills required in aircraft maintenance field. The outcome of the training includes improved work performance, training performance as well individual development. This itself brings the financial benefits in-directly. The training effectiveness outcome results in improved work outcomes. This include lower error, higher airworthiness of aircraft, more effective trouble shooting skills and knowledge as well as lower incidents and accidents. To adapt the S-OJT in an organisation, it will require application in an organisation to experience its benefits.

## REFERENCES

- Boyd, B. & Stolzer, A. (2015). Causes and Trends in Maintenance-Related Accidents in FAA-Certified Single Engine Piston Aircraft. *Journal of Aviation Technology and Engineering*, 5/1, 17-24
- Chandler, T.N. (1998). Training. In Maddox, M (Ed), *Human Factors Guide for Aviation Maintenance* (pp. Chapter 7). Washington DC: Federal Aviation Administration
- Conchúir, E. O., Holmström, H., Ågerfalk, P. J., & Fitzgerald, B. (2009). Benefits of global software development: Exploring the unexplored. *Software Process: Improvement and Practice*, 14, 201-212. doi:10.1002/spip.417
- Faagov. (2017). Faagov. Retrieved 8 October, 2017, from [https://www.faa.gov/regulations\\_policies/handbooks\\_manuals/aircraft/amt\\_handbook/media/FAA-8083-30\\_Ch13.pdf](https://www.faa.gov/regulations_policies/handbooks_manuals/aircraft/amt_handbook/media/FAA-8083-30_Ch13.pdf)
- Federal Aviation Administrator. 2016. faa-8083-30\_ch12.pdf. [ONLINE] Available at: [https://www.faa.gov/regulations\\_policies/handbooks\\_manuals/aircraft/amt\\_handbook/media/faa-8083-30\\_ch12.pdf](https://www.faa.gov/regulations_policies/handbooks_manuals/aircraft/amt_handbook/media/faa-8083-30_ch12.pdf) [Accessed 25 Oct 2016]
- Glass, F. (2013). *Work, money and power: Unions in the 21st century* (3rd ed.). Berkeley: The UC Berkeley Centre for Labour Research and Education.
- Gpogov (2). (2017). Gpogov. Retrieved 8 October, 2017, from <https://www.gpo.gov/fdsys/granule/CFR-2013-title14-vol3/CFR-2013-title14-vol3-sec121-378>
- Gpogov. (2017). Gpogov. Retrieved 8 October, 2017, from <https://www.gpo.gov/fdsys/pkg/CFR-2011-title14-vol3/pdf/CFR-2011-title14-vol3-part147.pdf>
- Harvard University. 2016. Harvard University Competency Dictionary. [ONLINE] Available at: [https://apps2.campuservices.harvard.edu/cas/empldocs/cs/harvard\\_competency\\_dictionary\\_complete.pdf](https://apps2.campuservices.harvard.edu/cas/empldocs/cs/harvard_competency_dictionary_complete.pdf). [Accessed 25 October 2016].

- Jacobs, R.L. & Bu-rahmah, M.J. (2012). Developing employee expertise through structured on-the-job training (S-OJT): an introduction to this training approach and the KNPC experience. *Industrial and Commercial Training*, 44(2), 75-84.
- Jacobs, R.L. (2003). *Structured on-the-job Training: Unleashing Employee Expertise in the Workplace*, Berret-Koeher, San Francisco, CA
- Jacobs, R.L. (2017). Knowledge Work and Human Resource Development. *Human Resource Development Review*, 16(2), 176-202.
- Kinnison, H.A & Siddiqui, T. (2013). *Aviation Maintenance Management*. (2nd ed.). USA: McGraw-Hill.
- Magpili, N.C & Pazos, P. (2017). Self-Managing Team Performance: A Systematic Review of Multilevel Input Factors. *Small Group Research*, 1(1), 1-31
- Martin, B.O & Kolomitro, K. (2014). Training Methods: A Review and Analysis. *Human Resource Development Review*, 13(1), 11-35
- McCall, M.W., Lombardo, M.M., & Morrison, A.M. (1988). *The lessons of experience: How successful executives develop on the job*. Lexington, MA: Lexington Books
- McCauley, C.D., Ruderman, M.N., Ohlott, P.J., & Morrow, J.E. (1994). Assessing the developmental components of managerial jobs. *Journal of Applied Psychology*, 79(4), 544-560.
- Moe, N. B., Cruzes, D. S., Dybå, T., & Engebretsen, E. (2015, July). Coaching a global agile virtual team. In *Global Software Engineering (ICGSE), 2015 IEEE 10<sup>th</sup> International Conference* (pp. 33-37). Ciudad Real, Spain: IEEE. doi:10.1109/ICGSE.2015.26
- Professional Aviation Maintenance Association (PAMA) (1992). Required Recurrent Training. PAMA News. Volume 13, Number 7
- Sackett, P.R & Walmsley, P.T. (2014). Which Personality Attributes Are Most Important in the Workplace?. *Perspectives on Psychological Science*, 9(5), 538-551
- Salvendy, G., & Pilitsis, J. (1980). The development and validation of an analytical training program for medical suturing. *Human Factors*, 22, 153-170
- Sheikh, S. A. (2008). Use of new knowledge and knowledge management to gain competitive advantage. *Communications of the IBIMA*, 1, 34-41.
- Spencer, F.W & Schurman, D.L (1995). Reliability assessment at airline inspection facilities. Volume 3: Results of an eddy current inspection reliability experiment (DOT-FAA-CT-92-12-V-3). Arlington, VA: National Technical Information Service.
- Srikanth, P.B & Jomon, M.G. (2015). Perception of Managerial Competency Needs: An Indian Perspective. *South Asian Journal of Human Resources Management*, 2(2), 139-170
- Torraco, R.J. (2016). Early History of the Fields of Practice of Training and Development and Organisation Development. *Advances in Developing Human Resources*, 18(4), 439-453
- Vipond, L.K (1990). FAA's proposed revision to Parts 145 and 65. In J.F. Parker, Jr.(Ed.), *Human Factor Issues in Aircraft Maintenance and Inpection, Training Issues*. Washington, DC: Federal Aviation Administration.
- Wu, J.L. (2013). The Study of CompetencyBased Training and Strategies in the Public Sector: Experience From Taiwan. *Public Personnel Management*, 42(2), 259-271

# IMPROVING METHOD OF ESTIMATION ACCURACY OF VALUE OF PRODUCT DEVELOPMENT BASED ON BOTH OF POSITIVE AND NEGATIVE DATA

**Tsuyoshi Koga<sup>1</sup>, Takao Eguchi<sup>1</sup>, Takayuki Isaka<sup>1</sup>, Ken Kaminishi<sup>2</sup>**

<sup>1</sup>*Department of Mechanical Engineering, Yamaguchi University, 2-16-2, Tokiwadai, Ube City, Yamaguchi Prefecture, 755-8611 Japan*

<sup>2</sup>*Graduate School of Innovation and Technology Management, Yamaguchi University, 2-16-2, Tokiwadai, Ube City, Yamaguchi Prefecture, 755-8611 Japan*

## **Abstract**

This paper proposes an improving method of estimation accuracy of value of product development. The value of product development is calculated using influence diagram and reverse-profit diagram based on discovery driven (DDP) method. Classical DDP method uses a subjective hypothesis as an input data. In product development lifecycle, huge data including positive and negative is obtained in research stage, design stage, and mass-production stage. Focusing on the utilizing the various kinds of data, this paper proposes an update algorithm of the subjective hypothesis into objective hypothesis using Bayesian probability. Bayesian probability is introduced into the influence diagram and updating algorithm. Likelihood function and odds are defined by experts at first. The likelihood function and odds are updated based on real data. An example of value estimation and improving process is shown using i-painter project.

**Keywords:** *Business value estimation, discovery driven planning, Bayesian probability*

## **INTRODUCTION**

### **Difficulties of Estimating Development Value**

Estimation of the value of the product development is difficult because there are many elements which affects to the business value. Not only direct elements of the product development but also environmental and economical elements affect to the product development profit. The value of the product development itself is difficult to define, because many firms including profitable and non-profitable organisation perform the design and creation activities. In many cases, the product development efforts are done by profitable organisation. Hence this research assumes that the product development is done by profitable organisation such as stock company.

### **History of Value Estimation of the Product Development**

The accurate value estimation of product development is important because it derives collect decisions about all details including product architecture, development organisation, milestones of development projects, and strategy of intellectual properties. Many efforts addressed to evaluate accurate value of product development. The risk-evaluation methodologies discussed in real-option society is one of the evaluation efforts. Based on definition of business risk using uncertainty, appropriate decisions are numerically and probabilistically evaluated based on combined method of probability of the branch and combination tree of the project options (Sawada and Satou, 2002). Focusing on not only

numerical studies but also learning processes for individuals and organisation, a discovery driven planning (DDP) method is proposed for estimating business value (McGrath and Macmillan 2009). This DDP matches to create a model of the value of the product development considering strong uncertainty and many risks involved in business system. Software implementations of DDP are proposed and case studies are applied today (Tezuka et al. 2007). Some extension methods are proposed based on the discovery driven method. During product development lifecycle, many alternative actions are selected to improve the project value and reduce the business risks. These actions are defined as strategic options or tactical options in the product development, and method to optimize the combination of the options by simulating and calculating the project value (Eguchi et al., 2015). Influencing elements to the product development consist of not only quantitative data, but also qualitative data. In the early development stage, the qualitative data is relatively much more important than the quantitative data. Isaka et al. (2015) focuses on the two aspects of the value estimation, and two-step approaches using both of qualitative checklist method and quantitative model simulation method is established (Isaka et al., 2015). In order to support this process, a computational algorithm for automatic calculation of the project value combining considerable strategic options are proposed (Muraya et al., 2016).

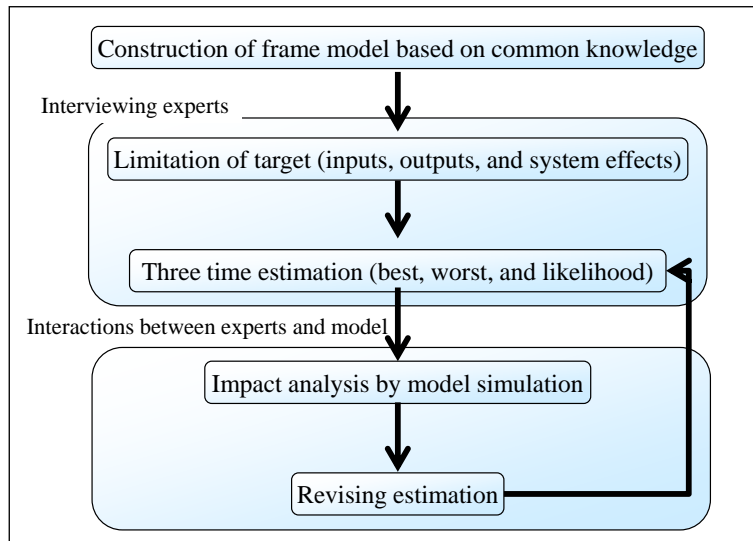
### **Focus Point and Purpose of This Research**

The discovery driven planning method is quite meaningful and effective as a learning method for product development team, although the value estimation mainly depends on the subjective hypothesizing of influencing elements. Today, sensor network and information channels are becoming to provide huge data related to the market, development, production, and supply-chain. Combining classical discovery driven method and recent mega data-driven approaches, this paper assumed that an updating and en-accurate method for discovery driven method would provide more accurate information about decision makings during project life-cycle. Because today's product development consumes a lot of time, there are few products which can be developed within one year. Many products such as computers, automobiles, medical devices, and sports equipment are required to take at least two or three years to be developed. In these days, one year is enough to change the development environment not only economically, but also technically and socially. This is why this paper focus on the real-time updating methodologies of the estimated project value by DDP based on on-time data internally and externally.

Considering these circumstances, purpose of this paper is to develop a computational updating method to make more precise decision of the product development. In order to achieve this goal, this paper expands an original discovery driven planning method to treat statistic variables related each other. In order to update using statistic data, this paper uses a Bayesian probability to define the probability in influence diagram. The real data involves not only positive data which describes a success of an event, but also negative data which describes a failure or fault of the event. Hence, this paper focuses on not only positive data but also negative data. In the last chapter, the proposed methods and algorithms are evaluated using an example product development project 'i-Painter' (Ateqah, 2013).

## ESTIMATION METHOD OF ATTRIBUTE HYPOTHESIS

### Method to Create Attribute Hypothesis Subjectively



**Figure 1.** Subjective method to create hypothesis of attributes

Basically, computer is useful to update and optimize the formulized problem, although it is difficult to apply computational algorithm to defining and formulizing a problem at first. Then the first stage of the estimating and refining the project value is to create the value-estimation model by interviewing or individual subjective approach.

Figure 1 show that the subjective estimation algorithm of target attributes of the value-estimation model. Many experts already have fragmental knowledge explicitly or implicitly. Usually the number of the constituent of the product development is huge. Then interviewing and limiting the target is the first step. What kind of relationships between inputs and outputs are required, how to affect to the other systems and all of the product is asked. Three questionnaires are recommended to as follows:

- (1) best value of focusing attribute
- (2) worst value of focusing attribute
- (3) likelihood value of focusing attribute

At the same time, the length and deepness of the experiences about this attribute is asked. The discovery driven method defines an attribute as range. This question provides not only the range of the attribute, but also the deviation of focusing attribute.

Using the proposed value estimation method, quickly the experts and interviewer can know the impacts on the business value by model estimation. If there are some wrong points,

revising value can be used to estimate the overall value. This is the learning process and extracting process of implicit knowledge of the experts.

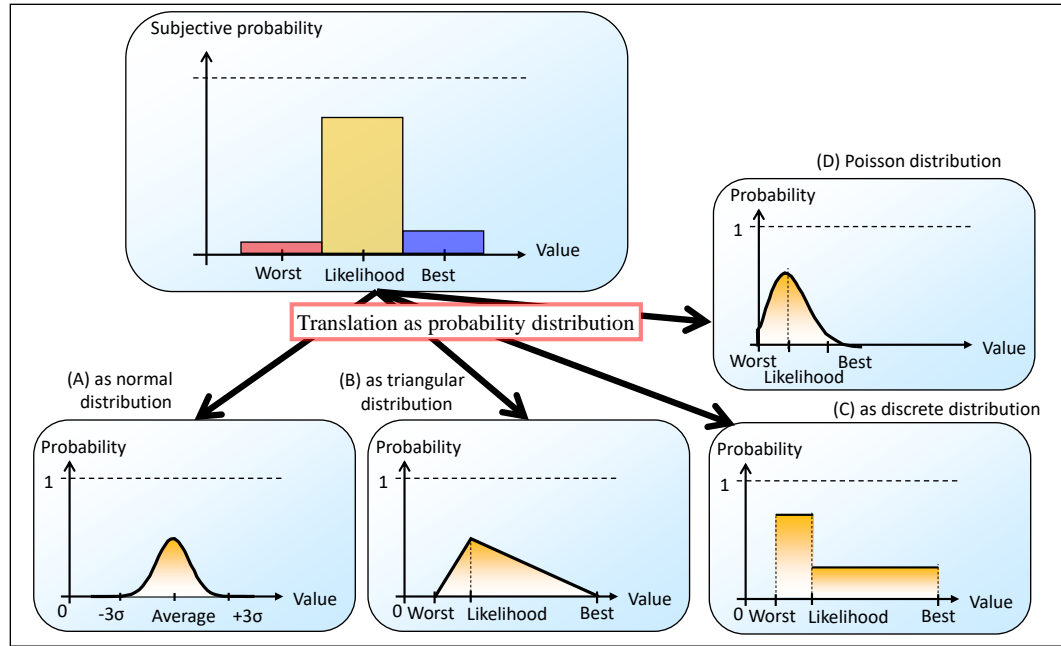
Table 1 provide a method of three-time estimation of elemental value and frequency. Values are estimated according to consider (1) best case, (2) most likelihood case, and (3) worst case. The level of frequency is defined as in Table 2. The frequency means how frequent the value is observed in the attribute. According to the level of the frequency, the number 1 – 5 is selected.

**Table 1.** Three-time estimation of elemental value and frequency

	Value	Unit	Level of frequency
Best case	120	JPY	4
Most likelihood case	100	JPY	1
Worst case	70	JPY	5

**Table 2.** Level of frequency in three-time estimation

	Level of frequency
5	Best throughout history
4	Best in your experience
3	Best in current situation
2	Prospected as it is usual
1	Reproduce-able with confidence



**Figure 2.** Translation from subjective probability to three types of probability distributions

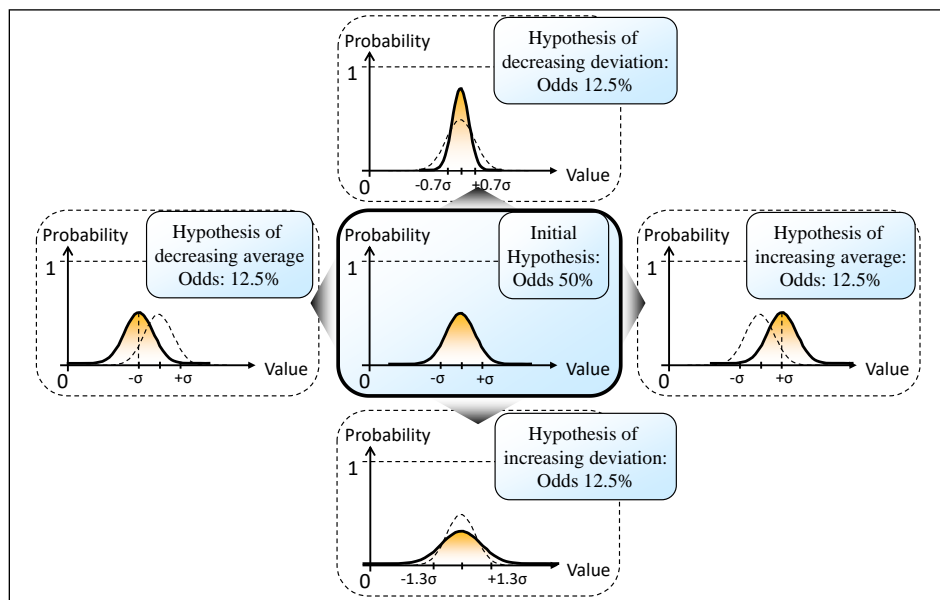
The value of the attribute versus level of the frequency provides a probability chart as shown in Figure 2. The subjective probability shows a subjective extraction result of the

probability. The horizontal axis shows a value of focusing attribute. In the three cases (1) worst, (2) likelihood, and (3) best, the subjective probability is estimated. The subjectively estimated probability is translated into four different types of probability distributions:

- (A) Normal distribution,  
in this case likelihood value is average and worst-best value indicates deviation
- (B) Triangular distribution  
in this case likelihood value is translated as statistic mode and worst-best value indicates the range
- (C) Discrete distribution, and  
in this case constant probability is defined between worst-best variables
- (D) Poisson distribution.  
in this case, average and deviation is extracted from subjective mean and deviation

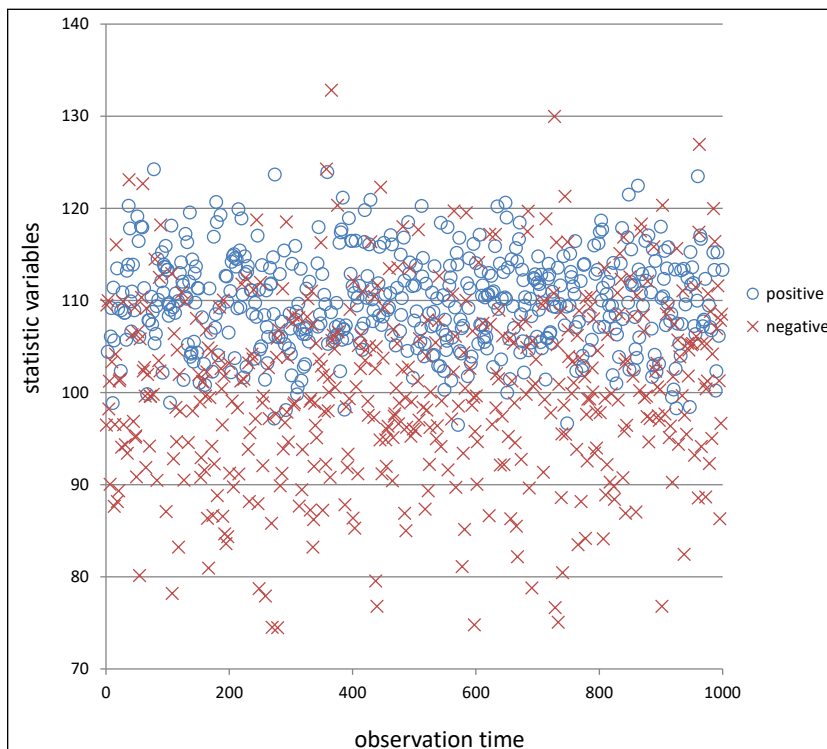
### Updating Algorithm Based on Collected Data

The hypothesis of each attribute is subjective and sometime wrong from real-actual one. For improving accuracy of the estimation, an update algorithm of subjective data using objective data is required. Figure 3 describes an automatic creation method of neighbourhood hypothesis. An initial hypothesis about probability distribution is defined by subjective interviewing result as in the centre. There are four directions of improving accuracy: (1) increasing average, (2) decreasing average, (3) increasing deviation, and (4) decreasing deviation. The odds are defined as 50% in the most likelihood probability distribution. The neighbourhood probability distribution is given rest of 50% as equally, so the odds will be 12.5%.



**Figure 3.** Automatic creation method of neighbourhood hypothesis





**Figure 4.** Example of the positive and negative data

Usually data surrounding the product development have two difficult kinds of state such as like succeed / failed, accepted / rejected, completed / uncompleted, or purchased / not purchased. When these two dimensions can be modelled as in the same simple form, connected model elements from different domains can be estimated on the same table.

Figure 4 represents the two aspects of the data as in the positive state and negative state, and shows the sequential data in the same graph. The vertical axis represents the time which the data is collected, and vertical axis represents the value of the statistic variables. By importing these real data, the actual distributions and mean of each statistic variable is estimated.

