Finding Relationship among NASA TLX components using Fuzzy DEMATEL method

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By

J Krishnakanth Naik
15MF3IM06

Under the guidance of

Dr. O. B. Krishna
Department of Industrial and Systems Engineering

Indian Institute of Technology, Kharagpur

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DECLARATION

I certify that

1. The work contained in the thesis is original and has been done by myself under the general supervision of my supervisor(s).

2. The work has not been submitted to any other Institute for any degree or diploma.

3. I have followed the guidelines provided by the Institute in writing the thesis.

4. I have conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute.

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Date: 24-05-2020 J Krishnakanth Naik

Place: Kharagpur 15MF3IM06

CERTIFICATE

This is to certify that the project titled “Manufacturing lead time estimation with machine learning approaches” is a bonafide record of the work carried out by Krishnakanth Naik (15MF3IM06), under my supervision and guidance for the partial fulfillment of the requirements for the Dual Degree: Bachelor of Technology in Manufacturing Science and Engineering and Master of Technology in Industrial Engineering and Management during the academic session 2019-20 in the department of Industrial and Systems Engineering, Indian Institute of Technology, Kharagpur.

Dr. O. B. Krishna

Department of Industrial and Systems Engineering

IIT Kharagpur

Date:

Place: Kharagpur

CONTENTS

ABSTRACT

In many events, it is very important to know the factors affecting the work. In numerous mishap events, failure in circumstance mindfulness is referenced as one of the quick reasons for those mishaps. In like manner, the identification of factors affecting circumstance mindfulness and their cooperation's are key factors in prevention of mishaps. This analysis aims to consider one of the key factors influencing the understanding of conditions in contemporary working environments. By the techniques of Fuzzy Delphi and Fuzzy DEMATEL, this investigation was led forced to rely on the evidence gained from the decisions of the experts. The findings demonstrate that administrative variables and other human factors are the essential elements that influence the consciousness of situations, and their consequences are rendered explicitly or indirectly by other factors influences. In addition, the findings of the evaluation could be used to prepare future studies in order to show the informative scale of factors that could influence conditions in the work environment. In this sense the analysis could also be used to draw up true guidelines on safety for industry supervisors and businesses.

2. INTRODUCTION

The exhibition and personnel excellence are strongly impacted by the load of work it receives. Eventually an estimate of the psychological workload is a crucial angle in the strategy and assessment of workplace responsibilities. The task schedule has an impact on worker and can trigger the individual's performance to decline more.

The National Aeronautics and Space Administration-Task Load Index (NASA-TLX) has indeed been extensively used throughout individual efficiency index assessments. Workload characterized as a theoretical development that speaks to the expense of achieving a specific degree of execution incurred by an organizational support. In this fashion, as opposed to task-focused, our meaning of the outstanding task at hand is human-focused'[1]. A few physical macro-scales used for ranking are: mental demand (MD), physical demand (PD) and temporal demand (TD), level of frustration (FL), level of effort (EL), and level of performance (PL) [2]. The complete outstanding task at hand measure is documented as a normal weighted of the six unique assessments. Each evaluation is weighted by some of its provided constant from the pairwise weighting method (PWT) in order to represent true figure: the inspector is required to pick which measurement is the most important as an outstanding source of burden, with more than 10 pairwise examinations [3]. The aggregate load of each origin is then estimated by taking into account of quantity of examinations at which it was first positioned, isolated by a number for standardization. At last, the accumulated file (TLX) is given a weighted whole:

$$TLX = \sum_{j=1}^{6} AA * W_{AA}$$

In which W_{AA} was the ranking weight based on AA sub-scale.

PWT is quantifiable accurately, but it still raises few conceptual and empirical issues, especially in the workplaces. For starters, the weighted normal depends for the most part on unconfirmed scientific suspicions [4]. Weights should be free of appraisals along these lines, as when administrators give evaluations and other specialists give weights autonomously [24]. However it might be, that's not really the case in the typical NASA-TLX program where each supervisor offers the two evaluations and weights. The big drawback of PWT is the way it just cannot find outstanding communication from the load source, given the reality that the effect of two or more load sources is usually inacceptable [5]. For example, potentiating impacts could occur where the consequences of Loads A and B multiply. In addition, traditional cooperative standards cannot make a difference: administrators who are working on (operation A & B) & (operation C) possibly will respond in a different way whenever presented to (operation A) & (operation B & C) etc. In addition, transitivity rules may be excluded sometime (For example, TD <= MD and EL <= TD, members may not react to MD >= EL) and pair checkups may also be difficult for low-skilled specialists due to the level of deliberation required (for example, increasingly important in your work: MD or FL?)[6]. Others, have also raised doubts about the significance of PWT v/s TLX. Fourth, there was a talk of the scale of reliability when a few things are not related to task requests: for example, PD in office workers [26]. Finally, the evaluation of the six sub-scales and subsequent performance of PWT is tedious, especially in working circumstances (including the time expected to educate administrators on the best way to complete the survey) or possibly when poll organization should be rehabilitated [7].

