FUZZY DEVELOPED TOOL FOR ASSESSING RISK OF FAILURE OF LEAN IMPLEMENTATION

[1]AHMED DEIF, [2]HOSAMELDEEN MOSTAFA

[1]Industrial Technology and Packaging, California Polytechnic State University, CA, USA.
[2]Management of Technology, Nile University, Cairo, Egypt.

Abstract— This paper introduces a new tool to measure the risk of lean implementation failure inside enterprises. The tool is designed based on a proposed model that manipulated fuzzy logic to measure the risk of lean failure and is called LIFRAT (Lean Implementation Failure Risk Assessment Tool). LIFRAT takes input from users in the form of multiple indicators that measure different aspect of lean inside the enterprise. The indicators are categorized into four main categories: Managerial indicators, Functional indicators, Human factors indicators and External indicators. A sensitivity analysis was carried out to investigate different relations between the four main categories of lean indicators and the associated risk of failure. The developed tool was further demonstrated using four hypothetical cases of enterprises at four different stages of business life cycle. Results showed the ability to quantify the risk of lean implementation failure. In addition, they showed that the risk of failure to implement lean system depends on the life cycle stage of the enterprise as well as the different weights allocated for the previous mentioned indicators. This research is an extra step to help managers in successful migration/implementation of lean concepts and tools via reducing the risk of failure of such process.

Index Terms— Lean production, Risk of failure, lean assessment.

I. INTRODUCTION

Lean production is a revolutionary management system that was invented by Japanese auto manufacturers and led to Japan pioneer in all industries especially automotive industry. More and more industries including service and healthcare are transforming their operations towards lean principles all over the globe. The simple yet effective concepts of lean can be summarized as "Doing more with less": More productivity, more quality, more variety, more profit with less effort, less time, less resources and less cost. However, lean system is not the magical solution for all enterprises in all industries, it is not just a system to be implemented then wait for risk-free success. Lean system - and like everything else – has its own risks that can lead to destruction of all the waited and hoped success if these risks have not been assessed and well-managed. What we mean by risk here is "the probability of unwanted event during lean implementation that may or may not occur and may be neutralized through pre-mediated action.

LIFRAT is a tool developed based on fuzzy logic approach to measure the risk of failure imposed by lean implementation/transformation prior the implementation/transformation itself. The ability to predict the situation during lean implementation is very critical because it can save a lot of money and effort by suggesting modifications and improvements very early in the system to avoid implementation failure.

II. LITERATURE REVIEW

This review presents samples of research work dedicated for lean implementation assessment. Examples include the work of the Lean Aerospace Institute LAI (2001)which prepared a detailed lean enterprise self -assessment tool (LESAT). The manual contains ready templates for assessment sheets and checklists. Srinivasaraghavan and Allada (2006) proposed a methodology to assist contemporary lean assessment tools that will provide a quantitative measure of leanness by benchmarking other exemplar lean industries along with specific pointers for improvements based on cost considerations, to overcome the weakness of most lean assessment tools that provide qualitative analysis and do not provide any clear direction of where the improvement efforts should be directed. Dakov and Novkov (2007) Focused on the sustainable industrial enterprise development. Authors compared the two main approaches of sustainable development, the first is revolutionary development and the second is evolutionary development. Taj (2008)adopted existing models on a sample of 65 manufacturing plant in china to measure the degree of leanness in Chinese factories. He investigated the adaptation of lean production and assessed its current state of practice in selected plants in electronics, telecommunication, wireless, computer, food/beverage, garment, pharmaceutical, chemical, petroleum, printing, A/C and heating, and a few others in China. Machado and Pereira (2008)presented an application model which can be used in a supply chain to be the foundation for the development of an integrated checklist for self-evaluation of the lean supply chain performance in organizations that are implementing lean strategies. Lanza, Book and Jondral (2011)authors presented a four-step approach that initially assesses the capability of certain lean production methods, simulates and valuates the effects of such an implementation. The proposed methodology offers a comprehensive monetary assessment of the application of lean methods that displays the net present value of an investment in lean advancement.Ming-Te, Kuo-Chung and Pan (2012)proposed new model for assessing lean performance based on data mining techniques with application to a Toyota supplier.

The previous work is a representative sample of the large literature body dedicated for assessing lean implementation, however, there is a clear gap for the lack of an assessment tool that can capture the potential failure of lean implementation. The work in this paper attempts to contribute to this gap.