Figure 5 shows an algorithm of updating odds based on Bayesian probability. Initial odds are given to the initial hypothesis and neighbour hypothesis, in this figure a hypothesis of increasing average is selected. In this probabilistic set and odds, after importing one data which have  $+2\sigma$  positive, the odds is updated. The updating logic is as like this – the probability of initial hypothesis with  $+2\sigma$  positive is the multiple of the initial odds ( $=50\%$ ) and probability of  $+2\sigma$  positive in cumulative curve of the normal distribution ( $2.2\%$ ), hence the result is approximately  $1.1\%$ . On the other hand, the probability of the hypothesis of increasing average with  $+2\sigma$  positive is the multiple of the initial odds ( $12.5\%$ ) and probability of  $+2\sigma$  positive in cumulative curve of the normal distribution ( $15.7\%$ ), hence the result is approximately  $2.0\%$ . New odds between initial hypothesis and hypothesis of

increasing average is given by the ratio of these two 1.1 % and 2.0 %, then the new odds for initial hypothesis is 64.5% and hypothesis of increasing average is 2.0 %.

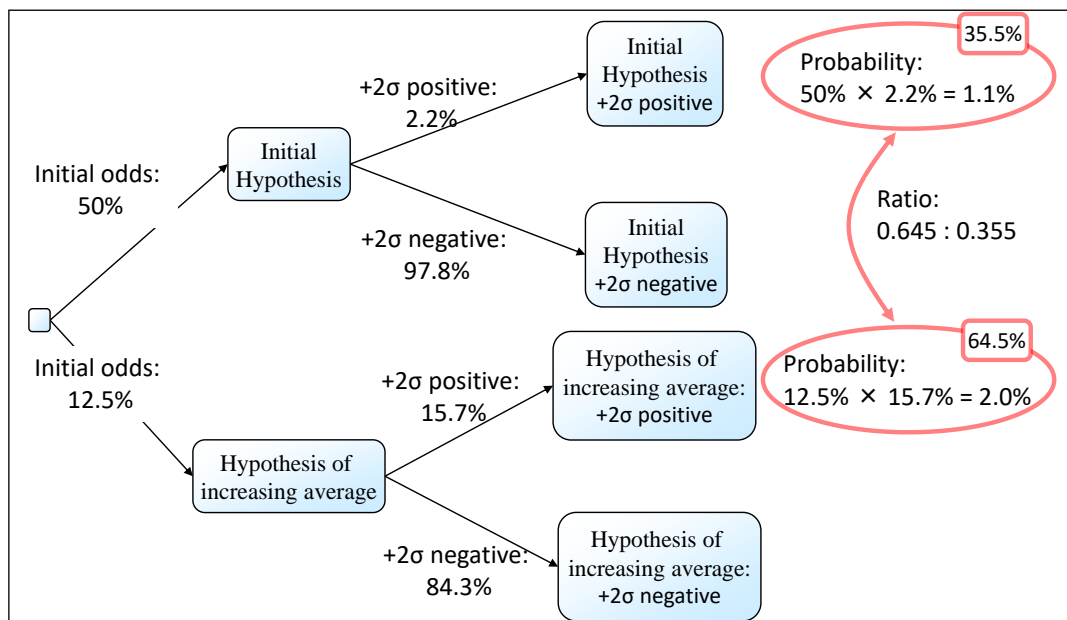
A question ‘how to merge the positive and negative state in the Bayesian probability’ becomes an issue. Figure 6 shows a method to create a new distribution from real positive and negative data. The creation process of combined distribution based on positive and negative data is as four steps:

(A) Importing positive negative data

At first, mixed data is gained from real-time observation. The positive data and negative data shows as each circular or cross dot which have each value as statistic variables.

(B) Creating histogram of positive and negative data

Using gained positive and negative data, a histogram of positive data and negative data is calculated. What kind of distribution they follow does not matter in this stage. Crossing area of the positive and negative data is the balanced zone of this statistic variable.



**Figure 5.** Algorithm of updating odds based on Bayesian probability

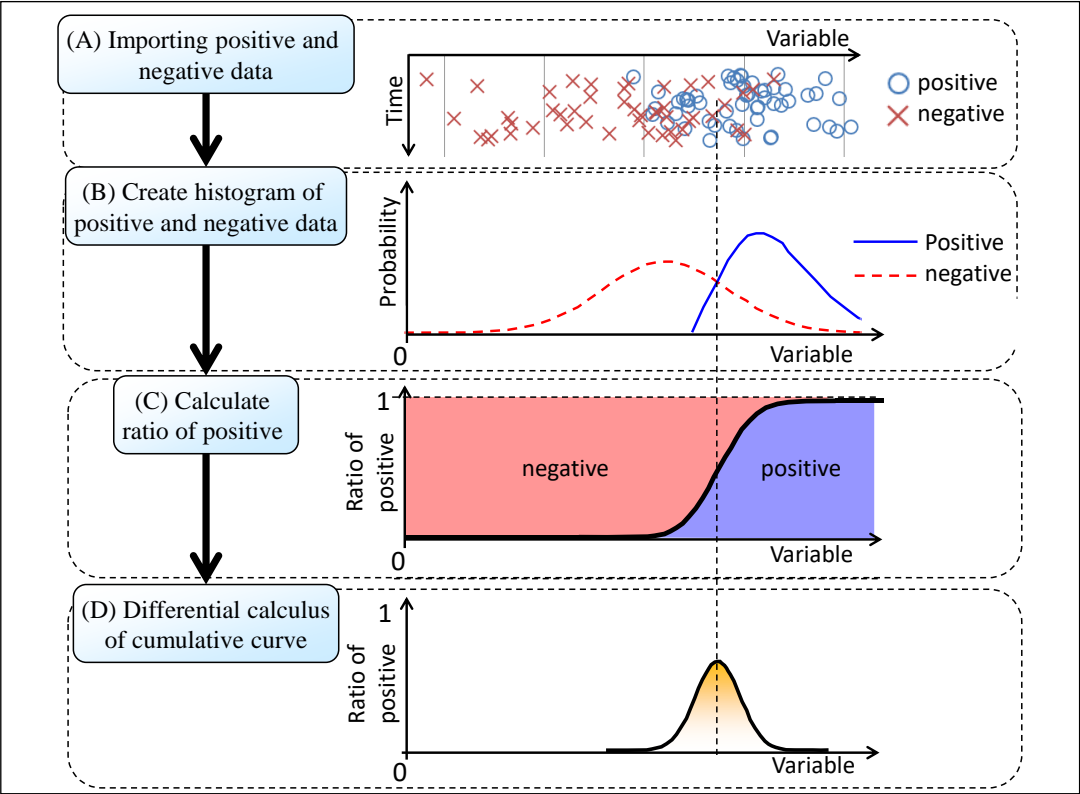
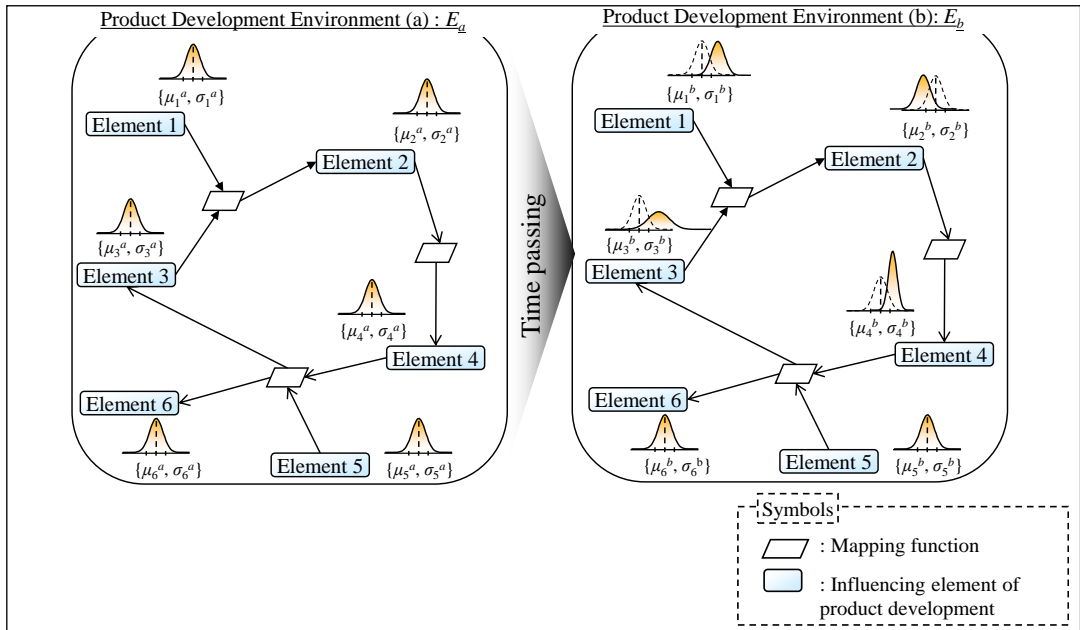


Figure 6. Combined distribution based on positive-negative data



## (C) Calculating ratio of positive / negative

The two-histogram data from real data have ratio in each value of statistic variable. The discussing point is the ratio of the positive data. Then the ratio of positive is calculated by the ratio of two histograms. The vertical axis represents a value of the statistic variable, and vertical axis displays the ratio of the positive. This curve can be understood as a cumulative curve of the probability of changing from negative to positive.

## (D) Calculation of changing distribution from negative to positive

By the ratio curve of the positive and negative, a cumulative curve is calculated. By differential calculus of this cumulative curve, a probabilistic distribution is calculated. This distribution indicates the distribution of change from negative to positive.

In product development lifecycle, all environmental elements such as economical, technological, competitors, and social elements will change greatly. The old data becomes not suitable to prospect the project value sooner or later. The old data have to be forgotten in proper way. This is a reason why this estimation method needs a forgetting algorithm of data.

The required forgetting level depends on how far the current business environment is from the circumstance which the data is gained. Then this paper proposes a measurement function of difference between two development environments. Figure 7 shows the two environments about product development. The development environment is modelled based on the influence diagram (Eguchi et al., 2015). Each element have mean and distribution, and the difference of mean and distribution determines the distance between two environments as in the formula (1) and (2).

Average difference between  $E_a$  and  $E_b$  :  $\mu_{a,b}$

$$\mu_{a,b} = \|\mu_a - \mu_b\| = \sqrt{\sum_{k=0}^n \frac{(\mu_k^a - \mu_k^b)^2}{(\mu_k^a)^2}} \quad \dots (1)$$

$$\text{where: } \mu_a = \{\mu_1^a, \mu_2^a, \mu_3^a, \mu_4^a, \mu_5^a, \mu_6^a\}$$

$$\mu_b = \{\mu_1^b, \mu_2^b, \mu_3^b, \mu_4^b, \mu_5^b, \mu_6^b\}$$

Variance difference between  $E_a$  and  $E_b$  :  $\sigma_{a,b}^2$

$$\sigma_{a,b}^2 = \sigma_a^2 + \sigma_b^2 \quad \dots (2)$$

$$\text{where: } \sigma_a^2 = (\sigma_1^a)^2 + (\sigma_2^a)^2 + (\sigma_3^a)^2 + (\sigma_4^a)^2 + (\sigma_5^a)^2 + (\sigma_6^a)^2$$

$$\sigma_b^2 = (\sigma_1^b)^2 + (\sigma_2^b)^2 + (\sigma_3^b)^2 + (\sigma_4^b)^2 + (\sigma_5^b)^2 + (\sigma_6^b)^2$$

Based on the distance of different development environment  $\mu_{a,b}$  and  $\sigma_{a,b}$ , forgetting filter is applied in importing data which have high weight for recent data and less weight for old data.

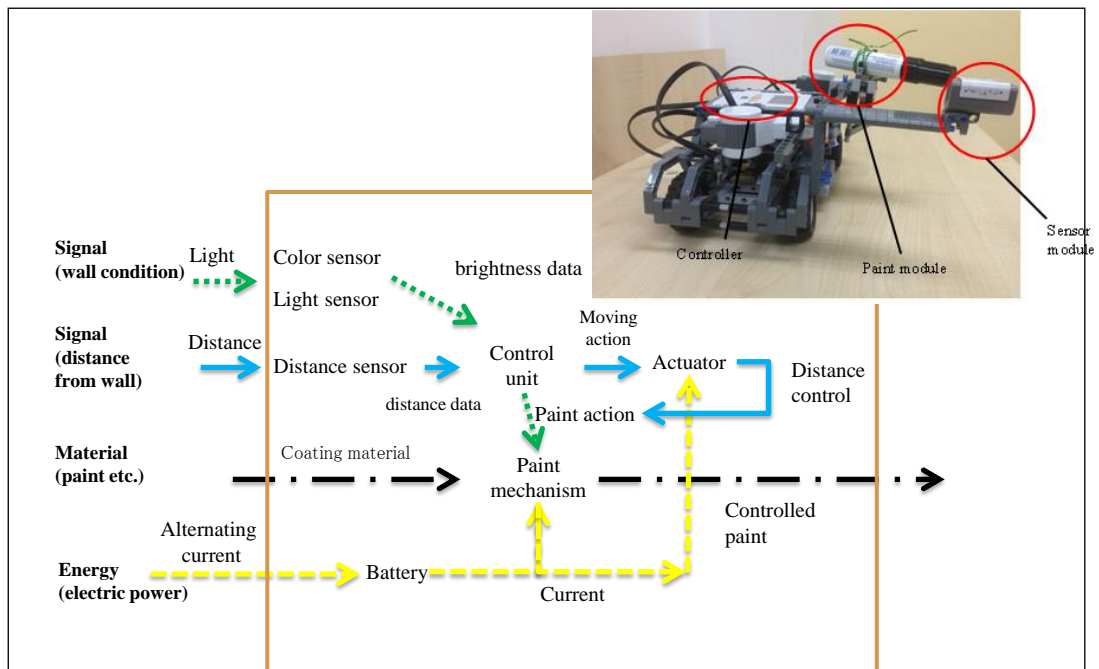


Figure 8. Example product development project: i-Painter

## EXAMPLE OF VALUE EVALUATION AND DISCUSSION

### Example Project 'i-Painter'

In order to confirm the effectiveness of the proposed method, a product development project 'i-Painter' (Ateqah et al., 2013) is evaluated its business value. The i-Painter project is the development project which maintains and repairs the wall of high building. Its function is to detect, paint, and repair the clack of the wall and lack of painting area to protect the strength of the high buildings from raindrops and wind. Figure 8 represents the functional diagram and components of the i-Painter.

### Estimation of Value of the i-Painter Development

According to the discovery driven planning method, a reverse profit diagram (figure 9) and an influence diagram (figure 10) is modelled. The reverse profit diagram represents the constituent of the overall present e.g. sales price, number of sales, initial cost, and running cost. The influence diagram represents relationships between the elements which relate to the market, development, and production. Based on these two diagrams, impact of element change is analysed for example, the economic environment rises, then the parts cost and utility cost is go up although the number of sales also increase at the same time.

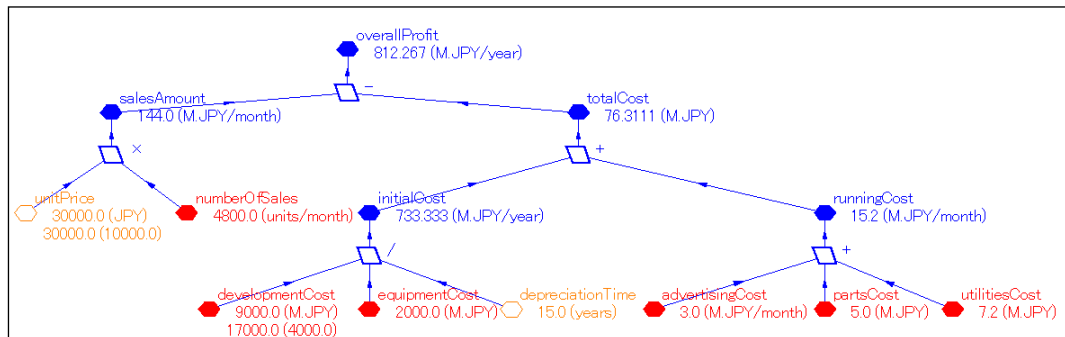


Figure 9. Reverse profit diagram of i-painter project

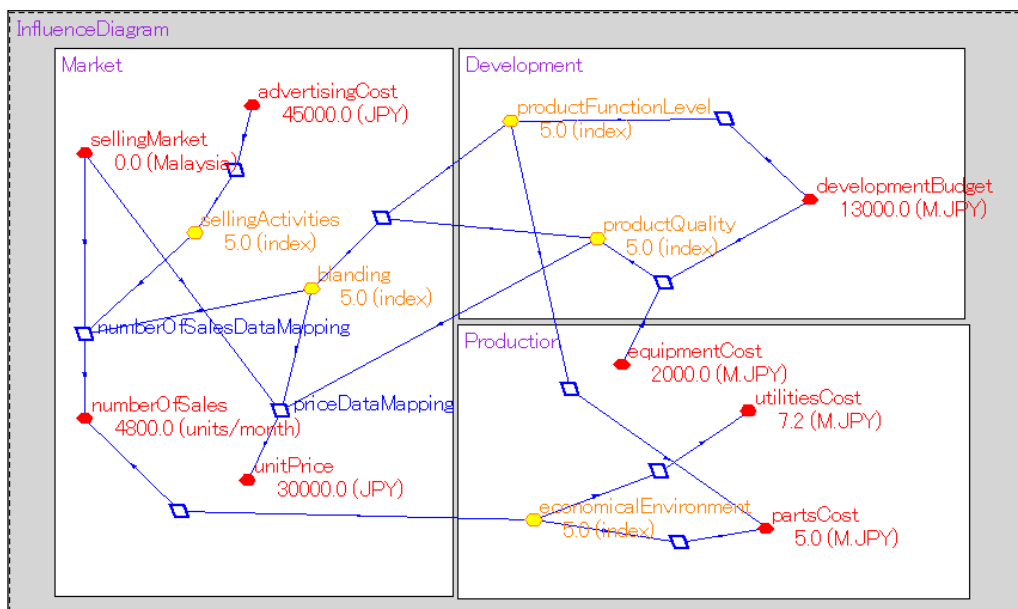


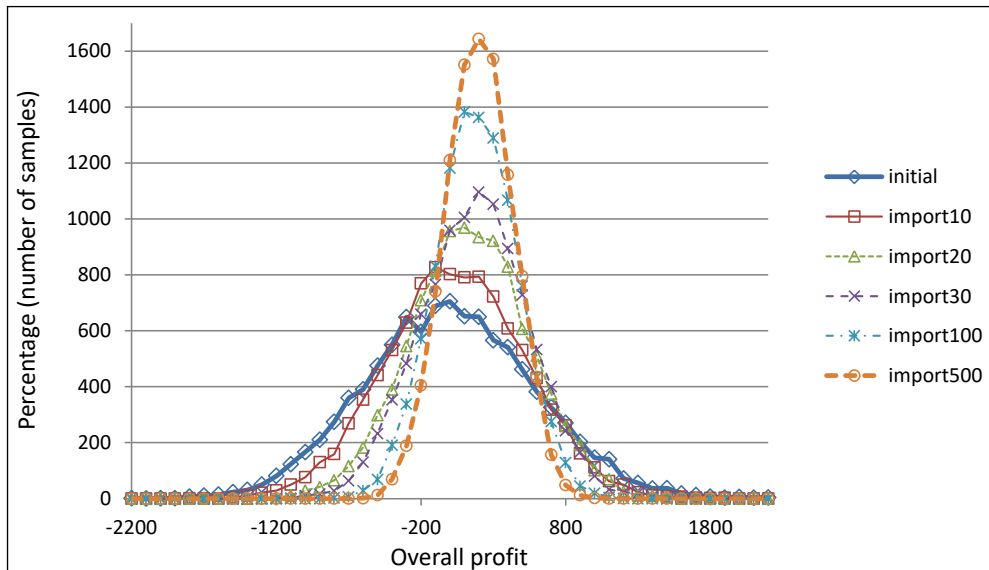
Figure 10. Influence diagram of i-painter project

## Revising Hypothesis Using Real Data

Every element is defined as the subjective range of the variable at first. On two elements (unit price and development cost), five hundred of real data is gained and imported. Based on proposed method and imported data, the mean value and deviation is revised.

Figure 11 shows a simulation result using Monte Carlo method. Horizontal axis means the value of the overall profit of the i-Painter project, and vertical axis represents the possibility. First distribution based on only subjective modelling is shown in 'initial' result. 'import10' result shows a result which revised the element distribution by 10 data. 'import20', 'import30', 'import100', 'import500' represents a simulation result which

revised the element distribution by 20, 30, 100, 500 data respectively. By this chart, process of reducing risk and en-precise of prospection can be grasped.



**Figure 11.** Reducing process of risk by importing data

## CONCLUSION

This paper proposes how to utilize huge size of data which effects to the value of the product development, and how to revise the estimation of the project value based on Bayesian probability. The result indicated that the average of the calculated overall profit of the i-Painter project is shifting by the number of the importing data. Not only the average, but also the deviation of the estimated project value is changed according to increasing the number of data which is imported. The accuracy of the estimated value is improved according to increment of the number of data. It means that the purpose that revising the value estimation by data is effectively working on the proposed method.

In future, proposed real-data importing method can be applied to massive, huge number of data. By connecting with IOT (internet of things) technologies, the proposed method could contribute to realize the automatic data accumulating method and debugging method for development decisions.

## REFERENCES

- Ateqah K. and Ushiro K. (2013) Prototyping of automatic wall painter in Asia Creative Design Project. *Proceedings of the 13th Design Engineering Workshop (DEWS) 2013*, IDC-20, Kitakyushu, Fukuoka, Japan (CD-ROM).
- Eguchi, T., Morihiro, J. and Koga, T. (2015) Business value estimation of product development project by introducing strategic option into real option. *TRANSACTIONS OF THE JAPAN SOCIETY OF MECHANICAL ENGINEERS Series A*, 81(825):14-00398.
- Eguchi, T., Morihiro, J., Matsuo T. and Koga, T. (2015) An assessment method of business value of product development project which is integrated with scenario planning method, *Proceedings of the Design and Systems Division Conference*, 3103, Shinshu University, Nagano, Japan.
- Isaka, T., Yoneda, W. and Koga, T. (2015) Proposal on Hybrid Check List Method For Bidding Decision for International Infrastructure Project. *Proceedings of the Design and Systems Division Conference, Japan Mechanical Society*, 3105, Shinshu University, Nagano, Japan.
- McGrath, R.G. and Macmillan, I.C. (2009) *Discovery-Driven Growth: A Breakthrough Process to Reduce Risk and Seize Opportunity*. Harvard Business School Press.
- Muraya, R., Matsuo, T., Eguchi, T. and Koga, T. (2016) Computational calculation method of impact elements of external factors for evaluating business value of product development project. *Proceedings of the Design and Systems Division Conference*, 3202, Keio University, Kanagawa, Japan.
- Sawada, M. and Satou, Y. (2002) Risk Analysis for Decision Making under Uncertainty. *Hitachi Technical Review*, (8):58-64.
- Tezuka, M., Saito, K. and Munakata, S. (2007) Influence Diagram Approach for Evaluating Project Value and Extension of the Diagram to Deal with Time Series. *Hitachi Technical Review*, (13):35-40.



# STUDY ON THE FOCUS STRATEGY OF SMALL TO MEDIUM ENTERPRISES AND START-UP COMPANIES IN THE SEMICONDUCTOR MANUFACTURING INDUSTRY – CASE STUDY OF MINIMAL FAB

**Kenji Miyake<sup>1</sup>, Ken Kaminishi<sup>2</sup>**

<sup>1</sup>PMT CORPORATION, 811-2115 1705-1 Satani, Sue, Fukuoka, Japan

<sup>2</sup>Graduate School of Innovation and Technology Management, Yamaguchi University, 755-8611 2-16-1 Tokiwadai, Ube, Yamaguchi, Japan

## **Abstract**

We have made the hypothesis verification for the focus strategy with the case study of Minimal Fab, which is a new concept of the National Institute of Advanced Industrial Science and Technology (AIST) in Japan, when Small to Medium Enterprises (SME) & start-up companies enter into the semiconductor manufacturing industry. We have used the framework of the business ecosystem as the verification method. We found that as a focus strategy: their technology development strategy should not follow International Technology Roadmap for Semiconductors (ITRS), they should have the high-mix low-volume production system which performs short delivery time and low cost and their product category should be a low-end semiconductor device under constrained conditions that the business ecosystem is needed and they have Absorptive Capacity.

**Keywords:** *Semiconductor Manufacturing, Innovation, Minimal Fab, Business Ecosystem*

## **INTRODUCTION**

In the 1990's, Japanese semiconductor device manufacturing companies accounted for more than half of the world's semiconductor top 10 companies and they occupied more than 50% of the world market share. According to the World Semiconductor Trade Statistics, they accounted for 24% of the world market share, even the bursting of the IT bubble in 2001. However, they lost market share every year. In 2013, it became 11%, and it was a half of the bursting of the IT bubble.

Currently the semiconductor device manufacturing is progressing oligopoly in Intel Corporation, TSMC and Samsung Electronics. The semiconductor industry has been conducting research and development in accordance with the International Technology Roadmap for Semiconductors (ITRS), which also has been referred to as the "Wish Map" (Kameyama, 2010) of leading semiconductor device manufacturing companies, such as Intel Corporation, TSMC and Samsung Electronic. How can Small to Medium Enterprises (SME) & start-up companies cause innovation if they follow ITRS? Additionally, in the maturity industry, even if innovation occurs, can they live with existing large semiconductor manufacturing industry makers? They also have limitations on their resources. Even if large companies have a lot of resources, the success probability of business is increased by the focus strategy to focus their resources on specific technology development and product areas (Matsuda & Suzuki, 2010). Based on these, we would like to issue our research question as

follows: “When SME & start-up companies try to enter the semiconductor manufacturing industry, which has such characteristics and issues mentioned above, what strategies do they focus on to enter it?”

Miyake (2015) described the hypothesis and constraint conditions of the focus strategy as follows:

The hypothesis are,

- i. The process innovation should not be to follow ITRS.
- ii. The process innovation should be the incremental innovation to enable short delivery time and low cost by conventional technologies.
- iii. The product domain should be a low-end semiconductor device that doesn't require microfabrication, such as MEMS, compound semiconductor.
- iv. The production method is the high-mix low-volume production system.

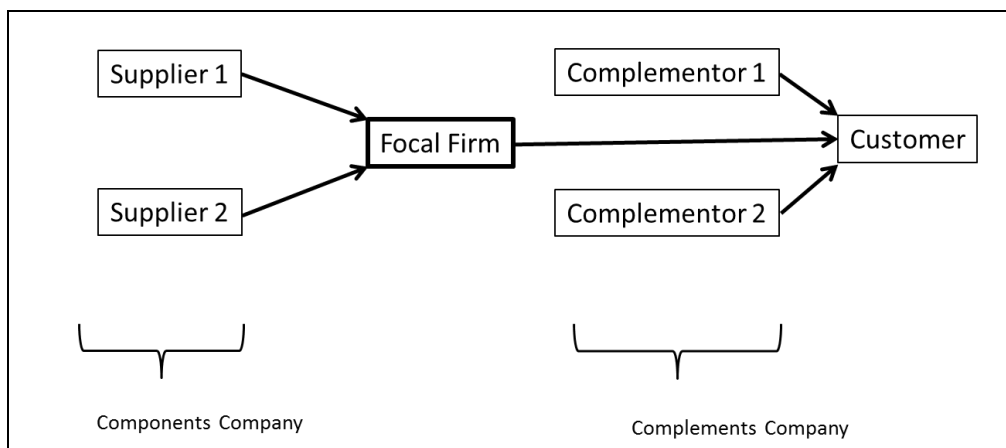
The constraint conditions are,

- i. An ecosystem should exist.
- ii. The SME & start-up company should have Absorptive Capacity.

We have conducted verification of these hypotheses by a case study, and we intend to show a constraint condition necessary to carry out the focus strategy when SME & start-up companies enter into the semiconductor manufacturing industry.

## THE FRAMEWORK OF THIS STUDY

Adner & Kapoor (2010) showed the general scheme of the business ecosystem as shown in Figure 1. It is composed of the following companies: Complements Company that complements innovation of the customer for value creation, the Focal Firm which becomes factors of the customer's innovation and the Components Company which supplies a component to the Focal Firm.



**Figure 1.** The Generic Schema of Business Ecosystem (Source: Adner & Kapoor, 2010)

Adner & Kapoor (2006) showed the business ecosystem of the lithography equipment in the microfabrication of the semiconductor production system like Figure 2 as an example using the framework of Figure 1. The success of innovation of the exposure manufacturer, which is the Focal Firm, dependent on the outcome of Components Company such as lens manufacturers and lamp manufacturers, which develop a component for part of the equipment. In addition, semiconductor device manufacturers, which are a customer of the Focal Firm, cannot produce leading-edge semiconductor devices by the exposure equipment alone, even if the innovation of the exposure equipment succeeded. Also, the semiconductor device manufacturer is affected by the results of the Complements Companies, which supplies materials such as photomask and photoresist. In this way, Adner & Kapoor (2006) analysed the impact of challenges of Components Companies and Complements Companies relate to the Focal Firm.

In the semiconductor manufacturing process, the primary equipment is not only the exposure but also more than 100 kinds of manufacturing equipment. Therefore, as the framework of the ecosystem in this study, we apply Figure 2 of Adner & Kapoor (2006) to all semiconductor production equipment as an analogy.

Furthermore, we adopt the following framework for the ecosystem generation that were described in three points by Adner (2012):

i. Co-innovation risk

This risk is that the success of the innovation of oneself depends on the success of the innovation of other companies.

For example, leading-edge semiconductor devices require fine resolution, such as the tens of nanometer range, that is needed for the innovation of exposure equipment makers, e.g. liquid immersion technology.

ii. Adoption chain risk

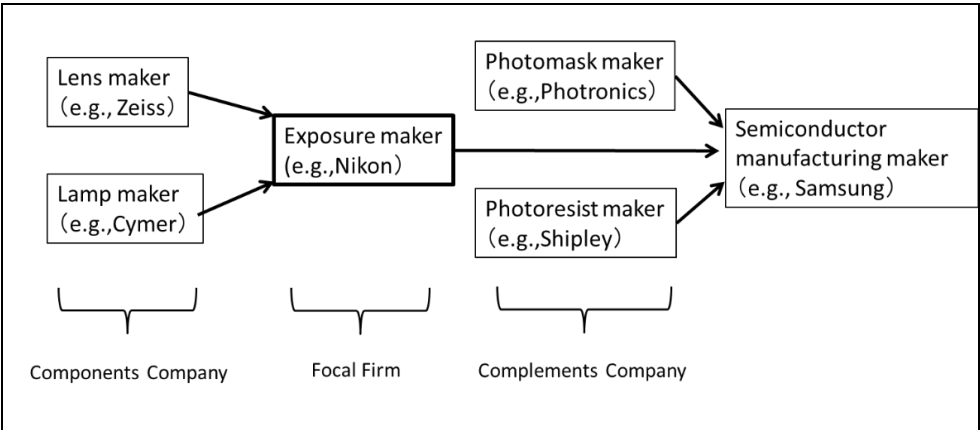
This risk is that the intermediary who offers the value to the end user, accepts the value before the end user evaluates it.

For example, when a semiconductor device manufacturer develops a leading-edge semiconductor device, the general consumers, who are an end user, cannot evaluate the device if a set makers does not implement the device in products such as a smart phones.

iii. Value blueprint

This represents an overall picture that shows the connection of the partners that make up the business ecosystem. In addition, we show the degree of connection with each partner using the familiar colour of a traffic light. The green signal represents being strongly connected. The yellow signal is a weak connection. The red signal is not connected.

For example, the ecosystem is not formed if we cannot draw the perspective with the connection similar to the food chain ecosystem.

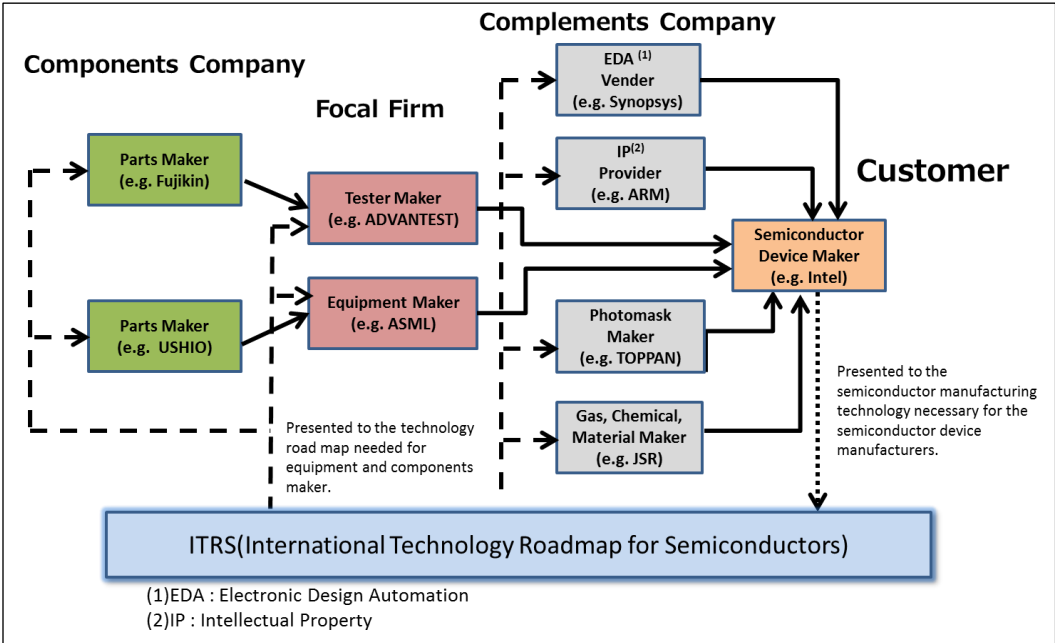


**Figure 2.** The Ecosystem of Semiconductor Lithography Equipment (Source: Adner and Kapoor, 2006)

**FRAMEWORK ANALYSIS OF EXISTING SEMICONDUCTOR PRODUCTION SYSTEM**

We apply the business ecosystem of semiconductor lithography equipment (Figure 2) to all process, e.g. diffusion process, thin film process, for semiconductor device production. This includes Focal Firm, Components Company such as a valve, a pump and Complements Company such as a semiconductor design tool, photomask, gas, and chemical (Figure 3).

The dashed line shows the association with ITRS. The major semiconductor device manufacturers such as Intel, which are the demand side, presents the time frame when the technology is necessary for the supply side, such as Complements Company, Focal Firm and Complements Company, in the necessary technology according to the product road map of the major semiconductor device manufacturers using ITRS.



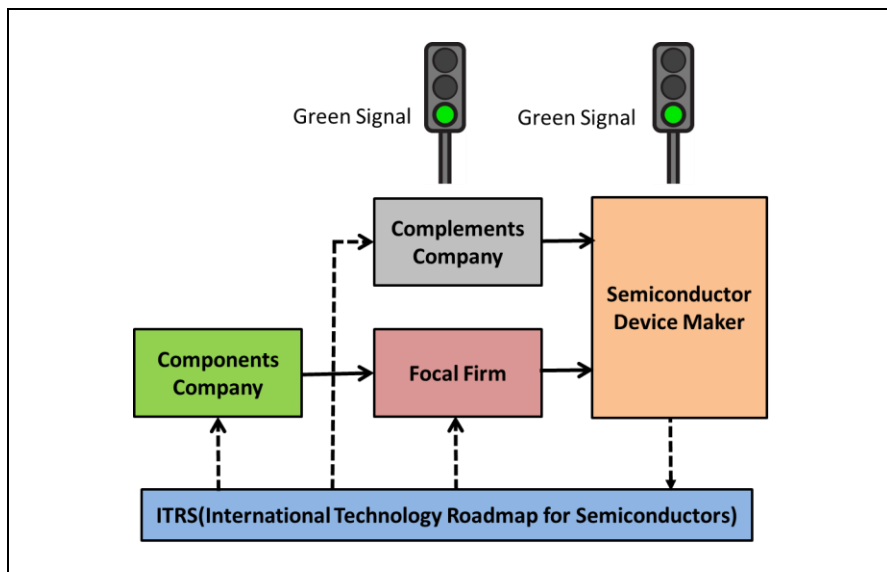
**Figure 3.** The Business Ecosystem of Existing Semiconductor Production System

Therefore, the success of its own innovation (Adner, 2012), by using ITRS means that the co-innovation risk which depends on the success of other companies innovation has become very low. Furthermore, the adoption chain risk has also become very low because ITRS is equipment and components in accordance with the Wish Map of leading semiconductor device manufacturer.

We show the value blueprint indicating the connection with the partner constituting the ecosystem in Figure 4. The dashed line shows connection with ITRS. This is the technology road map in accordance with the product roadmap of leading semiconductor device manufacturer. Therefore, products of Focal Firm, Components Company and Complements Company, related to semiconductor manufacturing, are always purchased. Thus, Focal Firm, Components Company and Complements Company in the value blueprint are connected to the semiconductor device manufacturer as shown by the solid line. Therefore, between the Focal Firm and Component Company, between semiconductor device manufacturer and Complements Company, Focal Firm, become all green signals.

As the business ecosystem circulates, we think that the huge ecosystem has been built on a global scale by ITRS.

In the next chapter, we will perform a Minimal Fab case study, and indicate that a new ecosystem that has a different value network than the business ecosystem of existing semiconductor device manufacturing has been established. Thereby we will verify that the focus strategy hypothesis is implementing.

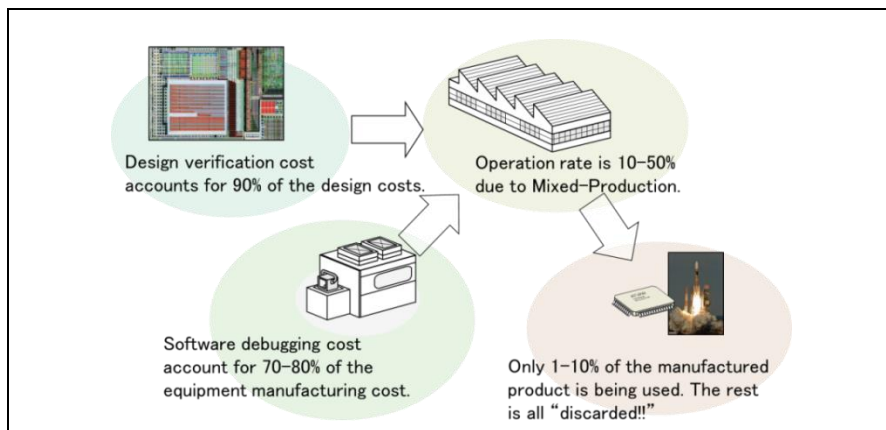


**Figure 4.** The Value Blueprint of Existing Semiconductor Production System

## MINIMAL FAB

### What is Minimal Fab?

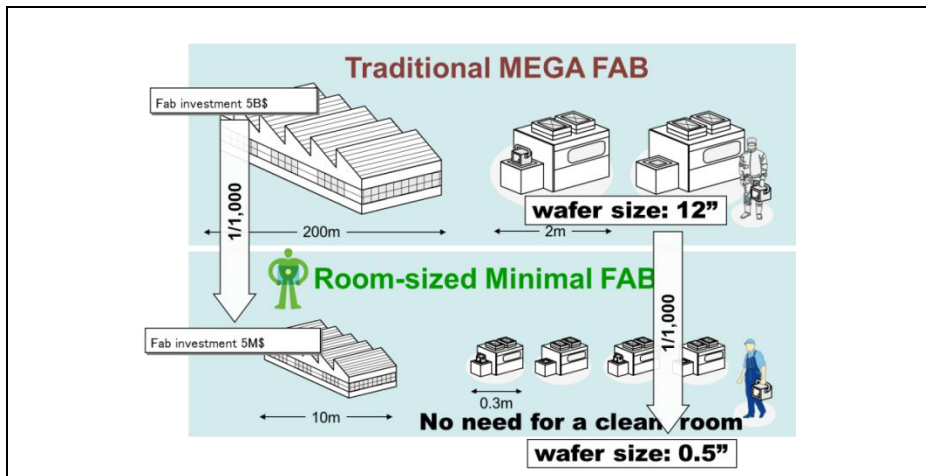
The semiconductor device production industry has proceeded oligopoly, and initial investment has reached more than 5 billion US dollars. Furthermore, there is great waste produced in existing semiconductor production systems as shown in Figure 5. For example, a complex circuit is designed by a semiconductor design miniaturization. Design verification cost accounts for 90% of the total design cost. Manufacturing equipment has multifunctional functions. So, software debugging cost account for 70-80% of the equipment manufacturing cost. Moreover, Fab is uneconomical in regards to the utilization rate of the manufacturing equipment, that has a price in the tens of millions US dollars, which is low because of mixed production of more than 500 kinds of semiconductor devices. Additionally, Fab wastes large amounts of semiconductor devices, which are mounted on a satellite, as only 1-10% of the product is used. The residual is discarded because the minimum unit of production of semiconductor devices is from hundreds to thousands.



**Figure 5.** Great Waste Produced in Existing Supply Chain (Source: Hara, 2012)

Fab System Research Consortium, which is organized by AIST, proposed a high-mix low-volume production system that is called Minimal Fab (Hara, et al., 2011) as a way to solve the problems mentioned above. This is contrary to the larger diameter wafer on ITRS, as shown in Figure 6, by using the diameter 12.5mm wafer is 1/1000 area compared to the diameter 300mm wafers in existing Fab, the width of the manufacturing apparatus is 0.294m from existing of about 2m, in addition, clean rooms and clean suits also are eliminated by developing a wafer transport container that is a minimal shuttle and PLAD (Particle Lock Air-tight Docking), that are the local cleaning front chamber system to simultaneously shut out the fine particles and gas molecules, therefor, the goal of capital expenditures of semiconductor factory has been 5million US dollars, that is 1/1000, compared to the existing system.

In existing semiconductor manufacturing systems, equipment contour and size vary in different from small to large by the manufacturing process. In Minimal Fab, the housing that has been unified as a consensus standard, it is 294 x 450 x 1440mm (Figures 7 and 8). In addition, they have performed a standardization of the transport system, wafer and the factory system, further, it has also carried out intellectual property and branding.



**Figure 6.** Minimal Fab (Source: Kubouchi & Hara, 2012)



**Figure 7.** Minimal Equipment (Source: Hara et al., 2013)



**Figure 8.** Minimal Fab at AIST

## The framework analysis of Minimal Fab

We have conducted the analysis of the Minimal Fab as shown in Figure 9, based on the framework analysis of the existing semiconductor production system was carried out above. The member companies of Fab System Research Consortium consist of Components Companies, Focal Firms, Complements Companies and the semiconductor manufacturing makers, which are the customers of Minimal Fab, as well as the business ecosystem of existing semiconductor production systems (Figure 3). As an alternative of ITRS, AIST is presenting the Minimal Fab development roadmap (Kubouchi & Hara, 2015). The dashed line indicates the relations. As with the existing business ecosystem, the co-innovation risk has become very low. However, Minimal Fab development roadmap of AIST isn't in accordance with the Wish Map of semiconductor device manufacturers. Hence, we think



that Minimal Fab will be difficult to be adopted by existing semiconductor device manufacturers. Accordingly, Minimal Fab has adoption chain risks.

We show the Value blueprint that is indicating the connection with each partner of Minimal Fab in Figure 10. As for the difference with existing production systems (Figure 3), the adoption chain risk of the existing semiconductor device manufacturer has become a yellow signal. We think that the entry barrier of Minimal Fab is relatively high, because the semiconductor device manufacturers have customized their production system for their semiconductor device manufacturing. For example, the automotive semiconductor devices. If the semiconductor device manufacturer has changed all of the production systems, such as manufacturing equipment and material, to Minimal Fab, it is necessary to take a product authorized examination by the automobile manufacturer again.

However, the value network is replaced from the mass production system of existing Fab to the high-mix low-volume production system of Minimal Fab. This system does not need a large amount of capital investment. Thus, the user companies in semiconductor device manufactures have become able to produce their own semiconductor devices by Minimal Fab. Therefore, the new connections that are from Focal Firms and Complements Companies to semiconductor device user companies are born. It is never seen in the existing value network. In fact, the first customer who purchased Minimal Fab is not a semiconductor device manufacturer but JTEKT which is automotive-related company in Japan. Moreover, SME & start-up companies have started a foundry service business (Nihon Keizai Shimbun morning edition, 10/20/2014) due to the low barrier to semiconductor manufacturing by Minimal Fab. In other words, these companies have forged a new path to complement the adoption chain risk of the existing semiconductor device manufacturers (Figures 9 and 10).