III. LEAN IMPLEMENTATION FAILURE RISK ASSESSMENT TOOL LIFRAT

The first step in building the tool was to categorize the sources of lean failure in the surveyed case studies and then categorizing them to facilitate their systematic study. They were categorized into four main categories:

Functional factors (FN): This is the category of lean parameters that are related to functionality and operations of the company like operations stability.

Human factors (HF): This is the category of lean parameters that are related to workers affairs like training and culture.

Managerial factors (MG): This is the category of lean parameters that are related to management on all levels, from top management to line managers like long-term planning and growing leaders.

External factors (EX): This is the category of lean parameters that are related to all activities outside the control of the company that are related to environment that the company exists in, like supplier, demand and country infrastructure.

The overall risk is the summation (fuzzy aggregation not linear summation) of risks resulted from these four categories together.

$$\mathbf{R} = \sum \mathbf{FN} + \sum \mathbf{HF} + \sum \mathbf{MG} + \sum \mathbf{EX}$$

Next step was to develop detailed indicators for each lean concept mentioned. However, due to the large number of concepts, a few major concepts were chosen to focus on; and develop their indicators (figure 1 and table 1). The final step in building the tool was to build the logic of the risk assessment tool.Due to the very large number of parameters and the high subjectivity in each one, fuzzy logic was the best choice to use for building the logic.The fuzzy system is composed of three stages (figure 2):

a- Input: Four main lean variables identified earlier.

b- Processing: Fuzzy Rules.

c- Output: Risk of failure of lean implementation.

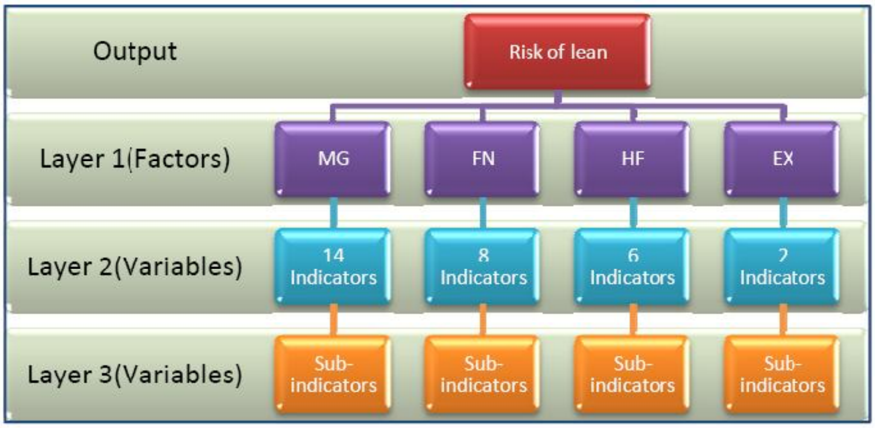

Figure 1. LIFRAT hierarchy of factors and variables.

Table 1. The four categories of main lean concepts.

FN	HF	MG	EX
Production Stability	Employee culture change	Management stability	Authority related
use reliable technology	Employee involvement	knowledgeable leaders Management persistence	Market related
Use "Flow" and "pull" principle		Become a learning organization	System Stability
Standardized tasks	Develop exceptional people and teams	Top-down support Motivating people	Capability to level out demand/or to meet fluctuations
visual control	Employees acceptance and satisfaction	Customer Focus Continuous improvement Standardization	Capability of sales network
High Tech quality checks Error proof production, quality in the source.	Employee Stability Training	communication long-term philosophy Grow leaders	Help and challenge partners and suppliers
		Go and see for yourself Make decisions slowly, implement them rapidly	Need for lean / lean-compliant suppliers