We think that Minimal Fab has been the incunabula of the new ecosystem showing to Figure 9 with the value network by the high-mix low-volume production system that is different from the existing system.

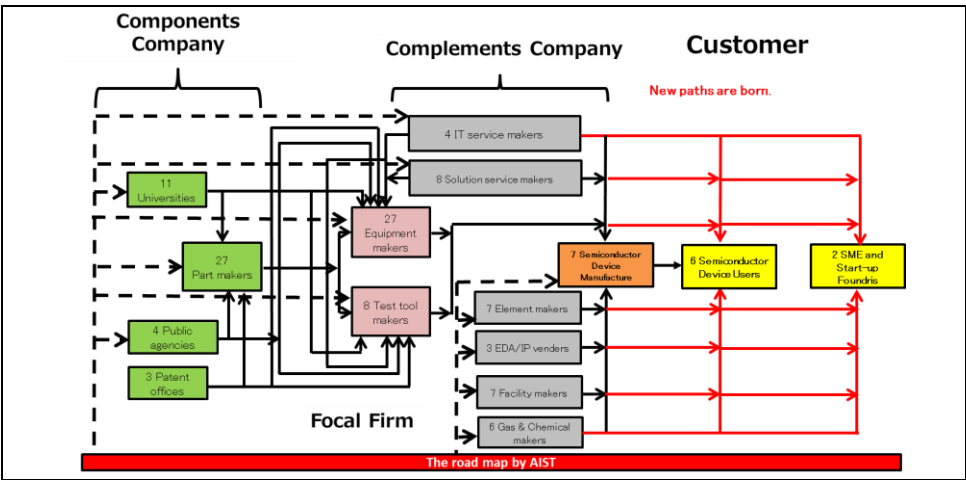


Figure 9. The Business Ecosystem of Minimal Fab

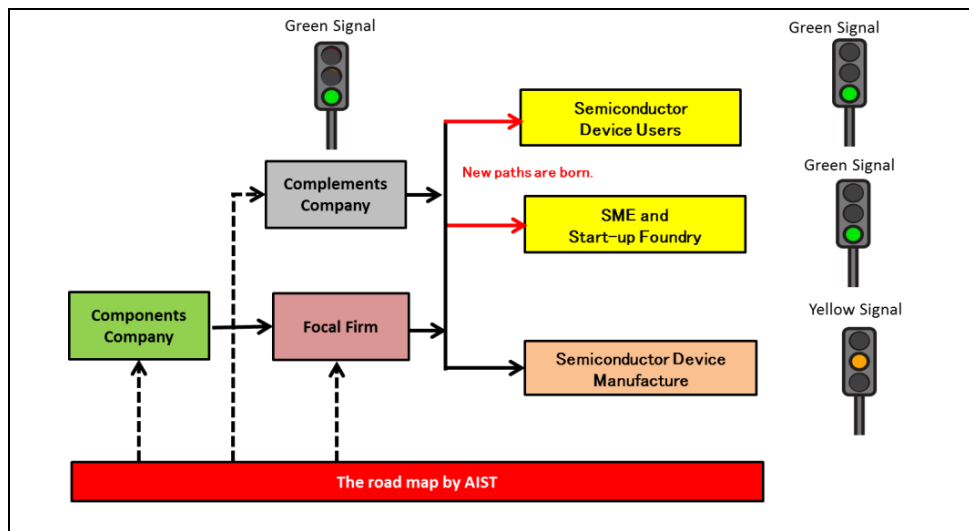


Figure 10. The Value Blueprint of Minimal Fab

## DISCUSSION

This study is based on the business ecosystem by the hypothesis with constraints, we have discussed the ecosystem of a semiconductor production system that compares to the existing Fab with Minimal Fab by the framework. Table 1 shows these differences.

The main constituents of Components Companies, Focal Firms and Complements Companies are SME & start-up companies. As this reason, the big companies, such as ASML, Tokyo Electron, have performed at leading-edge R&D that is indicated by ITRS, and the price of their developed equipment is more than several million US dollars. However, the price of Minimal Fab equipment is several hundred thousand US dollars, so the business model is different and we think that it has become the dilemma of the innovation (Christensen, 1997).

Miyake et al., (2015) conducted a questionnaire survey to Fab System Research Consortium. About 5% of the companies are conducting R&D that does not follow ITRS. The reason for this, we consider that the semiconductor industry has reached at a mature phase in the market and they actively participating in Minimal Fab innovation and they are looking for new business. In addition, as activities that contribute to the core technology improvement of the company, about 60% of companies have cooperation with universities, public research institutes, large companies and SME & start-up companies. In other words, it is open innovation. Ogawa & Tatsumoto (2009) considered that open innovation, such as a conventional national project, has not been made with the distinction of working with competitors, therefore, they have not generated a synergy effect. However, they have created synergies in Minimal Fab.

The reason for this, AIST has developed the minimal standards for PLAD (Particle Lock Air-tight Docking), user interface and the housing that are commonly part of Minimal Fab equipment as a consensus standard. In addition, AIST in the same way as ITRS

is responsible for the technology roadmap of Minimal Fab. A part of cooperation and competition became clear with these points. For example, Minimal Fab equipment maker competes with a process and control unit that are needed originally, but they have established some working groups for the synergy effect to develop the common parts such as, interface, transfer system, and vacuum system. The standardized equipment in this way has become the platform of Minimal Fab.

**Table 1.** The Difference of Ecosystem of Existing and Minimal Fab

	<b>Existing semiconductor production system</b>	<b>Minimal Fab</b>
Components Company	ULVAC, Carl Zeiss and so on large companies	27 companies to SME & start-up as the main
Focal Firm	ASML, Tokyo Electron and so on large companies	35 companies to SME & start-up as the main
Complements Company	Shin-Etsu Chemical Co., Tokyo Ohka Kogyo and so on large companies	35 companies to SME & start-up as the main
End User	Intel, TSMC and so on large companies	<ul style="list-style-type: none"> <li>• Semiconductor user company such as set maker, automotive parts maker</li> <li>• SME &amp; start-up that have entered the foundry business</li> </ul>
Platform	ITRS indicates the wafer size and finer level.	Standardized Minimal Fab equipment
Value network	Mass production system	High-mix low-volume production system
Co-innovation risk	Reduction by ITRS	<ul style="list-style-type: none"> <li>• Reduced by Minimal Fab development roadmap by AIST</li> <li>• Reduction by Fab System Research Consortium</li> </ul>
Adoption chain risk	Reduce by ITRS that is made by semiconductor device manufacturer, also they are an end-user	<ul style="list-style-type: none"> <li>• Because existing semiconductor device manufacturer customizes a production system, the entry barrier is high</li> <li>• The entry barrier is low for companies newly entering the semiconductor device manufacturing industry</li> </ul>
Others: Consensus standard	SEMI standard	Authentication by Minimal Fab standard

## CONCLUSION

As the findings of this study, we found that Minimal Fab has the potential that can be the new business ecosystem with the value network by high-mix low-volume production system that is different from existing. Also, this new ecosystem has the customer, not only semiconductor device manufacturers but also semiconductor device user companies and SME & start-up companies. In other words, it is possible to have the segregation from the existing semiconductor device manufacturing because the ecosystem is different.

Thus, a new ecosystem with the different value network to the business ecosystem of existing semiconductor manufacturing systems has been established and we found that they have carried out the following focus strategies as we postulated.

- i. R&D does not follow ITRS.
- ii. Deploy high-mix low-volume production system that will enable short delivery time and lower cost.
- iii. Focus on low-end semiconductor device manufacturing according to the Minimal Fab roadmap by AIST.

In order to enter the semiconductor device manufacturing industry, SME & start-up companies should implement this focus strategy. We think that the feasibility that the focus strategy will be enhanced more if they have "Absorptive Capacity" (Veugelors and Cassiman, 1999) that can absorb the technology of the other companies which they obtained by open innovation. Also, Miyake et al. (2013) describes a quantitative evaluation method of Absorptive Capacity.

This study analysed by the framework in the semiconductor device industry that has the technology road map. Therefore, in order to generalize the business ecosystem generation factor in the early stage, we think that it is necessary to continue to refine the system through a case study with the exception of semiconductor related cases.

## REFERENCES

- Adner, R. (2012) *The wide lens: A new strategy for innovation*. Penguin UK,
- Adner, R., & Kapoor, R. (2006). Innovation Ecosystems and Innovator's Outcomes: Evidence from the semiconductor lithography equipment industry, 1962-2004. *Unpublished working paper, INSEAD*
- Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. *Strategic management journal*, 31(3), 306-333.
- Christensen, C. M. (1997) *The innovator's dilemma: when new technologies cause great firms to fail*. Harvard Business Review Press,
- Hare, S. (2012) Kyuukyoku no syouryouseisan minimaru fabu tetteikaisetu. *Electronic Journal Archives*, 299: 1~74 (In Japanese).
- Hara, S., Maekawa, H., Ikeda, S., & Nakano, S. (2011) Concept of Minimal Fab and Development of Minimal Equipments. *Japan Society for Precision Engineering*, 77 (3): 249~253 (In Japanese).
- Hara, S., Maekawa, H., Ikeda, S., & Nakano, S. (2013) Minimal Fab Concept to Create Innovative LSI Factory System. *The Institute of Electronics, Information and Communication Engineers* . 96 (8): 649~655 (In Japanese).
- Kameyama, M. (2010) Risogurafhi to ITRS (No. 10-06). Institute of Innovation Research. Hitotsubashi University (In Japanese).
- Kubouchi, K., & Hara, S. (2015) Concept of Minimal Fab and The Organisation of The Development and The Promotion. *The Institute of Electrical Engineers of Japan*, 135 (8): 534~537 (In Japanese).
- Matsuda, Y., Suzuki, J. (2010) Empirical Analysis on the Focus Strategy of Texas Instruments. *The Development Engineering Society of Japan*, 30 (1), 53~60 (In Japanese)

- Miyake, K. (2015) A Focus Strategy of Semiconductor Manufacture Venture Company Based on the Case Study. *The Japan Association for East-Asian Business and Economic Studies*, (8): 63~72 (In Japanese).
- Miyake, K., Matsuura, Y., & Kaminishi, K. (2014) The Proposal of Metrics and Evaluation Methods to Explicit Knowledge of the Absorptive Capacity. *Journal on Innovation and Sustainability*. RISUS ISSN 2179-3565, 5 (2): 42~55.
- Miyake, K., Matsuura, Y., & Kaminishi, K. (2015) A Study on the Innovation Ecosystem for the Semiconductor Manufacturing Process Industries : Several Factors to Create the Innovation Ecosystem. *Venture review*, 26: 71~75 (In Japanese).
- Nikkei Morning edition, (10/20/2014) 1/2Ueha-kara handoutai denshikairo o jyutakuseizou. 13 (In Japanese).
- Ogawa, K., Tatemoto, H. (2009) Ohsyu no inobe-shon seisaku: ousyuugata o-puninobe-shon seisaku. *MMRC Discussion Paper Series*, 281 (In Japanese).
- Veugelers, R., & Cassiman, B. (1999) Make and buy in innovation strategies: evidence from Belg

# ISSUES AND CHALLENGES OF ENTREPRENEURSHIP EDUCATION IN MALAYSIA

**Hartini Mohamed, Akbariah Mohd Mahdzir**

*Management of Technology Department, Malaysia Japan International Institute of Technology, Universiti Teknologi Malaysia Kuala Lumpur*

## **Abstract**

This research is a program evaluation of an entrepreneurial education in public and private higher education institution in Malaysia. Among the problems of the Entrepreneurial Education face by Ministry of Higher Education Malaysia as stated in Entrepreneurship Development Policy for Higher Education Institution (HEI) is the lack of mechanisms for quality, effectiveness and impact measurement. This study aims to evaluate the issues and challenges in the implementation of entrepreneurship education practices by Higher Education Institution (HEI) in Malaysia. There are two higher institutions involved in this research, Universiti Teknologi Mara (UiTM) and International Islamic College (IIC). Both institution offer Bachelor of Entrepreneurship and have more than one cohort of students graduated. This study adopts qualitative approach utilizing case study method. The collection techniques included semi-structure interview, document analysis and observation. This study focuses on entrepreneurial program at public and private Higher Education Institution (HEI) and it contributes to the present literature on the real phenomena of entrepreneurship education in this country, specifically focusing the actual issues and challenges which relates to the monitoring and evaluating the effectiveness of the entrepreneurship education programs faced by the Ministry of Higher Education and the Higher Education Institutions in Malaysia.

**Keywords:** *Evaluation; Entrepreneurship Education; Issues and Challenges*

## **INTRODUCTION**

There are various policies and plan emphasizing on the human capital development. In Vision 2020 working paper in 1991, our former Prime Minister, Tun Dr Mahathir Mohamad has highlighted the need to establish 'a scientific and progressive society' as the sixth challenge out of nine outlined in the national agenda. Until now various efforts provide by the Malaysian government with the assistance of many agencies in establishing programs to the young entrepreneur and graduates in a tandem to this national agenda. Small Medium Enterprise Corporation (SME Corp), Malaysia External Trade Development Malaysia (Matrade), Ministry of Entrepreneur and Co-operative Development (MeCD), have been offering grants specifically for local SMEs and small/medium industries that meet the criteria. Obviously, the government wanted to see more technopreneur and entrepreneurs running the small and medium enterprises (SMEs) in the country.

As for the education sector, Ministry of Higher Education has instructed all local public and private universities and colleges students are required to seat for the entrepreneurship course. The intention of the Ministry of Higher Education (MoHE) of revitalizing entrepreneurial acumen of all graduates and also in tandem with the Ministry of Entrepreneur and Co-operative Development (MECD) to encourage young generations to venture into business and be courage to explore opportunities through this sector (Mansor & Othman, 2011). On top of that MOHE is also including the entrepreneurship skill as one out of nine

generic skills or domains that should be possessed by the students in a new Outcome Based Education System (OBE). This skill needed to ensure graduates at all discipline are not solely depending working with others but creating a thinking of having their own business in the future. "We are producing more graduates than jobs," said Minister of Higher Education (MoHE), YB Dato Seri Mohamed Khaled Nordin during the launch of Ready Work portal held at Universiti Teknologi Malaysia (UTM) Kuala Lumpur Campus. He added that entrepreneurship education helps stress the power of ownership to create wealth. (afterschool.my, November 2, 2012)

Several studies have shown that entrepreneurship has been identified as a potential catalyst for expanding economic growth and to maintain competitiveness in facing the challenges of globalization. (Minniti, M. & Levesque, 2008). The involvement of graduates in the field of entrepreneurship is supported by the government as an alternative to reduce the unemployment rate in the country (Othman, Othman, & Ismail, 2012). However, past studies are based on the studies conducted abroad of how the effectiveness of Entrepreneur Education implemented that lead to the reducing number of unemployment rate among graduates.

This present study focuses on issues and challenges of the entrepreneurial program within the public Higher Education Institution in Malaysia by using the system approach based program evaluation. This part will also touch the research gap, research objectives and research questions, research framework and research scope.

## **Research Gap**

There are a number of gaps that show the ineffectiveness of entrepreneur education in Malaysia as indicated by the previous researcher such as those involving the gap in skill expectation and skills acquisition. The studies show the ineffectiveness of entrepreneurship education in Malaysia in matching students' skill expectations with their skill acquisition. (Cheng, Chan, & Mahmood, 2009). Then it follows by the gap between the aim of Entrepreneurial Education and the curriculum imposed for this program. The aim of Entrepreneurial Education on the expected entrepreneurial characteristic hold by the students after they learn this field but there was no deeply evaluation done to the curriculum teach to the students, whether it is enough to meet the required expectation. (Ismail & Ahmad, 2013)

At the same time according to Ismail & Ahmad, 2013, The lecturer was rated low in term of performance, there were few research highlighted the competency standard that should be possess by the Entrepreneurial Education lecturer/ instructor. (Ismail & Ahmad, 2013)

Apart from that there is also a gap between the government aim and the actual outcome of the graduant. The government intention/aim/plan toward EE's students to be self-employed but the real outcome contradicts with this intention/aim/plan. (Liv Anne Storen, 2014). Gaps in the implementation of the entrepreneurship program, reflecting an imbalance

in the entrepreneurship education process (method of teaching, curriculum) and the program objectives aimed at producing future entrepreneur. (Nasrudin & Othman, 2012)

## **Research Objectives**

The purpose of the programme evaluation proposal is:

To determine issue and challenges of Entrepreneurial Program in Higher Education Institution in Malaysia in achieving its Program Education Objective through the lens of the System Approach Based Program Evaluation Model (Fatma Mizikaci, 2006)

## **Research Questions**

In this study a system approach based program evaluation model will be deployed, therefore the research questions will be divided into the three sub components that comprise of Social System, Technical System and Managerial System.

### *Social*

- To what extend does the Ministry of Education give support in ensuring the success of this program in meeting its objectives?
- Is there any mechanism use by the Ministry to monitor and evaluate the success of the Entrepreneurship Program in Higher Education Intuition in Malaysia?
- Are the stakeholders satisfy with the outcome of this program?
- Are the institutions concerned about the continuous improvement of this programme?
- What effort has been made to ensure the continuous quality improvement of this programme?

### *Technical*

- To what extent have the resources provided able to meet the program requirements
- To what extend the curriculum provided meets the Program Educational Objectives
- How is the institution following the activities/strategies that have been previously outlined? Execution/implementation strategies?
- To what extent does the program meet program educational objectives?
- Are the employer satisfied with the performance of the graduates?

### *Managerial*

- What are some alternative strategies or approaches that could be used to enhance the merit of this program?



- Does the policy, vision and mission of the organisation in line with the objective of the program?

## Conceptual Framework

This research will evaluate an existing entrepreneurial education in public higher education institution in Malaysia using System Approach Based Program Evaluation Model in quality system. According to (Mizikaci, 2006a), this model is powerful in two ways:

- it is a well-integrated model for program evaluation and understanding of the quality systems in higher education institutions from the perspective of systems approach; and
- it offers a multiple-sources approach to stakeholder-oriented measurement in terms of both varieties of dimensions and sources. (Mizikaci, 2006b)

The entire system is open to internal interactions and external influences. The relationships are analysed using a program evaluation approach. Quality implementations are described in relation to the subsystems for achieving the overall goals. Subsystems are set up for developing systematic evaluation and methods for the analysis of, e.g. social, technical and managerial processes in the given institution. As listed by (Mizikaci, 2006a), there are six steps to follow by this model.

- Set criteria for program evaluation:
  - The criteria and the programme are based on the quality concepts re-defined accordingly, representing shift from industry-based concepts to education based concepts and issues for higher education.
  - Adopt the systems approach model in order to set the strategies for the program.
- Stakeholder identification:
  - Define the stakeholders as those that have an influence directly or indirectly on higher education of the programs such as students, academic staff, administration, parents, graduates, employers, Higher Education Council, Ministry of Education and other related institutions.
  - Conduct interview to define the needs and expectations of the stakeholders.
- Sector analysis
  - Analyse inputs sources, e.g. the graduates and trained personnel in the employment market.
- Analyse performance skills and knowledge expected from trained employees.

- Analyse existing employment sources embedded in the community which can have indirect influence on higher education, e.g. public offices and non-governmental institutions, other national and international bodies of research and education.
- Identification of resources:
  - Identify what resources are available.
  - Identify whether the resources are appropriate to the objectives defined.
- Data gathering:
  - Gather data from multiple sources.
  - Use data analysis procedures.
  - Adopt a systematic data collection procedure (collect, analyse, interpret and make use of data systematically)
- Programme development:
  - Plan all the stages identified in the technical system of the model.
  - Make use of quality measurement tools in planning instructional processes.
  - Make use of relevant educational research on planning teaching/learning processes.
  - Make use of technologies when planning instructional material
  - Emphasize frequent feedback and evaluation.
  - Plan continuous education strategies.
  - Adopt suitable evaluation strategies for programme improvement.
- As can be seen here, each stage provides for the implementation of the model components and directs the data interrelated to the sub-system components: social, technical and managerial systems. (Mizikaci, 2006b)

## Research Scope

This research will specifically focus to the undergraduate Entrepreneurial Program offered by Public Higher Institution in Malaysia. Through System Approach Program Evaluation Model, the issues and challenges of program will be view through the stakeholder and the organisation system as a whole. Therefore, in this research the stakeholder composed of students, the academic staff and the managerial level were interviewed.

## Conclusion

Most of the Higher Education Institution in Malaysia focuses on quality and program evaluation but it has been done in isolation. Therefore, it is a time to use System Approach to Program Evaluation Model which involves a comprehensive evaluation that covers internal and external aspect. This research involves students, teachers, management and stakeholders.

## AN EXAMPLE

In Malaysia, several researchers have conducted a study on the effectiveness of EE in various aspects, such as focusing on entrepreneurial skills and characteristics. The results show the ineffectiveness of entrepreneurship education in Malaysia in matching students' skill expectations with their skill acquisition. Thus, educational institutions need to review the existing curriculum and design a more appropriate curriculum to develop effective entrepreneurship programs and enterprising individuals. (Cheng et al., 2009). There were also researchers who study the ability of entrepreneur students in highlighting the characteristics of leadership that should be possessed by the entrepreneur. The main purpose of this study was to explore personal competencies of student entrepreneurial leaders (Bagheri, Lope Pihie, & Krauss, 2013).

Like other developing countries, Malaysia should also look at the level of readiness for the implementation of this program. The study indicates that Malaysian students' readiness in terms of entrepreneurial willingness and capabilities are strong. However, the readiness of entrepreneurial attitude and readiness for entrepreneurship education within the internal environment of public universities remains insufficient and requires improvements. (Othman et al., 2012). The level of readiness should also be viewed from the curriculum adopted by the HEI. Does theoretical and practical contents are balance in the existing curriculum. Curriculum and co-curriculum activities need to adopt a more practical and hands-on approach, distinct from business education, while public universities should open up opportunities for students to pursue entrepreneurial education, in order to increase awareness and change the mentality or culture of "wage-earning" careers in favour of entrepreneurship. (Othman et al., 2012).

Effective curriculum is crucial to ensure that the objectives are achieved. This can be seen from the research done on the polytechnic in Malaysia which still have problems with the curriculum. Indeed, this result gives important impact to Ministry of Higher Education (MoHE) in Malaysia, especially polytechnics, in planning and developing Entrepreneur Education in the institutions. Regarding these issues, the reformation of curriculum and pedagogy is important. The entrepreneurship modules, activity and programme executed throughout polytechnics are unable to provide students with entrepreneurial tendencies. (Ismail & Ahmad, 2013). In addition, a competent instructor is needed to ensure that students are motivated and really understand the need to become an entrepreneur. Unfortunately, most of the instructors who teach Entrepreneurial Education in HEI, equip with theoretical knowledge but do not mastered this entrepreneurial knowledge practically. This finding confirmed that polytechnic lecturers are not imbued with entrepreneurial tendencies. (Ismail, 2013)

## DATA AND METHODOLOGY

Data for this study were collected through two higher education institutions, Universiti Teknologi Mara (UiTM) and International Islamic College (IIC) where both institutions offer undergraduate entrepreneurship program. The data obtained through interviews conducted with lecturer and coordinator who have been involved in entrepreneurship

program (manage to get consent from both interviewee). Researcher also managed to obtain documents which related to the curriculum and course syllabus of these two institutions.

In this study, qualitative method is adopted for data collection and analysis. Qualitative research is an inductive process that used to reveal the meaning of significant of participants in their context. It is as described by. (Merriam, 2009, p. 13), qualitative researchers are interested in understanding the meaning people have constructed, that is, how people make sense of their world and the experiences they have in the world.

Case study was chosen to describe in detail and analyse a system that has limits and boundaries. As mentioned by (Merriam, 1998, p. 40), a case study is an in-depth description and analysis of a bounded system. Entrepreneurial Program is a bounded system where researcher can limit or fence in what is going to be studied.

Semi-structure interviewing, observations and document review are the techniques chose as data collection method for this study. Interview is best used when researcher does not know one's feelings through observation and how people describe what is happening around them. Semi-structure interview according to (Merriam, 1998, 71) is in the middle between structure and unstructured.

## **RESULT – ISSUES AND CHALLENGE**

### **Curriculum**

The existing curriculum needs a lot of improvement because it must meet the requirements of a future changes. “For present yes, for future always have to review because the trend that change very fast. So we have to keep up. We have to quite regularly, keep up with the current need of our society”. (Interviewee - 1). At the same time, the course that teaches on how to deal with risks in the business should also be included in this curriculum. It is very important that students know how to deal with a business risk. That was recommended. I think Prof Hassan from Univesiti Teknologi Malaysia, he mentioned about risk course, because recently we have round table dialog with industry. He said, Entrepreneurship is about risk taking. Our students are not tough enough. To become entrepreneur, we need to be very strong, when we go down we have to go up, that is why Chinese they are very persistence, they want to be success and always look forward. (Interviewee - 1)

Most of the contents of this curriculum emphasizes on theory. (Please refer to the Appendix 1 - Curriculum Structure of Bachelor in Administration (Entrepreneurship)) While experiential learning through practical training are required by the students “Theoretical enough, practical is still insufficient. As University Malaysia Kelantan UMK, its organize practical training during semester break to expose students” (Interviewee - 1). It happens to the other HEI, where the existing curriculum is not appropriate to the current requirements. The present curriculum should be improved to meet the current changes. According to the feedback, the majority of the IHLs recognize the current challenges faced in executing entrepreneurship education into the present curriculum. (Yusoff, Zainol, & Ibrahim, 2014)

## Practical Training

Practical training should be given priority as well as providing students with incubator facilities, shops and the like to enable students to always practice what they learned. “To make it difference you have to embed them with the industry then to exposes them with lots of entrepreneur stuff, provide them with incubator and let them practice. Like retail, the program that I teach, we provide the simulation store. Students go in, and then for a week they have to go for three-hour training, to expose them on how to handle customer, how to handle with difficult customer and to make sure how to arrange the goods in order, that’s in retail right. It same to entrepreneur, I think we need to provide store so that they can practice what they have learn. This is not materialized yet”. (Interviewee - 1)

The time allotted for practical training was too short, which is supposed to be extended to one year. “Just being discuss and need to revise our curriculum, we are a in the process of reviewing and try to put forward the ideas of one year of internship instead of four months” (Interviewee – 2)

## Redundancy

The importance of learning how to create or do a business plan is one of the things that have been emphasized in the Entrepreneur Education. But repeated learning can make students every semester feels bored and lose focus on the lesson. “I think that is redundant. It’s really redundant. In New Venture course students are required to produce with a business plan. Semester 3,4,5 and even in semester 6 they also have to do the business plan, for what?” (Interviewee – 2). This causes students to feel unhappy and expressed their dissatisfaction with the frequent task that they need to do every semester. “So many complain from the students, that’s why at this moment we try to revise back our curriculum, we try to eliminate, for example the latest news I heard last week, Small Business Management will be eliminated. It will be eliminated probably due to the redundancy”. (Interviewee – 2) This shows there are still weaknesses, not only at the curriculum level but the instructor ability in providing a more creative learning technique are still lacking. Academicians should teach entrepreneurship through learning focus that is upon ‘know how’ and ‘need to know’ rather than functional expertise. The ‘need to know’ stems from the development problems and opportunities of the business. The challenge to academician is therefore to organize knowledge around organisation development processes, radically different from the conventional functional paradigms. In guiding them to the survival of a business in the early years, the target might, for example, be to anticipate the problems that lead to business failure and ‘bring forward’ the knowledge in such a way as to enable entrepreneurs to anticipate development problems before they occur and take remedial action. (Zakaria et al., 2011)

## **Different Thought and Limited Time**

### *Different thought*

To ensure an effective curriculum, all those involved, lecturer, program developer and management must work together and unite. The problem faced by many HEI is disagreements between parties. This led to the failure of implementation of the good ideas. We are in the process of reviewing our curriculum and try to put forward the ideas of one year of internship instead of four months. The problem we are facing here. Sometime, those seniors do not support the new ideas. Sorry to say, this department is having little tribes, who are untouchable. That's a problem. When we proposed they cannot accept. Just need to listen to them. (Interviewee – 2). Opinions and ideological differences arising on Entrepreneurial Education are among the issues and challenges stated in The Entrepreneurship Development Policy for Higher Education Institutions (HEIs). This matter must be addressed by all involved HEI so that it does not give a negative impression on the implementation of this program

### *Limited time*

Way of learning Entrepreneurial Education is different from other education programs, it requires a lot of time doing practical tasks, participate in training and workshops related to entrepreneurship. Unfortunately, in most HEI, most of the students are busy, they involved in activities initiated by the HEI. They have no time to get involved in the entrepreneurial activities. “(Extra curriculum or activities) Being provided but some time if we want to conduct team building, there is no room, no room here means no time, there is so many activities in the UiTM, sometime we cannot put any slot in one semester. It's very hard to arrange our own activities”. (Interviewee – 2)

## **Monitoring and Evaluation**

### *Centre of entrepreneur education and development*

To ensure the success of EE, a special centre should be established in each HEI. The role of this Centre is to mediate between HEI and industry, it is also necessary to evaluate the effectiveness in producing entrepreneur graduates entrepreneurs as expected by the government. The centre needs to keep track of graduates and get the latest information about their involvement in the field of entrepreneurship. Besides that, the centre is also responsible for providing information about the development of Entrepreneurial Education in the HEI to the Ministry of Higher Education as well as reporting on the effectiveness of EE activities to the Ministry. Unfortunately, most of the centre is not properly played a role. Ministry do ask about the number of entrepreneur graduates? That's why (Malaysian Academy of SME & Entrepreneur Development) MASMED under hot seat. if you want to ask, ask MASMED, as Retail Program, when the ministry ask, they have some figure. (Interviewee -1)

A radical yet practical approach is to separate entrepreneurship education initiatives from business schools by creating a unique entrepreneurship centre parked under a strategic

division that oversees the entrepreneurship development activities at faculties, including Engineering, IT, Humanity, Arts and others (Hindle & Lansdowne, 2005)

### *Resource person*

To evaluate the extent of the effectiveness of this Entrepreneur Education it should be handled by a centre or department or unit. In some HEI, a representative of the centre is responsible for the respect of the graduates. It is possible if the number of graduates produced is too many. "The effort actually being tried to do by the resource person, I think she does its own her own effort, she made a wide data base, because we are just new, she tried to gather students information, anyone who going into business, which got loose, who further study who did not. She basically did that She simply cannot do that when the increase in number of graduate. She created her own initiative, imagine she was also lecturer in MASMED handling training, I thing by now she could not cope. She did that time I was a coordinator. I remember she said, she created data base, address, contact. (Interviewee -1)

Because there is no special department or unit responsible for the alumni. Most lecturers have to make their own initiative. This is the evidence that shows the absence of a special evaluation conducted by HEI and in getting information about the graduates and no effort to determine whether the PEO is reached or not. "There is no actual person who handle this but through the informal conversation, we try to seek their(students) opinion than we know where they are, that's how we contact our students. For example, my students and I, we always contact, ask about their current position"( Interviewee – 2).Through studies conducted by a group of researchers , the failure of HEI not only in handling Alumni , in fact, there is lack of commitment from the staff that led to the ineffectiveness of the Entrepreneur Education implementation. Among the top challenge was lack of commitment among IHLs' staff and students. This feedback came from five IHL participants who found that staff and students were not committed to the entrepreneurship programs. (Yusoff et al., 2014).

### *The effort done by the HEI in getting a right entrepreneur students*

To be an entrepreneur is not only necessary to have knowledge but require high interest and passion in this field. At the top of the list was a lack of soft skills among the students. Students following the entrepreneurship programs lacked communication skills, leadership skills, knowledge of marketing strategies, general business knowledge, and abilities in networking .(Yusoff et al., 2014). Thus in UiTM starting this semester, students who want to enter into this entrepreneur program has to go through an interview session to ensure that they are really interested. We just started recently. Before this, the student intake just like any other program that's why we decided recently, we just implemented this semester, we need to interview. Otherwise we get garbage. Just people who come in not interested and then they become not so interested. The first batch was quite bad because the students they don't know, they took this program because they have the opportunity to study. (Interview - 1)

## CONCLUSION

Various issues and challenges are centred on an unstable curriculum between practical training and theory as well as internal problems between the academic staff with different opinions and thought as well as the absence of the role played by entrepreneurship centre on the implementation of the program. There is also repeated topic in the curriculum especially on the business plan preparation which cause students feel pressured. All of these issues and challenges need to be improved in order to ensure comprehensive impact on graduates

## REFERENCES

### Journal

- Bagheri, A., Lope Pihie Z. A. & Krauss, S. E. (2013) Entrepreneurial leadership competencies among Malaysian university student entrepreneurial leaders[J], *Asia Pacific Journal of Education*, 33 (November 2014), 493–508. doi:10.1080/02188791.2013.822789,
- Cheng, M. Y., Chan, W. S. & Mahmood, A. (2009) The effectiveness of entrepreneurship education in Malaysia. *Journal of Education + Training* , 51, 555–566. doi:10.1108/00400910910992754 (In Chinese).
- Ismail, M. Z. & Ahmad, S. Z. (2013) Entrepreneurship education: An insight from Malaysian polytechnics. *Journal of Chinese Entrepreneurship*, 5, 144–160. doi:10.1108/JCE-02-2013-0003.
- Minniti, M. and Levesque, M. (2008) Recent Developments in the Economics of Entrepreneurship, *Journal of Business Venturing*, 23(6): 603-12.
- Mizikaci , Fatma. (2006) A systems approach to program evaluation model for quality in higher education. *Journal of Quality Assurance in Education*, Vol 14, 37–53. doi:10.1108/09684880610643601.
- Mansor, M. & Othman, N. (2011) CoBLAS: Inculcating Entrepreneurial Culture among Higher Education Institutions' Students[J], *International Journal of Social Science and Humanity*, 1(1), 86–91. doi:10.7763/IJSSH.2011.V1.15.
- Othman, N., Othman, N. H. & Ismail, R. (2012) Impact of Globalization on Trends in Entrepreneurship Education in Higher Education Institutions, *International Journal of Trade, Economics and Finance* 3(4).
- Yusoff, M. N. H., Zainol, F. A. & Ibrahim, M. D. (2014) Entrepreneurship Education in Malaysia's Public Institutions of Higher Learning—A Review of the Current Practices. *Journal of International Education Studies*, 8(1), 17–28. doi:10.5539/ies.v8n1p17.
- Zakaria, S, Fadzilah W, Yusof. (2011) Entrepreneurshi Education in Malaysia: Nurturing Entrepreneurial Among Students. [J], *Journal of Modern Accounting and Auditing*, 7(6), 615–620.

### Book

- Merriam, S. (2009) Qualitative Research: A guide to design and implementation. San Francisco, CA: John Wiley & Sons,13pp
- Merriam, S. (1998). Qualitative research and case study applications in education. San Francisco,USA : Jossey-Bass.40 pp & 71pp



# WEB-BASED COMMUNICATION MODEL BETWEEN TEACHER AND STUDENT IN FOREIGN LANGUAGE SOFTWARE

**Yan Watequlis Syaifudin, Imam Fahrur Rozi, Atiqah Nurul Asri**

Information Technology Department, State Polytechnic of Malang, 65141 Malang, East Java, Indonesia

## **Abstract**

The needs for communication with the world community requires people to be able to master some kind of foreign language well. To support that, several schools and university in Indonesia are required to have a language lab that can be used as a means of learning a foreign language. But to build a language lab certainly require no small cost. On the other side, today almost all schools and colleges already have computer labs. So it is possible for the computer is functioning laboratories such as language laboratories, in particular by implementing a software system. To make the language learning software system becomes interactive and as real-time communication media between teacher and student, then it should be implemented chatting features on it. On this research will be discussed about the data communication model between computers (servers) teacher with student computer (client) in supporting streaming feature of learning video data and teacher's live video, as well as in supporting the chatting features between teachers and students. Audio and video streaming technology is more relevant to implement, because this time computer technology, multimedia and internet are growing up. The Use of LAMPP stack, Node.js, NPM and VLC on the server side, the use of RTSP as the protocol to send video/audio data from the server to the client and the VLC plugin embedded in the client browser, have been able to collaborate optimally to make audio/video streaming system.

**Keywords:** *Language Learning, Communication Media, RTSP, Audio, Video, Streaming*

## **INTRODUCTION**

Globalization requires every citizen to be able to compete in the international arena. The needs for communication with the world community requires people to be able to master some kind of foreign language well. In the world of education in Indonesia, one of the foreign languages most widely taught in English. Although there are several other foreign languages that be taught in some schools in Indonesia, but the English still number one as a foreign language that must be mastered by the citizens in Indonesia. Moreover, English began to be given to students in grade 1 primary school level. It aims to support Indonesia in preparing the HR community in the era of globalization and competition at ASEAN regional level. To support that, several schools and university in Indonesia are required to have a language lab that can be used as a means of learning a foreign language.

But to build a language lab certainly require no small cost. On the other side, today almost all schools and colleges already have computer labs. So, it is possible for the computer is functioning laboratories such as language laboratories, in particular by implementing a system of foreign language learning software. Among the features that must be provided by a software system that is learning a foreign language is (Syaifudin et al., 2015):

- Learning media feature

- Group discussion feature
- Quiz feature
- Attendance list feature

By applying information technology for implementing foreign language learning software, it is expected (can) reduce the cost of procurement language laboratory, can maximize the computer lab usage, and can ultimately provide a new atmosphere in learning foreign languages and can improve learning outcomes (Asri et al., 2015). One of the key features in language learning software is a feature of learning media. This feature makes it possible to display a various of media, both text and multimedia media. Included in the multimedia-based teaching materials is a video tutorial / learning materials and live video when teacher delivering they materials. Size large of multimedia teaching materials to be delivered from the teacher's computer to computer students, necessitates a mechanism for effective streaming multimedia data which can minimize delay and maintain the quality of the data.

Besides feature of learning media, to make the language learning software system becomes interactive and as real-time communication media between teacher and student, then it should be implemented chatting features on it. Chatting feature can be used in group mode or private mode. And just like the learning media feature that require of data transportation model effective, likewise with the chatting features. Chatting features have to be running in real-time with a minimal time delay possible.

On this research will be discussed about the data communication model between computers (servers) teacher with student computer (client) in supporting streaming feature of learning video data and teacher's live video, as well as in supporting the chatting features between teachers and students.

## LITERATURE REVIEW

Some previous research has been implemented to apply information technology in the learning process. In 2005 Dolzani develop Streaming Video system via the Internet network to support the learning process called LODE system (Dolzani, 2005). In applying, 66 % students have accessed and used that system in the learning process. In 2013, Rozi did research to implement VoD (Video on Demand) to support the process of long distance education at the Politeknik Negeri Malang (Rozi, 2013). The system can organize and manage instructional video data, user data and provide services to users in the form of instructional video display in accordance with the request of the user.

In a different research, Hartsell and Yuen, in 2006 did the research about usage of video streaming on online learning process (Hartsell et al., 2006). There are several things to notice in streaming video technology, such as, (1) making a video in the right format (2) the availability of server streaming media (3) enough bandwidth to download and upload video files. Streamed video generally has real media format, Windows Media, Quick Time. All of them support the protocol RTSP (Real Time Streaming Protocol) which can do streaming in real time. MPEG-2 and MPEG-4 are new formats which can also be used for streamed video.

Syaifudin in 2015 has made the design of software for learning a foreign language is one of its main features is to streaming video and live video learning from teacher to student (Syaifudin et al., 2015). Also in the design of the software also has features to recap student attendance, quiz, question bank, and other learning data management features. The design of foreign language learning software is oriented on improving the effectiveness of the process of learning a foreign language. In addition, the drafting is also intended to improve the efficiency of the use of the computer lab, which has been at the school, as well as a language lab (Asri, 2015). That is, simply by installing the software in the computer lab, then the school can function as a computer lab and language lab at once.

## **Video Streaming**

Along with the development of computer technology, multimedia and networking, the educators saw the opportunity to create a more productive learning environment. One product of collaboration from third technologies is video streaming. Video streaming can be used as a facility for delivering on instructional material in audio and video format. The term is commonly used streaming video to show the process of compression and buffering the video, so that video content can be viewed in real time by the user through the Internet. Streaming video service users can see the video you that they want by downloading some parts of the video and pass on other parts to see next. This method is more effective than download all the video section in the same time and see it later. In the video streaming process, the program will download the video file to be displayed in a small packet buffer. If the packet buffers that have been downloaded are sufficient to display, then the program will start showing. And the download process for the next part started back. In other words, the process of streaming media can be defined as the transfer of digital media (such as video, audio and data) that take place simultaneously with the application server that can be displayed in the client application in real time (Hartsell, et.al., 2006). If the streaming process has been completed and the file has been displayed, the file is no longer available in the user's computer (Reed, 2003).

Special for the educator, streaming video technology offers the advantage of creating a virtualized instructional material that more could attract the attention of students. In addition, good streaming video management system will help educator to manage instructional video content into a database that is easy to find time (Hartsell, et.al., 2006).

And of course, this technology can expand the dimensions of time and space to do learning process. If during this time we can only meet a lecturer in a classroom on a specific schedule, then by streaming video, visualization of the teacher can be presented in a video format and can be accessed by students wherever and whenever they want.

## **RTSP (Real Time Streaming Protocol)**

RTSP is one of protocol that is frequently used to do streaming digital media, such as audio or video in real time. the use of RSTP can allow live viewing video from the direct source (such as encoder or camera) using the standard media player and compatible with the protocol. What is meant by standard in this case is it has already implemented RTSP standard

that has been listed in RFC2326 (Simon, 2010). Some examples of media player which have implemented standard RTSP, are VLC, QuickTime Vide LAN Client and there are many other media players that have implemented it.

RTSP set and control either one or several time-synchronized streams of a continuous media such as audio and video. It does not typically deliver the continuous streams itself, although interleaving of the continuous media stream with the control stream is possible. In other words, RTSP acts as a "network remote control" for multimedia servers. Some operations supported by RTSP protocol are:

- a. **Retrieval of media from media server:** The client can request a presentation description via HTTP or some other method. If the presentation is being multicast, the presentation description contains the multicast addresses and ports to be used for the continuous media. If the presentation is to be sent only to the client via unicast, the client provides the destination for security reasons.
- b. **Invitation of a media server to a conference:** A media server can be "invited" to join an existing conference, either to play back media into the presentation or to record all or a subset of the media in a presentation. This mode is useful for distributed teaching applications. Several parties in the conference may take turns "pushing the remote control buttons".
- c. **Addition of media to an existing presentation:** Particularly for live presentations, it is useful if the server can tell the client about additional media becoming available.

RTSP has some of the same functionality as same as HTTP protocol. Nevertheless, basically have differences in the data transmission process. HTTP is an asymmetric protocol, where the client can leave request, and the server will respond to the request behind. In RTSP, both the client and server can leave request. Also RTSP requests are not stateless; they may set parameters and continue to control a media stream long after the request has been acknowledged.

## Node.js

NodeJS included in one of the latest software tools for developing web-based applications The system software is written using language NodeJS Javascript, using the base of events and asynchronous I / O. If most Javascript applications is run by a web browser, Node.js executed as an application server (McLaughlin, 2011). Node.js uses non-blocking technique to execute the process. It is means, Node.js will execute independently. Node.js will make the execution of an operation without waiting for another operation finishes. It is believed to create web applications that are built by using Node.js can run faster and more efficiently. Node.js has Node Package Manager (NPM) which can allow the developers to build and use the modules required to support Node.js. Popularity of Node.js more readily apparent, when several major IT players such as Google and Microsoft use it to build the application. Some examples of platforms that use Node is LinkedIn and Azzure. In addition to developing a web application, Node.js can also be used to develop network applications and cloud. Request processing model on Node.js is shown in Figure 1.