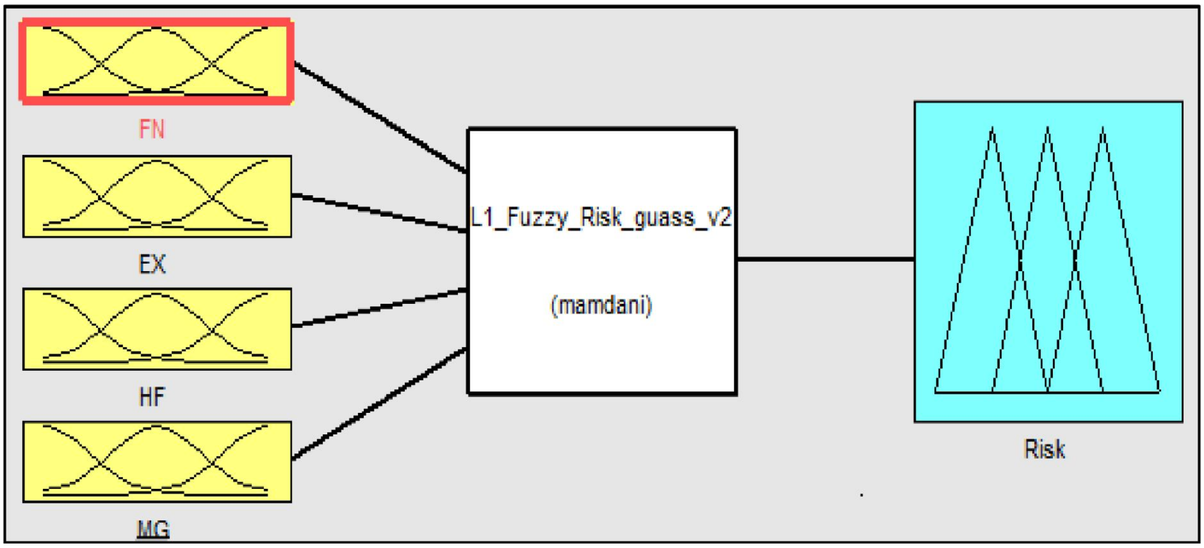

Figure 1. Overview of LIFRAT fuzzy approach.

The fuzzy system for LIFRAT was built using SIMULINK® as shown in figure (2).The four main variables of lean are represented here by (EX_2, FN_4, HF_3, and MG_8). Each one of these names represent variable that holds the value of this category. This value of the variable is calculated from the values given to each indicator of that variable. E.g., EX_2 is the variable that represents the value of category External factors. The value of EX_2 is calculated by the sum of the values of EX indicators.

Each variable value goes to the fuzzy block associated with it. This block holds the fuzzy rules that govern the calculation of the risk level (fuzzy rules are explained in details in the following sections).The risk block is the final stage of calculating risk level. The risk calculation is composed of three stages.

Level 1: Risk block (L1_Risk), calculates the risk of lean implementation failure based on the summed input coming from the prior stage (level 2). Risk block contains the fuzzy rules that calculate risk calculation using input values.Level 2 : composed of four blocks (L2_MG,L2_ FN ,L2_HF,L2_ EX), each one of these blocks calculates the value of the variable associated with it; MG block calculates MG variable’s value, FN block calculates FN variable’s value, HF block calculates HF variable’s value and EX block calculates EX variable’s value. Each block calculates the associated values based on the inputs from the prior stage (level 3). Each block contains the relevant rule set that calculates the associated variable value based on the block input.Level 3: Simulated input for variables’ indicators. Each variable of the four variables (MG, FN, HF, EX) has indicators that are needed to calculate its value. Each one of these indicators should be handled as separate variable with fuzzy block and fuzzy rule set to calculate it value accurately. E.g., EX variable has two indicators at (level 3), so to calculate them, we should have created fuzzy block and fuzzy rule set for each indicator, and so on for the rest of variables. However, for the sake of simplicity, we simulate the output value of this stage as direct values (saved as vectors) to the next stage (level 2) omitting fuzzy calculations in (level 3).

IV. PRELIMINARY ANALYSIS

The developed model is analyzed to gain some lean failure risk management insights and to better understand the model. A simple sensitivity analysis is carried out for the four main variables constituting the risk measurement. The sensitivity analysis was limited to the first level of the model (these main four variables) to keep the analysis simple while still gettingmeaningful results.

The developed tool measures the risk of failure of lean implementation quantitatively then transforms it to qualitative levels for better understanding. The tool measures two types of variables: input variables (MG, FN, HF, EX) and output variable (risk). The interpretation of the variable values (high, normal, low) differs as follows:

High: when assigned as an input to the developed tool in the analysis phase, it takes value = 0.8. When represents the risk calculated by the tool, it means the range shown on the chart.

Normal: when assigned as an input to the tool in the analysis phase, it takes value = 0.5. When represents the risk calculated by the tool, it means the range shown on the chart.

Low: when assigned as an input to the tool in the analysis phase, it takes value = 0.2. When represents the risk calculated by the tool, it means the range shown on the chart.

Figure 3 outlines the different scenarios considered in the sensitivity analysis.