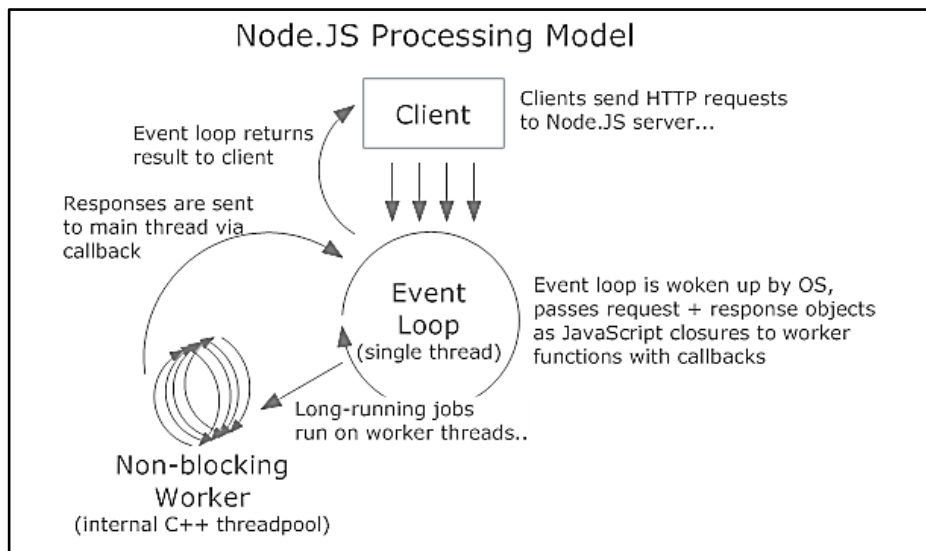


Figure 1. Node.js Processing Model

## VLC Plugin

VideoLAN is a project to provide streaming video solution. It developed by students of the Ecole Centrale Paris and developers from all over the world, under the GNU General Public License (GPL). VideoLAN is designed to stream MPEG videos on high bandwidth networks. Figure 2, shows a thorough solution provided by VideoLAN. The VideoLAN solution includes (Fallon, 2003):

- VLS (VideoLAN Server), which can stream MPEG-1, MPEG-2 and MPEG-4 files, DVDs, digital satellite channels, digital terrestrial television channels and live videos on the network in unicast or multicast,
- VLC (initially VideoLAN Client), which can be used as a server to stream MPEG-1, MPEG-2 and MPEG-4 files, DVDs and live videos on the network in unicast or multicast; or used as a client to receive, decode and display MPEG streams under multiple operating systems.
- Recognizing that the current highly developed web application, then VideoLAN provide the VLC plugin. So that the browser has been installed VLC plugin in it, can take advantage of VLC player that supports various formats of video in the browser.

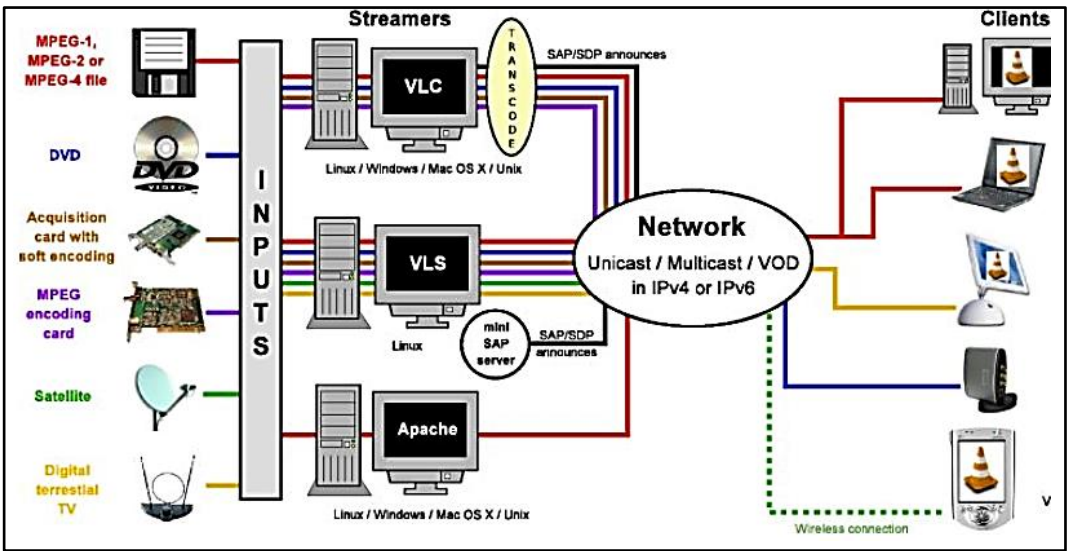


Figure 2. VideoLAN Solution Architecture

ARCHITECTURAL DESIGN STREAMING

The system's software architecture is illustrated in Figure 3, which consists of resource management needs, streaming media, group discussion and examination.

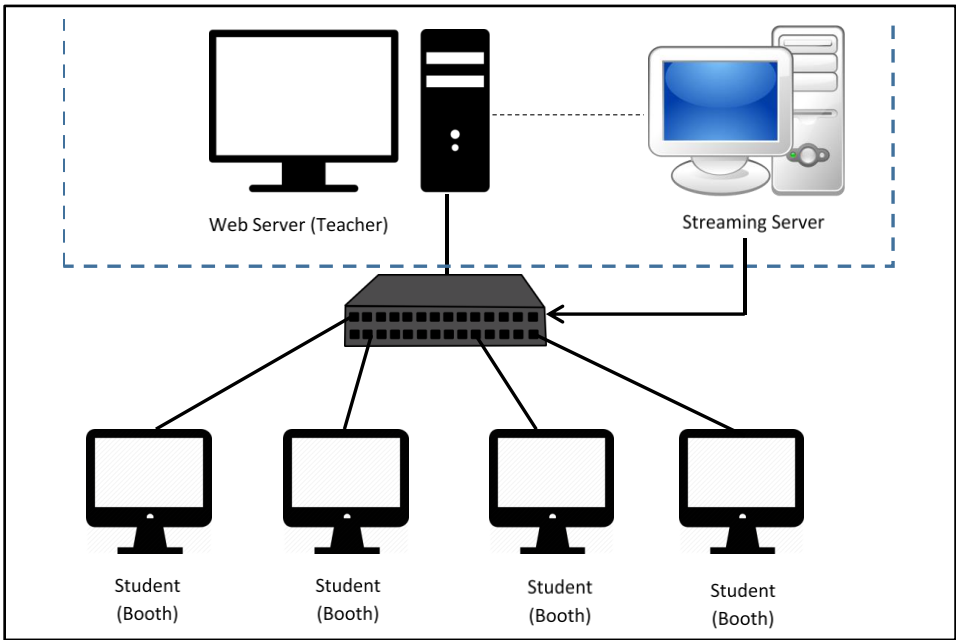


Figure 3. Architecture of Streaming

On the streaming features above, there are two types of user-level they are the control panel (Teacher) and booth (Students). In Figure 3 the teacher acts as a control panel. teachers have a role or duty to control the activities of teaching and learning in language laboratory such as giving streaming video to students who have been determined and have the permission to access such material, sending a message to students through group chat or private chat and starting video chat to all the students in the lab, the teacher also has the role to supervise or ask one of the students with private video chat.

While the definition of booth is student, the students have a role to receive learning activities. Like watching material in the form of streaming video or document, besides students can also contact teachers through video chat or chatting text through private chat or even through a video chat. Each booth has a single IP and student. Teaching and learning activities in this system uses the LAN network, where the LAN network is the connector between teachers and students, this means that when the teacher will conduct teaching activities in the language laboratory, the teacher will go to the system and use the interactive learning media facilities where the learning material will be distributed or shared to all the students that are in the language lab through LAN network. All the students in the lab will be able to access the learning media and the learning media contains a file of learning in the form of audio or video stored on media server.

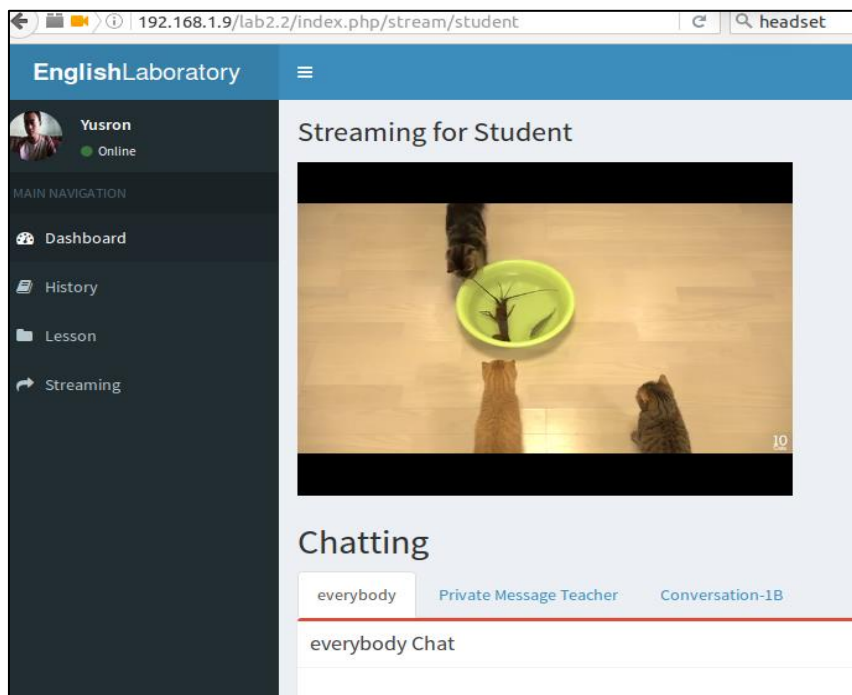
## IMPLEMENTATION

From architectural design shown in Figure 3, an outline of the software system will be implemented on the sis server and client. Hardware and software specifications of each server and client that has been used by researchers in implementing foreign language learning software is shown in Table 1.

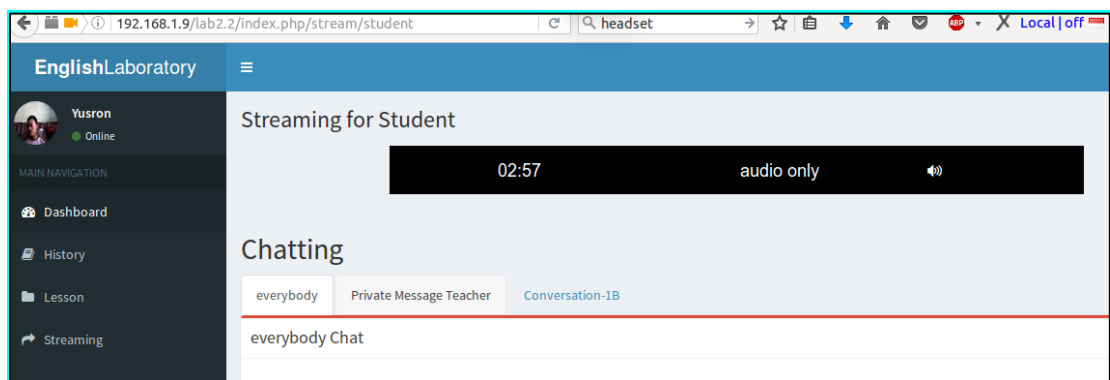
**Table 1.** Software and Hardware Specification

Server		Client	
Software	Hardware	Software	Hardware
-VLC	-Computer/Server intel core i3	-VLC	-Computer intel core i3
-VLC Browser Plugin	-RAM 1gb	-VLC Web plugins	-RAM 1gb
-NodeJS	-HDD 2gb	-Firefox	-webcam
-NPM	-webcam		-headset
-Firefox	-headset		-RAM 1gb
-LAMP Stack			-HDD 2gb

After the software system has complete implemented, the display of the video streaming process is shown in Figure 4. As Figure 5 shows the process to see streaming audio.



**Figure 4.** Display of Streaming Video and Chatting



**Figure 5.** Display Streaming Audio and Chatting

Next, there must be a testing process to know the big influence of streamed file and the influence of the number of clients who do streaming at the same time. The test is aimed to know the delay that may appear when a video file of a certain size is streamed or seen by some clients. The test is intended to determine the delay that may appear when a video file with a specific size streamed or viewed by some client.



**The experiment is based on the size of the video:**

1. 3 Mb-> the first time the play occurs delay for 5 seconds when streaming but there is no delay
2. 10Mb-> the first time the play occurs delay for 5 seconds when streaming but there is no delay
3. 15Mb-> the first time the play occurs delay for 5 seconds when streaming but there is no delay
4. 20Mb-> the first time the play occurs delay for 5 seconds when streaming but there is no delay
5. 50Mb-> the first time the play occurs delay for 5 seconds when streaming but there is no delay

**The experiment is based on the size of the audio:**

1. 3 Mb-> the first time the play occurs delay for 2 seconds when streaming but there is no delay
2. 10Mb-> the first time the play occurs delay for 2 seconds when streaming but there is no delay
3. 15Mb-> the first time the play occurs delay for 2 seconds when streaming but there is no delay
4. 20Mb-> the first time the play occurs delay for 2 seconds when streaming but there is no delay
5. 50Mb-> the first time the play occurs delay for 2 seconds when streaming but there is no delay

**The experiment is based on the amount of time video streaming client:**

1. 1 client-> the first time the play occurs delay for 5 seconds when streaming but there is no delay
2. 2 client-> the first time the play occurs delay for 5 seconds when streaming but there is no delay
3. 3 client-> the first time the play occurs delay for 5 seconds when streaming but there is no delay

**The experiment is based on the amount of time audio streaming client:**

1. 1 client-> the first time the play occurs delay for 2 seconds when streaming but there is no delay
2. 2 client-> the first time the play occurs delay for 2 seconds when streaming but there is no delay
3. 3 client-> the first time the play occurs delay for 2 seconds when streaming but there is no delay

From the test results, it is visible that the delay only occurs at the beginning of the video file when it is run. And after the video file successfully executed, until the completion delay is hardly noticeable at all. This shows that the combination of architecture and technology used to build the streaming system in this study has been able to minimize the delay premises more efficiently.

## CONCLUSION

The use of streaming audio and video technology in the process of learning offers an opportunity to make the learning process more interesting for students and the process of content management is more effective for teachers. Audio and video streaming technology is more relevant to implement, because this time computer technology, multimedia and internet are growing up. Delay time which firstly became an issue in the process of audio and video streaming, has recently been reduced and minimized. The Use of LAMPP stack, Node.js, NPM and VLC on the server side, the use of RTSP as the protocol to send video/audio data from the server to the client and the VLC plugin embedded in the client browser, have been able to collaborate optimally to make audio / video streaming system.

## REFERENCES

- Asri Nurul, Atiqah. Syaifudin W. Yan, Fahrur Rozi, Imam. Developing Language Laboratory by Utilizing Computer Laboratory to Improve the Teaching of English Language. 2<sup>nd</sup> National Conference on Language and Language Teaching (NCOLLT 2). 2015
- Dolzani M., Ronchetti M. *Video Streaming Over the Internet to Support Learning: the LODE System*. WIT Transactions on Informatics and Communication Technologies, v. 34, p. 61-65. 2005
- Fallon, Henry. et.al. VLC User Guide. 2003
- Hartsell, T., & Yuen, S. Video streaming in online learning. *AACE (Association for the Advancement of Computing in Education) Journal*, 14(1), 31-43. 2006
- McLaughlin, Brett. What is Node.js? Accessed from: <http://radar.oreilly.com/2011/07/what-is-node.html>, 6th Oct 2016
- Reed, R. Streaming technology improves student achievement. *T.H.E. Journal*, 30(7), 14-20. 2003
- Rozi, Imam F., Ariyanto, Rudy. Siswoko. *Pengembangan Sistem Video on Demand untuk Mendukung Pendidikan Jarak Jauh Politeknik Negeri Malang*. Distance Learning Research Grant from Seamolec. 2013
- Schulzrinne, A. Rao, R. Lanphier. Real Time Streaming Protocol (RTSP). 1998
- Simon, Konrad. Tech Note: Streaming Video from BVIP using RTSP. 2010
- Syaifudin W. Yan, Fahrur Rozi, Imam., Nurul Asri, Atiqah. *The Design of Foreign Language Teaching Software in School Computer Laboratory*. First Asia Pacific Conference on Contemporary Research (APPCR). 2015

# INNOVATION MANAGEMENT IN OIL TANKER VESSELS SAFETY

**Alireza Fili, Ahmad Rahman Songip**

*Management of Technology Department, Malaysia Japan International Institute of Technology, Universiti Teknologi Malaysia Kuala Lumpur*

## **Abstract**

Oil pollution is caused by the maritime casualty that effecting safety of environment. While lot of research, work and investigation carried out in order to find out the cause of oil spillage attributed during accident in shipping industry, very rare research has been done to determine the aspect of safety in relation with effectiveness of innovation in structure for oil tanker vessel for controlling oil pollution. The International Maritime Organisation (IMO) believes that innovation in technology is paralleled with the International Management and Safety Convention somehow reducing the oil spillage. Hence, in this research great emphasis will be made on its effect globally in relation to aspect of management and innovation technology in oil tanker vessel safety, ways to improve safety management, reduce casualty and marine pollution, and review some potential innovations and ideas to achieve the optimal maritime safety for oil tanker vessels.

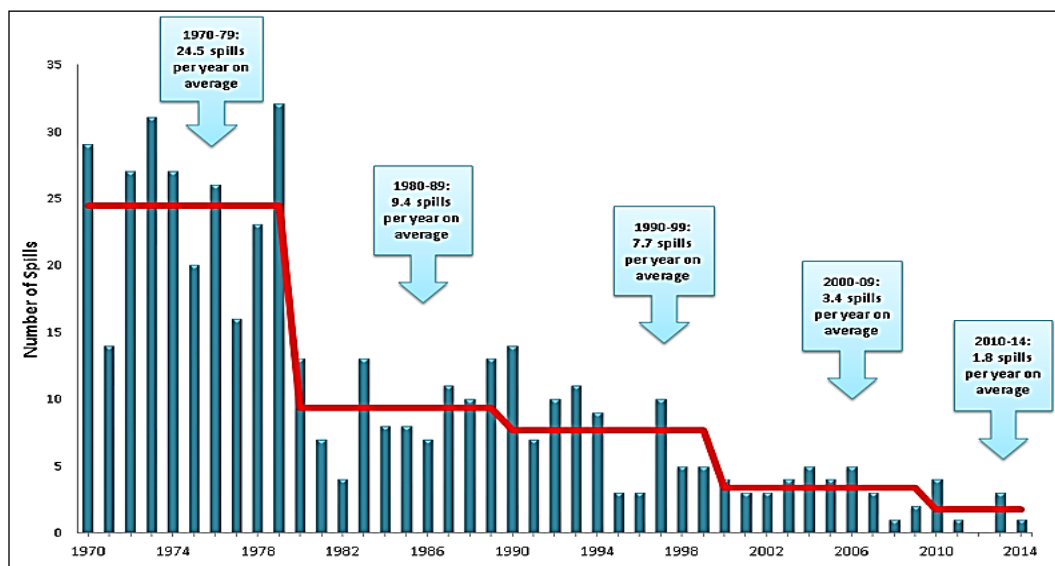
**Keywords:** *Innovation Management, Oil Tanker, Vessels Safety*

## **INTRODUCTION**

United Nations was the main international body that promotes the maritime safety to be more effective and reducing the accidents involved maritime casualty. After 1948 conference conducted by United Nations, the countries were agreed to form the International Maritime Organisation (IMO) as the specialized agency that deal with the international maritime and shipping. The main purpose of this organisation is to improve and develop the maritime safety and protection of the environment of the sea (Wieslaw, 2012). The first convention in safety was “Safety of Life at Sea” (International Maritime Organisation, 1974).

For this purpose, International Maritime Organisation has identified a measurement of technical and operational to improve the maritime safety, particularly in oil tanker in reducing the oil pollution (Acomi & Acomi, 2014). Total adoption is about 40 conventions and 700 codes and recommendations pertaining to the prevention of pollution and maritime safety (Wieslaw, 2012). The major convention for oil pollution was “International Convention for the Prevention of Pollution from Ships” (Convention, 1973).

Main disaster to the maritime ecosystems in worldwide is oil pollution (Bertazzon, O’Hara, Barrett, & Serra-Sogas, 2014). Pollution can be defined as contaminated (Vikas & Dwarakish, 2015). Oil pollution is the main source of marine pollution (Wei, Hu, Dong, & Zhao, 2015). Oil pollution can be happened during the shipment of the oils at seas as shown in Figure 1. Despite of fact that the amount of the oil spills might be in small or large portion, but any oil spills may leave the effect of ecological damage to coastline or sea (Viggor et al., 2013)



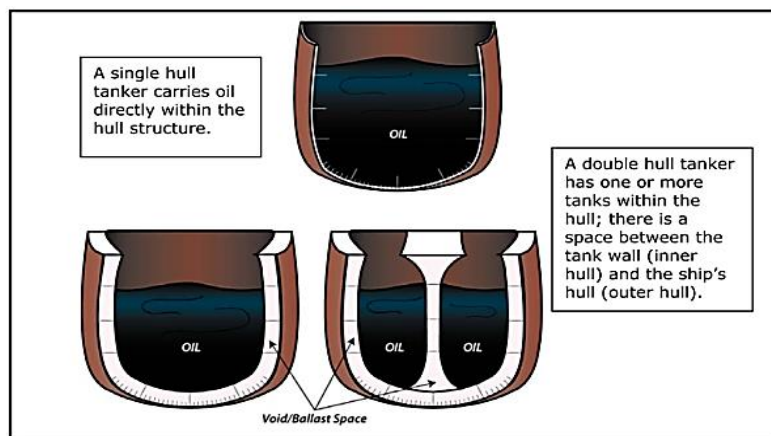
**Figure 1:** Oil Tanker Spill Statistic 2014 (Original Source taken from ITOFF, January 2015)

The main reasons of the accidents are caused by human error particularly in oil tankers is about 80 % (Rothblum, 2000).

In order to comply with safety environment in organisation, the IMO has specified the International Safety Management (ISM) code and “*Standard Training for Certificate of Competency of Watch Keeping Seafarers*” (STCW 1995) (Ng, Yip. 2009) code which have been endorsed to become compulsory for all shipping owners and operators (Grabowski *et al*, 2007).

For the beginning, there were only single hulled oil tanker vessels for oil transportation as shown in Figure 2. Due to some accident disaster in oil pollution, particularly the Exxon Valdez tanker vessel in 1989, the technology has been changed from single hulled tankers to double hulled tankers for best solution in preventing oil pollution (Terhune, 2011).

The rapid changes of shipping industry led to the increasing of operational cost, commercial legislation and challenging new technology and innovation in order to achieve and maintain the optimal maritime safety and to add value to the ship owner (Goh & Yip, 2014).



**Figure 2:** Typical Single and Double Hull Configurations (Original source taken from William, Rcac, & DeCola, 2009).

## THE ROLE OF THE IMO IN MARITIME SAFETY

The IMO is the specialized agency that deals with the international maritime and shipping affairs (Wieslaw, 2012). The participation members of IMO are 170 endorser States, including the UK and other major marine countries. Hence, IMO has the command ability to control more than 96% of world ship owner and operators (Maclachlan, 2004).

### LEGAL ASPECT OF IMO IN MARITIME SAFETY IN THE OIL TANKERS VESSELS PARTICULARLY IN MAJOR CASUALTY CASES

The major convention for oil pollution was “International Convention for the Prevention of Pollution from Ships” (MARPOL 73/78) (Wonham, 1996).

In 1971, the IMO has adopted another important legal measurement in maritime safety, particularly in oil pollution which was the “International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage” (Article 1, 1992). The aims of this convention were to establish the providing of repayment for pollution damages and also to contribute results for the intention that has been set out from this convention (Merchant Shipping Bill, 2013).

Also, IMO has supported compensation as Civil Liability Convention (CLC) for oil pollution. It is stated that any ship owners, from time and position of accident which happened, were going to be responsible for any pollution damage affected by oil spillage or oil discharged out of the vessels as an effect from the accident (Article 3, 1969).

Another important tool to control and assist the vessel in distress in oil tanker accident was “Port of Refuge” (Vaughan, 1994). Port of Refuge is any port that can provide shelter for damaged of any type vessels that can endanger life, health and surrounding or port who

can assist any vessel so that the vessel can stabilizing their position, reducing the danger in navigation and also protection for seafarers and surrounding (Article 949, 2003).

After the oil disaster by the Exxon Valdez (1989), the Oil Pollution Act in USA has been imposed in adapting the new technology in oil tanker vessel (Double Hull Steel Structure) and also the standard in constructing vessels for carrying oil in bulk (Oil Pollution Act, 1990).

IMO also has invented the idea of double hulled oil tankers in 1992. The convention was determined to request that oil tankers constructed after 1993 must be appropriated with double hulled tankers (Transport Canada, 2009). When Erika tanker, 1999 (No & Casualties, 1999) and Prestige tanker, 2002 (SSC, 2003) broke and spilling the oil into the sea, the IMO agreed to revise the phase out of single hulled tankers in earlier. The final revision declared that the legal phase out for existing single hull tankers will be changed on 2010 (101 Congress of USA, 1990).

## **Flag State and Coastal State Control**

Any state that giving the authority by registering any ships in using their state flag are responsible in handling all the matters of controlling the administrative for the ships (J.N.K. Mansell, 2009). In the other hands, Coastal State Control is to monitor the usage of the ships in the foreign coastline (Hare, 2004). The Flag State Control can be defined as requirement needed by any ships in measuring the safety of the ships during operation in all aspect. In monitoring the status of the ships on the flag, duty on the flag state is being imposed in acknowledging the accepting of international regulation. (Haiyuan Wang, 2008).

In controlling the registration of the flag, it can be categorized into two section; National Flag and Flag of Convenience (Bill Shaw, 1987).

### **National Flag**

National Flag registration is the record with genuine connection between the ships flags and the holder (Secretary, 2012), also acknowledged as closed registers and first registers of the vessels. (John Frittelli, 2014).

### **Flag of Convenience**

Flag of Convenience is the record of the ship flags is created deceit in another place other than the ship flag is displayed, whether it is the flag for other record country (William R. Gregory, 2012).

Flag of Convenience also known as “open register” parallel with the national register. Ships that register under this flag of convenience can gain some advantages whereby they can reduce the operating and technical cost such as lower taxation and lower payroll costs (The Merchant, 1927).

However, there are measure disadvantages in the safety regulation and controlling of the vessels in proper manners of safety with international convention which directly affected to the maritime safety (Zwinge, 2011).

### **Port State Control**

In usual procedure, many vessels are not commonly calling for Flag State and Coastal State which can reduce the authority for effectiveness of the Flag State to monitor and administer the standard aspect of the vessels (International Association of Dry Cargo Ship-owners, 2000).

However, with Port State Control, the movement of all vessels can be monitored accordingly. Port State Control (PSC) may consider as a third regime of authority that focus on the validity, quality and activity control of the vessels in respect of safety (Lloyd Register, Revision Four, 08/05). This is one part of the three-primer abridgement that took the responsibility to assure regarding the sea standard of maintenance (Paris MoU, 2005).

### **Regional Port State Control**

A “Port State Control regime” has been set up under “memorandum of understanding” (MoU) or very much alike within the same neighbouring port state (Christodoulou-Varotsi & Pentsov, 2008). Its practice the harmony investigation process that has been designed to aim the inferior vessels with the major objective relates to the IMO industrial convention such as SOLAS and MARPOL that consist of plan for vessels to be investigated when they were at the foreigner port. Some of regional port state controls are Paris Memorandum, Tokyo memorandum and etc. (Suter, 2012).

### **International Association of Classification Society (IACS)**

IACS can be defined as a non-government society that endorsed and approved for maritime safety particularly in technical support, construction design, and conformity of certification and also the study of improvement (Journal of International Association of Classification Society, 2011). This endorsement is aligned with the guideline and standard setup by the IMO (Rauta, 2004).

At the first, there were only seven leading society in the IACS (Journal of International Association of Classification Society, 2006). After getting the consultative status from the IMO in 1969, the membership has expanded to the present fifty members (Vaughan, 1994). The main intention as a Classification Society is to support the classification and lawful assistant service to the marine industry as well as in maritime safety for preventing pollution that gathered from maritime expertise and technology (Boisson, 1994).

The goal in supporting the vessel classification is to validate all aspect in the vessel i.e. the capability and availability of the vessel including parts, systems and other components in maintaining the safety while on board (IMO Library Service, 2001).

In other words, any vessel that gotten the endorsed and approved certificate by IACS, are entitled to get the international insurance that can protect the vessel while on board in international waters and coastline (Hare, 2004).

Even though IACS have a crucial character and carry out their role in the shipping industry, but still the liability of the vessels will be borne by the ship owners, operators and also by marine insurance providers (Lindfelt, 1991).

As such, IACS main responsibility is to inspect and investigate the compliance of the ship with the appropriate standard by issuing the related certificate, without any guarantee and liability of the wellness of the vessel. If anything happened to the ship during the operation, the ship owners and operators ought to manage the loss of the vessel which may compensate by insurance company, since the ship owners and operators remains eventually in charge and have the absolute power of the vessel's condition (Durr, 1997).

For examples of IACS members are Det Norske Veritas (DNV); Bureau Veritas (BV); Lloyd's Register of Shipping (LR); American Bureau of Shipping (ABS); and Nippon Kaiji Kyokai (NKK) (Durr, 1997).

## **THE ROLE OF VOLUNTARILY ORGANISATIONS IN OIL TANKER'S SAFETY**

When it comes to the safety on the vessel, there are lots of aspects that need to be considered from the condition of technical and up to the operation performance of the vessel. The responsibility in maintaining this up-to-date condition of the vessel is lies under the jurisdiction of ship-owners and operators (Eyres, 2007).

As a result from the high-risk responsibility of the ship-owners, they agreed to form non-legal pressure organisation to manage the transportation and maritime safety risk of their vessel (Kanjilal, 2015). Which are including of followings:

### **EQUASIS**

One of the tools that have been developed by the ship-owners is EQUASIS. EQUASIS is the general admission of information system on quality and safety-connection analysis regarding the world's merchant fleet (Article 16, 2009).

The database consists of more than 4500 ships safety-connection analysis containing full report of investigations done by port state control. In 1997, this collection of database has been launched as the part of the quality shipping campaign by the EU. (Lloyd's Register of Ships online).

EQUASIS is officially endorsed by marine agency, classification society, Protection and Indemnity Club (P&I Club) (Hormann, 2006) and also from the International Transport Workers' Federation (ITF) (United Nations Informal Consultative Process on Oceans and the Law of the Sea, 2007).



### **International Chamber of Shipping (ICS)**

The International Chamber of Shipping (ICS) is the primary international trade association of ship-owners and operators concerning in all aspect that effected the operation of international vessel i.e. technical, seafarers, world economy issues and etc. (Annual Review of International Chamber of Shipping, 2014).

### **International Association of Independent Tanker Owner (INTERTANKO)**

The International Association of Independent Tanker Owners, also known as association of harbour and port power (Journal of International Maritime Organisation, 2013). Their aims are to share and swap of ideas and industrial information on issues concerning people who work in the port and shipping industry, Latest joint venture of IMO, IAPH and the shipping industry is to coordinate the full utilization usage of port, terminal spaces and cargo loading framework i.e. for landing purposes and related safety matters (World Shipping Council, 2011).

INTERTANKO represent one of the non-government group committee of the ship owners and operators. Their members including the oil tanker owners, chemical tanker owners, classification society, financial institution, and non-government controlled tanker owners for the safety oil and chemical shipping industry (Rauta, 2004).

### **Oil Company International Marine Forum (OCIMF)**

Incorporated in April 1970, the Oil Companies International Marine Forum (OCIMF) is one of the freely association of dominant oil companies which are concerned in the shipping activity and safety, terminal line of crude oil and oil products (Companies & Marine, 2009). The formation of OCIMF is aligned with the feedback of community concern in oil pollution in the sea (Prince William, 2009). By using this program, members of the association are able to send and review the assessment report with each other to value the safety of the ships (OCIMF Annual Report, 2014).

### **International Association of Port and Harbour (IAPH)**

IAPH or International Association of Port and Harbour are a global independent association of harbour and port power (Journal of International Maritime Organisation, 2013). Their aims are to share and swap of ideas and industrial information on issues concerning people who work in the port and shipping industry, Latest joint venture of IMO, IAPH and the shipping industry is to coordinate the full utilization usage of port, terminal spaces and cargo loading framework i.e. for landing purposes and related safety matters (World Shipping Council, 2011).

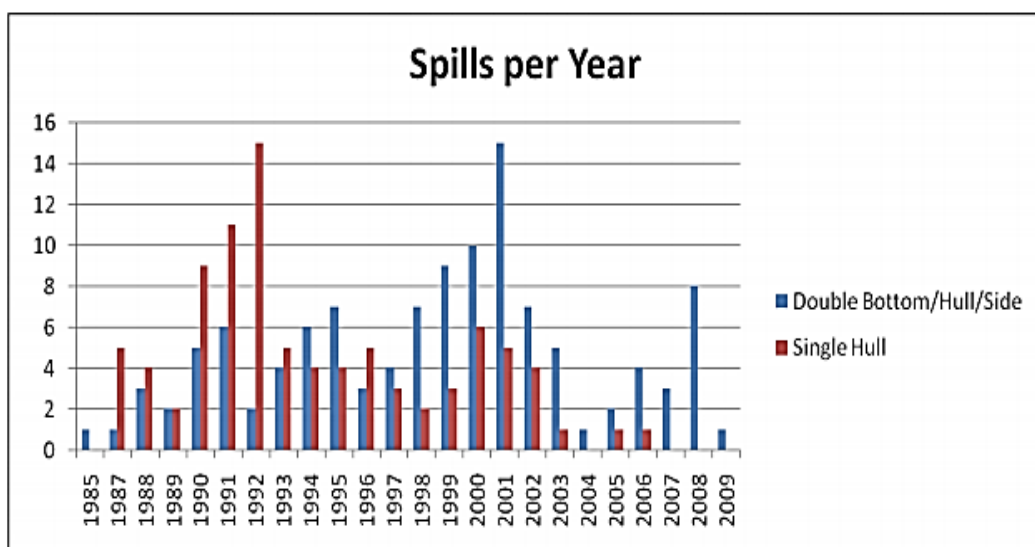
### **Committee Maritime International (CMI)**

Committee Maritime International or CMI is a non-profit political universal organisation that incorporated in Antwerp in 1897. The objective of CMI is to provide

suitable way and activities to the consolidation of all aspects in marine law (Journal of CMI, 2010).

## ASPECT OF IMPLEMENTATION OF DOUBLE HULL TANKER

The evolution in technology and innovation management for oil tanker vessels has evolved from the single hulled oil tanker vessels to double hulled oil tanker vessels for oil transportation in shipping industry. The main idea for this evolution is preventing oil pollution and controlling the safety aspect of marine industry. Holding to this idea, The IMO and its organisations believed it can stop the level of oil pollution by double hull tankers. But as reported and analysed the changing in technology to double hulled tankers stopped (Living Ocean Society, 2004), later it demonstrates that other ideas of innovation in technology also need to be considered in preventing oil pollutions as well as improving the safety level of marine industry (Prince William, 2009) (as shown in Figure 3).



**Figure 3:** Comparison of Oil Spill by Double Hulled and Single Hulled Tanker (Original Source taken from the Review of Double Hulled Tanker, William, Rcac, & DeCola, 2009)

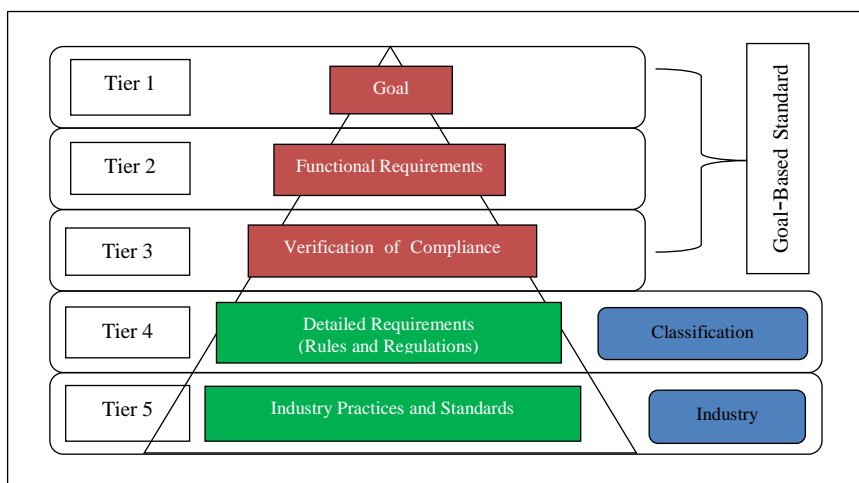
Despite of the accidents happened in double hulled tanker, there are some other advantages and disadvantages for double hulled oil vessels (Michel et al, 2001). The invention in technology of double hulled tankers show that the operation of loading clearance become faster and produce good rate of loading. In fact, the cleaning process of double hulled tanker become easy and faster (Greig et al, 2015).

However, there some increasing in the cost whereby the manufacturing cost of the vessel under double hulled became high due to usage of more steel, required more construction time as well as in maintenance aspect of the vessel (Brown & Savage, 1976). On the operation issue, double hulled tankers are easily leaking caused by the crack in bulkhead between cargo and the ballast tank (Living Ocean Society, 2004).

## IMPLEMENTATION OF INNOVATION IN OIL TANKER VESSEL

In 2004, the IMO and its organisation have amended Chapter 11-1 in SOLAS 74 (new Reg. 3-10) (Hoppe, 2005). The Marine Safety Committee under IMO has endorsed a decision MSC.290 (87) which enclosed with a new SOLAS arrangement that requires new single side skin carrier vessel for oil tankers and bulk vessels of 150m in length, and above to be formed and manufactured according to the class society's guidelines that have been approved and confirmed by the IMO to fit the new Goal Based Standard (GBS) creation specification, which were also being endorsed by MSC 87 (IMO Circular Letter, 2010). For strategic plan, the IMO should authorize the GBS for the design and construction of new ships. (BV, 2010).

Followed by the Bahamas, Greece and IACS, they agreed to use the 5-tiers framework of GBS (as shown in Figure 4) (The American Club, 2007). The first 3-tiers are comprised by the development of the IMO standards and the last 2-tiers are comprised of other organisation i.e. classification society' standards (Peng, 2011).

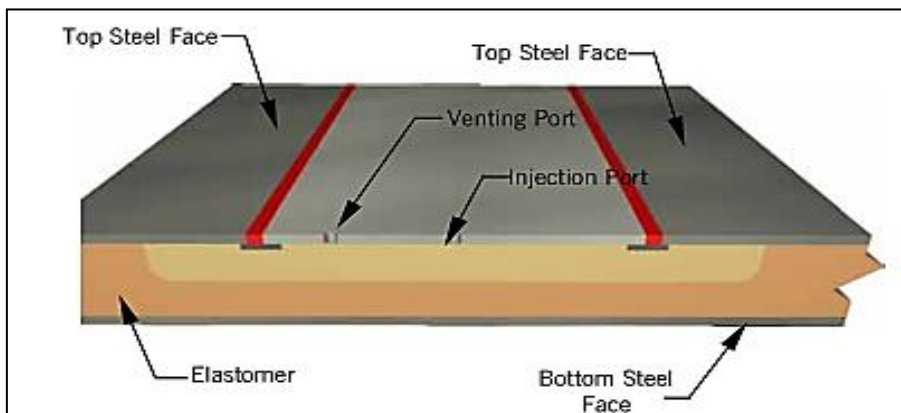


**Figure 4:** Goal-Base Standards Framework (Original source taken from An Analysis of the Implementation of Future GBS, 2011).

After endorsed by the IMO and its organisations, they invented the new open innovation for the design of the oil tankers and bulk vessels. This new open innovation is developed to increase the possibility of reducing in oil pollutions and also at the same time, promoting the new innovation with the lower cost. These standards approved and endorsed by the IMO and the design is confirmed by the IACS are to create the goal-based standards that being adopted by all ship builders, ship owners and also marine industry (Wendel, 2012). Goal-Based Standards (GBS) are the standards set up by the IACS for the structure and design of the new vessels for single side skin to be implemented to the oil tankers and bulk vessel in increasing the safety and reducing the percentage of oil pollution (Skjong, 2005). The advantages of the standards are low in the construction cost, maintenance cost and ease of access for inspection, as well as eco-friendlier. The implementation of the new standards is scheduled on the 1st July 2016. Any ships manufactured before July 2017 is not comply

with the standards. The standards are complying only for the ships that manufactured after July 2017 (Bulletin of International Ship and Offshore Structures Congress, 2009).

Addition to this and on base of these rules some researchers have invented the idea for new technology as added value to the current technology. One of the new ideas of technology invention is Sandwich Plate System (SPS, as shown in Figure 5. SPS is a lightweight material that separated two metal plates with elastomer core to make it stable and solid (Momcilovic, 2009).

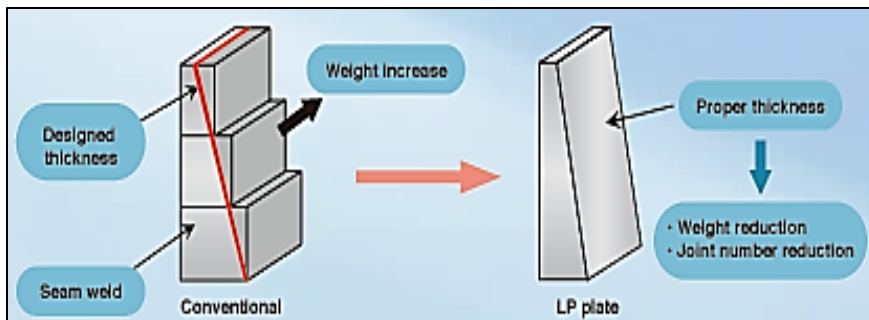


**Figure 5:** Conventional Structure and SPS Structure (Original Source taken from The Performance, Safety and Production Benefits of SPS Structures for Double Hull Tankers, 2004).

These plates have been proven to be stronger than a single stiffened metal plate. The dimension of the sandwich component and metals used for the front plate can be customized to fit the specification (Liu et al, 2010). It also proven that by adding the system to the current structure, it will reduce the weight, simple in structure, less maintenance, easy for doing inspection and reduce the risk in vessel collision too (Brooking and Kennedy, 2004). Even though the system has been applied in small ship's construction and bridge decking, the consideration in applying this new idea of technology to the vessel hull operation promise the effectiveness of safety in shipping industry. (Joshua et al, 2007).

Researchers also invented some idea for New Anti-Corrosion Steel for Crude Oil Tankers (NACS). The upper deck of oil tankers is open to mix the drain gas and H<sub>2</sub>S. The reaction between the drain gas and H<sub>2</sub>S will contribute some vaporization that leads to the corrosion. Therefore, the usage of NACS is believed to prolong the service life of the deck for the oil tankers with the lower risk of vaporization (Suzuki et al., 2004).

Longitudinal Profile Plate a.k.a. LP also one of the innovation in technology for oil tankers. As shown in Figure 6, LP can be defined as the continuous changes of the thickness of the plate in longitudinal way to cut down the construction cost and lighten the steel in many grades with the wide range of plate dimension for shipping manufacturing (Bulletin of JFE, 2011).



**Figure 6:** Various thickness and shapes of the steel plate (Original Source taken from the JFE Technical Report)

Other type of ships i.e. passenger ships have invented the steel bulkhead subdivision for reducing the percentage rate of dead passenger during accidents as well as marine pollution. Internal steel bulkhead subdivision is the manufacturing of the ship in watertight section are calculated by the maximum allowable distance between two adjoining bulkheads with differ to the length of the ships and the service provided by the ships (Rotfeld, 1998). The bigger the ships, the highest level of subdivision required. The designation of engine according to the requirement as the guarantee for the safety of the vessels and the seafarers is maintained in optimum level in facing the danger situations (Konovessis, 2012). This technology might be alternative to the innovation technology in oil tanker vessels (Yip et al., 2011).