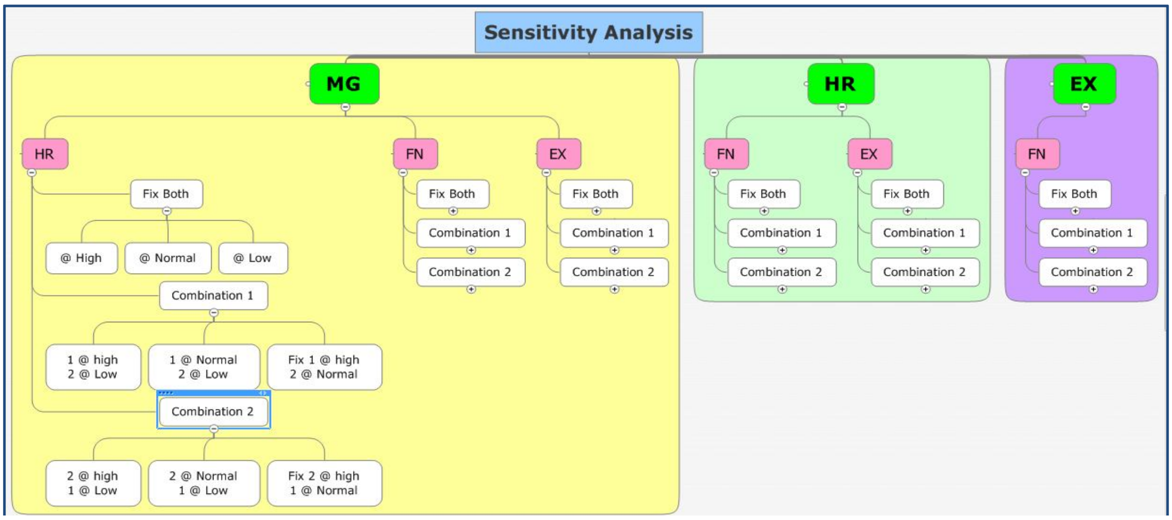

Figure 3. Different scenarios for sensitivity analysis.

Table 2. Summary of business life cycle analysis using LIFRAT model.

	Start-up	Growth	Maturity	Decline
MG	NORMAL	NORMAL	HIGH	LOW
FN	HIGH	HIGH	NORMAL	LOW
HF	HIGH	NORMAL-TO-HIGH	NORMAL-TO-HIGH	LOW
EX	LOW	NORMAL	NORMAL	LOW

The results of the sensitivity analysis were mapped to explore the relation between the risk of lean implementation failure and the different stages in the life cycle of a company. The age of the company plays an important role in determining the risk level (High, Normal and Low) associated with implementing lean management by each one of the selected variables that measure the risk. We identified different levels for each of the considered variables at every stage of the company's life cycle as outlined in table 3. Figure 4 plots the calculated risk at the different stages of the company's life cycle based on the different variables scenarios in table 3.

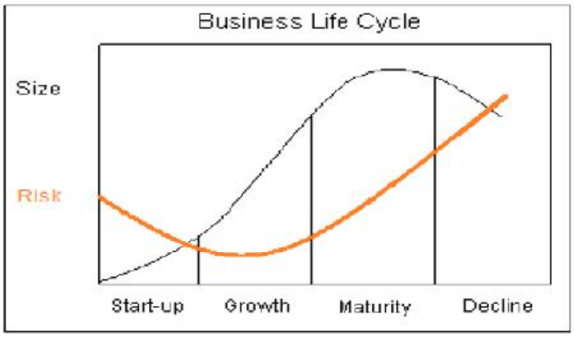

Figure 4. Risk of lean implementation failure associated with the company's life cycle

V. SUMMARY

Lean thinking is being applied in different organizations, either manufacturing-based or service-based, has proven great results in improving the performance inside them. Lean transformation process faces many difficulties and challenges that could lead to the failure of this transformation process. This risk of failure of the transformation process needs to be identified and measured. The lean implementation failure risk assessment tool (LIFRAT) was developed to measure the expected risk of lean implementation failure in a specific enterprise using fuzzy logic.

The analysis of the different scenarios for lean implementation at the different stages of a company's life cycle was conducted to determine, in a general sense, which stage of the "Business life cycle" is the best to implement lean principles. LIFRAT will also help the company to determine in a quantitative way the risk level the company will face when implementing lean in present time. LIFRAT does not measure the impact and usefulness of lean implementation, nor the degree of leanness inside the company. Results show that it is easier and less risky to start lean implementation/transformation at growth phase as in growth phase, HF level is normal or high, MG level is normal, FN level is high, EX level is normal. The results show that the highest risk to start that implementation/transformation is at decline phase as in decline phase, HF level is low, MG level is low, FN level is low, and EX level is low or normal.

Results of the sensitivity analysis results also suggest that some factors are more critical to the lean implementation process and dominate other parameters. The most important and critical factor is managerial aspects, in most cases, managerial variable dominate other variables and affect the overall risk of lean implementation failure.

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