## THE ROLE OF ISM AND STCW IN HUMAN FACTOR IN MARITIME SAFETY

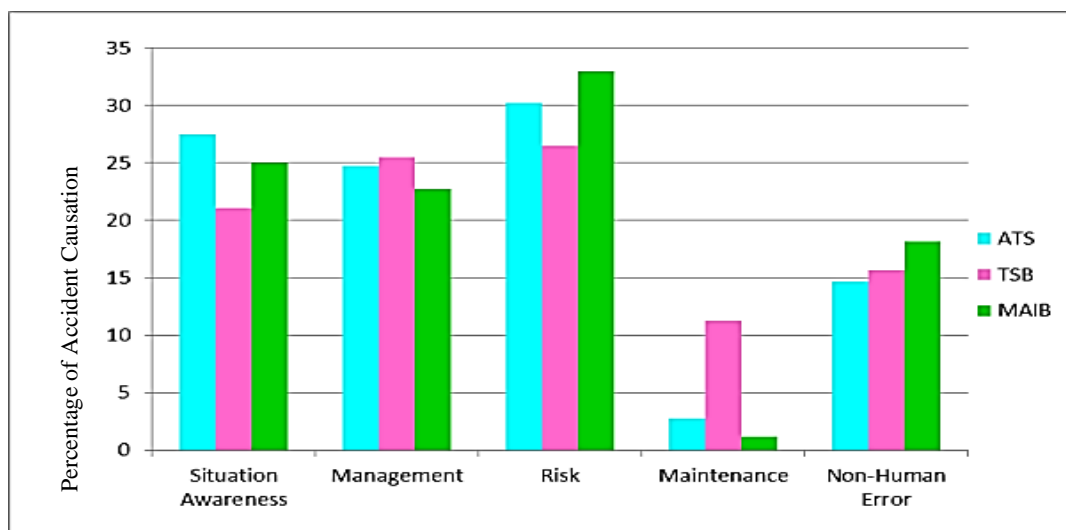
As stated in Figure 7, it shows that 80% of accidents in shipping industry particularly in oil tanker vessels are caused by human error. The advancement in technology, the system, rules and regulation are useless without consideration of human factor as the major factor to the safety in maritime industry.

Some researchers also believed that dispute in human error leads to the catastrophic of oil pollutions and tankers accidents (The Nautical Institute, 2001). When accidents happened to oil tankers, a pilot study particularly in human factors is conducted to measure the percentage defect caused by human error (Lee, 1999). They believed that tiredness, careless and misunderstandings are the main focus in human factor that leads to the safety environment in marine industry (Lu, Hsu, & Lee, 2016).

Aware of the effect of human error in safety of marine industry, the IMO engage development in advancing the arrangement in human factors by ISM code and regulation (Wu & Jeng, 2012). The IMO has widen the focus to be more on administration structure in the vessel, in align with the form proof of a Document of Compliance and a Safety Management Certificate in controlling the human factor (Tarelko, 2012).

On top of that, the IMO also improvising the Standard Training for Certificate of Competency of Watch Keeping Seafarers (STCW) focusing on implementation of minimal

standards of marine training and control of seafarer's capability (Bulletin of the Bahamas Maritime Authority, 2010).



**Figure 7:** Percentage of Oil Tanker Accident Causation by Human Error from ATSB, TSB and MAIB database. (Original Source taken from ABS Review and Analysis of Accident Database in Oil Tanker Disaster, Baker & Seah, 2004)

### The Relationship of Technology with Other Safety Factors in Oil Tankers Vessel

Beside the changes in innovation of technology for oil tankers, some of the researches believe that advancement in navigation system may help in reducing the percentage of sea accidents and at the same time can act as the tool in increasing the safety in maritime industry. ECDIS is an information system that adapts with the IMO rules and control using the computer-based navigation to show the marine area and ocean region. It can be used alternately for printed paper nautical chart (Bulletin of the Bahamas Maritime Authority, 2010).

While ENC is an electronic navigation control which has been created to be used along with ECDIS. The information gathered from the system covered i.e. position, heading, speed for every vessel in the system (Journal of International Hydrographic Organisation, 2010). Additional system to this sensor is Automatic Identification Systems (AIS) that have been invented in Navy ships then to be adapted for security as well as safety while on the sea or in the port (Perez et al, 2008).

Salvage can be defined as the act of helping any vessel, person or its cargo from danger on the seas. For example if any double hulled tanker vessel grounded and need to be saved, the vessel will having a problem during the operation of salvage where the reflating was very difficult due to the heavy weight of the vessel. It shows that when the double hulled tanker damaged, the percentage of water level from the outside will be entered the tanker.

The flood water also contributed to the heaviness of the tanker. However, for single hulled tanker, the small amount of oil spill will lighten up the ship and make it easy to reflate (Bulletin of OCIMF, 2003).

In allocating the oil spill area, EU has been invented an active sensor called “Synthetic Aperture Rader (SAR)”. This sensor provided by the satellite images to identify the area of oil pollution in any climate and all time (Singha et al, 2013). S AR may be used in aircraft and satellites where the images of satellite captured the area of oil spill, the vessels of the affected area and the vessel that responsible to the oil spill. Developed in the last 20 years, SAR has become one tool in saving the marine environment and increasing the percentage of safety in maritime operation (Alpers, 2008).

Maintaining the safety assessment in oil tanker also can be highlighted as the factor in increasing the safety level of the vessel. Formal Safety Assessment (FSA) can be defined as a form and standard procedure in improving the safety levels involving life preserving, health, maritime environment and ship in accordance with the IMO approval by evaluating the risk and assessing the benefit (Circular of IMO, 2002).

Despite of the allowable unidentified and challenging to accuse in civil and criminal actions, the vessels that registered under flag of convenience are recorded to have high percentage of detention level which can jeopardized the safety of the vessel, if compared with the vessels registered under national flag (Cabezas & Kasoulides, 1988).

The increasing number of detention ships under open register is contributed by the fewer and narrow rules and regulation intervention by the registered flag (Li, 1999). Due to the high percentage in ships detention, some regional agreement of the Port State i.e. Paris MoU, Tokyo MoU and US MoU have blacklisted some vessel under open register (Journal of Shipping and Ocean Engineer, 2014).

Therefore, in reducing the percentage of detention ships under the Flag of Convenience, some European country i.e. France, Norway and Germany, came out with the idea of quasi open register whereby the cost affected as the open register but at the same time the enforcement of marine regulation for the vessel administration and safety environment of the vessel are highly defined, accountable for liability and worldwide implemented (Hosanee, 2009).

In other words, the vessels registered under quasi open register have flexible cost with high requirements of legislation in the form to increase the safety of the marine environment. After seeing the advantages in conducting the quasi open register, some other Flag of Convenience countries also reinvented the same idea i.e. Singapore, Hong Kong, Bahamas and Cambodia (Luo, Fan, & Li, 2013). However, the reinventing idea of using quasi open register still has the breach. Numbers of Vessels registered under quasi open registered are recorded with inspection detention for Germany International Ship Register and French International Ship Register (Paris Mou Annual Report, 2013).

Despite of ship detention under registered flag, other factor that also needs to be studied in securing the marine safety environment is the detention ship under the IACS by Port State. Any vessel that inspected by the Port State under the Classification Society will be detained and will be considered as dangerous for sailing. Classification Society plays role as the approved endorser starting from the beginning of the construction up to the routine inspection of the vessel. However, due to the unreliable risk, lack of time of inspection by class survey and may negligent, the liability of class is limited only for endorse and issuing the certificate of class for the purpose of the marine insurance, many vessels went for detention in aspect of safety under IACS and also Non-IACS by MOU regional port state control (Journal of Shipping and Ocean Engineer, 2014).

## CONCLUSION

Many parties in the marine industry are depended to the role of IACS. Any type of flag states either National, FOC or quasi open, also need to admit liability in the wellness of the vessels and must avoid to give legislative immunity to IACS for negligent of surveys during inspection in order to make guarantee for safety in vessels and crews on the sea. As well as port state control play measure roles in this respect for safety of the vessels.

To reach to the optimal maritime safety, all elements in the industry themselves need to be integrated. It could start from first step in structure and design of the vessels, legal authorities for the rules and regulations and liability, and other safety factors need to be communicated in contributing the idea of preventing oil pollution. Innovation in design of the vessels, parallel with the Administration and Authorities i.e. the IMO, IACS, Flag State, along with the voluntarily association i.e. INTERTANKO, ICS, OCIMF, EQUASIS and IAPH.

Also, the added value for open new innovation in design i.e. SPS, NACS, LP and advancement of innovation in technology along with the human as the main factors in succeeding this objective and reaching to the optimal marine safety with excellent management team and trusted organisation

## REFERENCES

- Acomi, N., & Acomi, O. C. (2014). Improving the Voyage Energy Efficiency by Using EEOI. *Procedia - Social and Behavioural Sciences*, 138: 531–536.
- Alpers, W. (2008). SAR Principles of Oil Spill Detection • Mineral oil spills floating on the sea surface are detectable by imaging radars, because they damp the short for the radar backscattering on radar images, (March).
- Baker, C., & Seah, A. (2004). Maritime accidents and human performance: the statistical trail. *MarTech Conference*, Singapore: 225–240.
- Ballantyne, B. (2011) Global Shippers Forum. *Journal of Annual Report of World Shipping Council*. 1 - 24.



- Bertazzon, S., O'Hara, P. D., Barrett, O., & Serra-Sogas, N. (2014). Geospatial analysis of oil discharges observed by the National Aerial Surveillance Program in the Canadian Pacific Ocean. *Applied Geography*, 52: 78–89.
- Bill Shaw, Winslett, B. J., & Cross, F. B. 1987. The global environment: a proposal to eliminate marine oil pollution. *Natural Resources Journal*, 27(1): 157–185.
- BMA (2010) Marpol Annex VI Record Book for Fuel Oil and Ozone Depleting Substances. Bulletin of the Bahamas Maritime Authority. 1 - 3.
- Boisson. Classification Society Liability: Maritime Law Principles. Must they be requisitioned? (1994).
- Brooking, M. a., & Kennedy, S. J. (2004). The Performance, Safety and Production Benefits of SPS Structures for Double Hull Tankers. *Design & Operation of Double Hull Tankers*: 1–18.
- Brown, R. S., & Savage, I. A. N. (1976). Maritime Policy and Management. *Maritime Policy & Management*, 4(1): 1–1.
- Cabezas, P. R., & Kasoulides, G. (1988). International Maritime Organisation. *The International Journal of Marine and Coastal Law*. 3(3): 235–245.
- Calleya, J., Pawling, R., & Greig, a. (2015). Ship impact model for technical assessment and selection of Carbon Dioxide Reducing Technologies (CRTs). *Ocean Engineering*, 97: 82–89.
- Carolina, N., Chairman, V., Michel, R. K., & Corporation, H. E. (n.d.). (2001). Environmental Performance of Tanker Designs in Collision and Grounding: Method for Comparison. Washington: Transportation Research Board Special Report 259.
- Centre for International Law (1969) Article 3. *Journal of International Convention on Civil Liability for Oil Pollution Damage*. 1 - 12.
- Christodoulou-Varotsi, I., & Pentsov, D. a. (2008). Maritime work law fundamentals: Responsible shipowners, reliable seafarers. *Maritime Work Law Fundamentals: Responsible Shipowners, Reliable Seafarers*.
- CMI (2010) The Carriage of Hazardous and Noxious Substances by Sea. *Journal of Committee Maritime International (CMI)*. 1 - 46.
- D.J. Eyres, M.Sc., F.R.I.N.A. (2007). Ship Construction and Ocean Engineering. 6th edition: *Journal of Elsevier Ltd*. 1 - 99.
- Davies, P. M. (2009). US House of Representatives Sub-Committee on Coastguard & Maritime Transportation, February 4 th; Director Oil Companies International Marine Forum, 44(0): 1–17.
- Durr, S. D. (1997). An Analysis of the Potential Liability of Classification Societies: Developing Role; Current Disorder and Future Prospects: University of Cape Town.
- Feng, G. Q., Li, G., Liu, Z. H., Niu, H. L., & Li, C. F. (2010). Numerically simulating the sandwich plate system structures. *Journal of Marine Science and Application*, 9(3): 286–291.
- Frittelli, J. (2014). Shipping U. S. Crude Oil by Water: Vessel Flag Requirements and Safety Issues.
- Goh, L. B., & Yip, T. L. (2014). A way forward for ship classification and technical services. *Asian Journal of Shipping and Logistics*, 30(1): 51–74.
- Grabowski, M., Adviser, T., Berg, D., Willemain, T. R. & Yang, Y. (n.d.). (2007). Identifying Significant Safety Factors and Leading Indicators in Shipping Organisations with Oil Tanker Operations, May.

- Haiyuan Wang. (2008). Safety Factors and Leading Indicators in Shipping Organisations: Tanker and Container Operations.
- Hare, P. J. E. (n.d.). Tan Twan Eng Student No : Degree : Llm Shipping Law United States of America ' Supervisor : 1–78.
- Hoppe, H. (2005). Goal-Based Standards – A New Approach to the International Regulation of Ship Construction. *WMU Journal of Maritime Affairs*. 4(2): 6–8.
- Hormann, H. (2006). Classification societies. *WMU Journal of Maritime Affairs*, 5(1): 5–16.
- Hosanee, N. M. (2010). A Critical Analysis of Flag State Duties as Laid Down Under Article 94 of the 1982 United Nations Convention on the Law of The Sea. Division For Ocean Affairs And the Law of the Sea Office Of Legal Affairs, The United Nations New York.
- IACS (2011) Rules of IACS: *Journal of International Association of Classification Society*. 1 - 93.
- IACS Proc. Req. Procedure for Providing Lists of Classed Ships to Equasis and Hull Classification Surveys. Article 16. *Journal of International Association of Classification Society Procedure*. 1 - 33.
- IMO (1999) Adoption of the Code of The International Standards and Recommended Practices for A Safety Investigation Into a Marine Casualty or Marine Incident. 1 - 24.
- IMO (2001) Information Resources in Recycling of Ships. IACS under International Maritime Organisation Library Services. 1 - 21.
- IMO (2006) International Maritime Security and ISPS Code. *Journal of INTERTANKO Catalogue*. 1 - 97.
- IMO (2010) International Goal-Based Ship Construction Standards for Bulk Carriers and Oil Tankers. Circular Letter on GBS. 1 - 5.
- International Hydrographic Bureau (2010) Cooperation with International Organisations. (Element 1-1). *Journal of International Hydrographic*. 1 - 75.
- International Maritime Organisation (2003) Guidelines on Places of Refuge For Ships in Need of Assistance. Article 949. *Journal of International Maritime Organisation Resolution*. 1 - 14.
- International Maritime Organisation. (1974). SOLAS - International Convention for the Safety of Life at Sea. SOLAS - International Convention for the Safety of Life at Sea: 1–910.
- International of Dry-Cargo Ship-Owners (2000) Port State Control. *Journal of International Association of Dry Cargo Ship-owners*. 1 -33.
- INTERTANKO (2014) The Oil Tanker Spill Statistics. *Journal of The INTERTANKO Pollution Federation*. 1 - 259.
- J.M. Ng, T.L. Yip. (2009). Maritime Education in a Transdisciplinary World Volume: The Case of Hong Kong. *The Asian Journal of Shipping and Logistics* 25: 69-82.
- Joshua L, Gilbert Y G and Scott D B A (2007). Sandwich Plate System Under In-Plane Load and Uniform Lateral Pressure.
- Kanjilal, B. (2015). Enhanced Marine Oil Spill Response Regime for Southern British Columbia, Canada. *Aquatic Procedia*, 3: 74–84.
- Kawasaki, H. (2011) Large Block Ring; a new revamping method. *Bulletin of JFE*. 1 - 8.
- Konovessis, D. (2012). An investigation on cost-effective tanker design configurations for reduced oil outflow. *Ocean Engineering*, 49: 16–24.

- L. Lindfelt. (1991). The Underwriter's Perspective, The Society of Naval Architects and Marine Engineers.
- Legal Affair (2007) Law of The Sea - Division for Ocean Affairs and The Law of The Sea of Legal Affairs. Bulletin on United Nations Informal Consultative Process on Oceans and the Law of the Sea. 1 - 105.
- Li, K. X. (1999). The safety and quality of open registers and a new approach for classifying risky ships. *Transportation Research Part E: Logistics and Transportation Review*, 35(2): 135–143.
- Lloyd Register, Revision Four. (2005). Circulation of IACS. August.
- Lloyd's Register (1973) Resolution MEPC 111-116. *Journal of International Convention for the Prevention of Pollution from Ships. MARPOL Convention Outline*. 1 - 584.
- Lu, C.-S., Hsu, C.-N., & Lee, C.-H. (2016). The Impact of Seafarers' Perceptions of National Culture and Leadership on Safety Attitude and Safety Behaviour in Dry Bulk Shipping. *International Journal of E-Navigation and Maritime Economy*, 4: 75–87.
- Luo, M., Fan, L., & Li, K. X. (2013). Flag choice behaviour in the world merchant fleet. *Transportmetrica*, 9935(August): 1–22.
- MacLachlan, M. (2004). The Shipmaster's Business Companion. The Nautical Institute. 4: 1-385.
- Mansell, J. N. K. (2009). Flag State responsibility: Historical development and contemporary issues. *Flag State Responsibility: Historical Development and Contemporary Issues*: 1–269.
- Marine Pollution Bulletin, Congress of USA. (1990).
- Merchant Shipping Bill, Republic of South Africa. (2013).
- Merchant, T., & Act, S. (1927). Safety at Sea. *Scientific American*, 137(5): 407–408.
- Mom, N. (2009). Estimation of Ship Lightweight Reduction by Means of Application of Sandwich Plate System. 123–128.
- Morooka, M (2014) Representing the Global Shipping Industry. *Annual Review of International Chamber of Shipping*. 1 - 60.
- No, I. M. O. R., & Casualties, M. (1999). Report of the Enquiry Into the Sinking of the Erika Off the Coasts of Brittany on 12 December 1999. *Commentary*, 1–150.
- OCIMF (2003) Health, Safety and Environment at New-Building and Repair Shipyards and During Factory Acceptance Testing. *Bulletin of OCIMF*. 1 - 45.
- OCIMF (2007) Identify Safety and Environment Issues Facing the Oil Tanker and Terminal Industries. *Journal for Framework of GBS under IACS, the American Club*. 1 - 36.
- Paris MoU (2005) Nations of Maritime Authorities. *Journal of Paris Memorandum of Understanding*. 1 - 37.
- Paris MoU (2013) Port State Control Under Paris MoU. *Journal of Annual Report*. 1 - 37.
- Peng, Y. U. E., Science, M. O. F., & Affairs, M. (2011). An Analysis of the Implementation and Future Development of IMO Goal-Based Standards.
- Perez, H. M., Chang, R., Billings, R., & Kosub, T. L. (2009). Automatic Identification Systems (AIS) Data Use in Marine Vessel Emission Estimation. *Time, (Cmv)*: 1–25.
- Rauta, D. (2004). California Land Commission, Prevention First: 1–7.
- Rotfeld, A. D. (1998). October 1998, 44(October).
- Rothblum, A. (2000). Human error and marine safety. National Safety Council Congress and Expo.

- SDR (Special Drawing Right) (1992) Merchant Shipping (International Oil Pollution Compensation Fund (Bill). Article 1. (1992) Fund Convention, Republic of South Africa. 1 - 3.
- Secretary, G. (2012). Flag of Convenience or Not ? Challenging the Flag of Convenience Status of EU Registration States : An Introductory Contribution to a Controversial Debate Iliana Christodoulou-Varotsi, 18(Article 94): 1–12.
- Singha, S., Vespe, M., & Trieschmann, O. (2013). Automatic Synthetic Aperture Radar based oil spill detection and performance estimation via a semi-automatic operational service benchmark. *Marine Pollution Bulletin*, 73(1): 199–209.
- Skjong, R. 2005. IMO MSC 80. Lunch Presentation May 12th, 2005. 1: 1–22.
- Soares, GC. & Garbatov, Y. (2009) Proceedings of the 19th International Ship and Offshore Structures Congress. *Bulletin of International Ship and Offshore Structures Congress*. 1 - 925.
- Suter, W. N. (2012). Qualitative Data, Analysis, and Design. *Introduction to Educational Research: A Critical Thinking Approach*: 342–386.
- Suzuki, S., Muraoka, R., Obinata, T., Endo, S., Horita, T., Omata, K., & Plates, S. (2004). Steel Products for Shipbuilding, 2(2): 41–48.
- Tarelko, W. (2012). Origins of ship safety requirements formulated by International Maritime Organisation. *Procedia Engineering*, 45: 847–856.
- Terhune, K. (2011). Tanker Technology: limitations of double hulls. A Report by Living Oceans Society. Sointula, BC: Living Oceans Society.
- The Nautical Institute (2001) The Mariner's Role in Collecting Evidence. *Journal of Nautical Institute*. 1 - 45.
- US Senate (1990) Oil Pollution Liability and Compensation. *Journal of Oil Pollution Act*. 1 - 66.
- USCG (2001) Proceedings of the Marine Safety. *Journal of United State Coast Guard*. 1 - 76.
- Vaughan, B. B. B. (1994). The liability of classification societies. *Lloyds Maritime and ...*: 1–19.
- Viggor, S., Juhanson, J., Jõesaar, M., Mitt, M., Truu, J., Vedler, E. & Heinaru, A. (2013). Dynamic changes in the structure of microbial communities in Baltic Sea coastal seawater microcosms modified by crude oil, shale oil or diesel fuel. *Microbiological Research*, 168(7): 415–427.
- Vikas, M. & Dwarakish, G. S. (2015). Coastal Pollution: A Review. *Aquatic Procedia*, 4: 381–388.
- Wei, L., Hu, Z., Dong, L., & Zhao, W. (2015). A damage assessment model of oil spill accident combining historical data and satellite remote sensing information: A case study in Penglai 19-3 oil spill accident of China. *Marine Pollution Bulletin*, 91(1): 258–271.
- Wieslaw, T. (2012). Origin s of Ship Safety Requirements Formulated by International Maritime Organisation. *Procedia Engineering*. 45: 847–856.
- William R. Gregory. (2012). Flag of Convenience: The Development of Open Registries in the Global Maritime Business and Implications for Modern Seafarers.
- William, P., Rcac, S., & DeCola, E. (2009). A Review of Double Hull Tanker Oil Spill Prevention Considerations, (December).

- Wonham, J. (1996). Some Recent Regulatory Developments in IMO for Which There Are Corresponding Requirements in the United Nations Convention on the Law of the Sea – A Challenge to be Met by the States Parties? *Marine Policy*, Vol. 20: 377-388.
- Wu, W. J., & Jeng, D. J. F. 2012. Safety management documentation models for the maritime labour convention, 2006. *Asian Journal of Shipping and Logistics*. 28(1): 41–66.
- Yip, T. L., Talley, W. K., & Jin, D. (2011). The effectiveness of double hulls in reducing vessel-accident oil spillage. *Marine Pollution Bulletin*, 62(11): 2427–2432.
- Zwinge, T. (2011). Duties of Flag States to Implement and Enforce International Standards and Regulations - And Measures to Counter Their Failure to Do So. *J. Int'l Bus. & L.*, 10(2): 297.

eISSN 2590-4140