One of the primary variables to achieve superior is workload. The burden of work could be classified into two classes: physical workload and mental workload. In view of the state, the workload could be more precisely

classified into three more conditions to be a specific remaining burden as per the standard, exceeding the limit and under the remaining load [22]. Calculating the psychological workload is an important phase in designing and estimating the psychological workload can be the degree to which an individual controls the level of aptitude and execution of work. The estimation of the psychological workload can be carried out subjectively using the NASA-Task Load Index, which is also known as NASA-TLX [8].

NASA TLX requires six factors to examine the burden of mental needs, physical necessities, and time requirements, degree of dissatisfaction, execution and level of business. There is a scale from each size of the outstanding task at hand which the respondent will fill out. Scale estimates to each pointer [9]. Fuzzy logic is a technique that can obscure or one-sided procedural factors and cannot be depicted with conviction [10]. In fuzzy logic, obscuring factors are spoken to as a set whose individuals are an estimate of yields on the set and its degrees of participation [23]. On the Fuzzyfication stage, the contributions of the genuine estimation of truth (input values) are NASA TLX requires six factors to examine the burden of mental needs, physical necessities, time requirements, degree of dissatisfaction, execution and level of business. There is a scale from each size of the outstanding task at hand which the respondent will fill out. Scale estimates to each pointer [9]. Fuzzy logic is a technique that can obscure or one-sided procedural factors and cannot be depicted with conviction [10]. In fuzzy logic, obscuring factors are spoken to as a set whose individuals are an estimate of yields on the set and its degrees of participation [23]. On the Fuzzyfication stage, the contributions of the genuine estimation of truth (input values) are changed into the Fuzzy input type. A Triangular fuzzy number is often seen as M = (p, q, r) where p < q < r, has a triangular membership, and a trapezoidal Fuzzy number is also often seen as M = (p, q, r, s), where p < q <= r < s, has a trapezoidal membership function [11].

3. OBJECTIVE:

The main objective of this project is to "*Find the relationship among NASA Task Load Index components using Fuzzy DEMATEL method*".

4. METHODOLOGY:

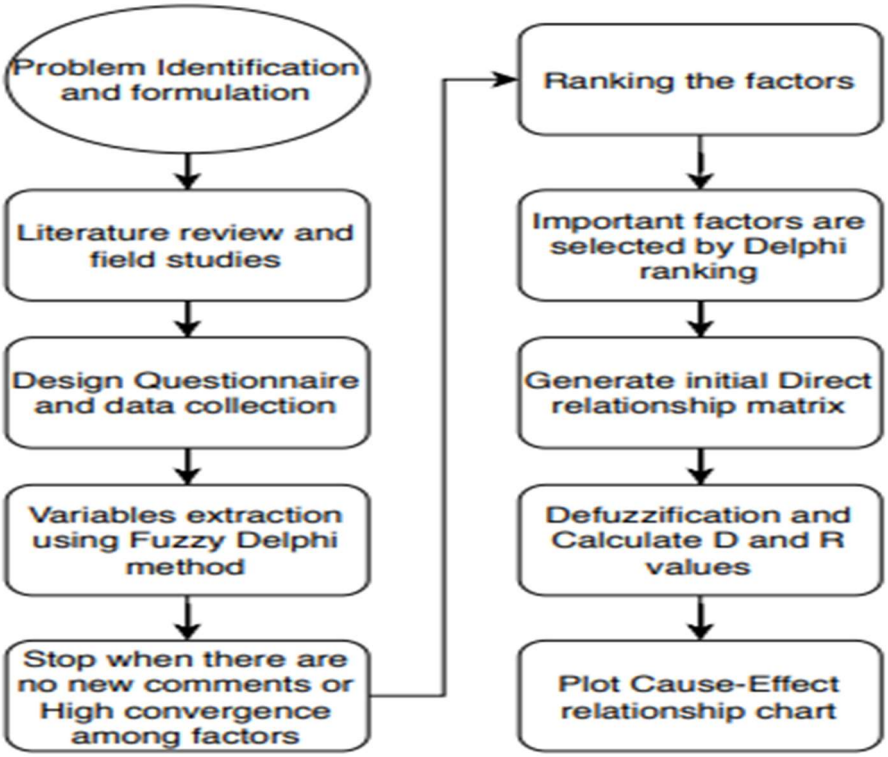


Fig: Roadmap for conducting the survey

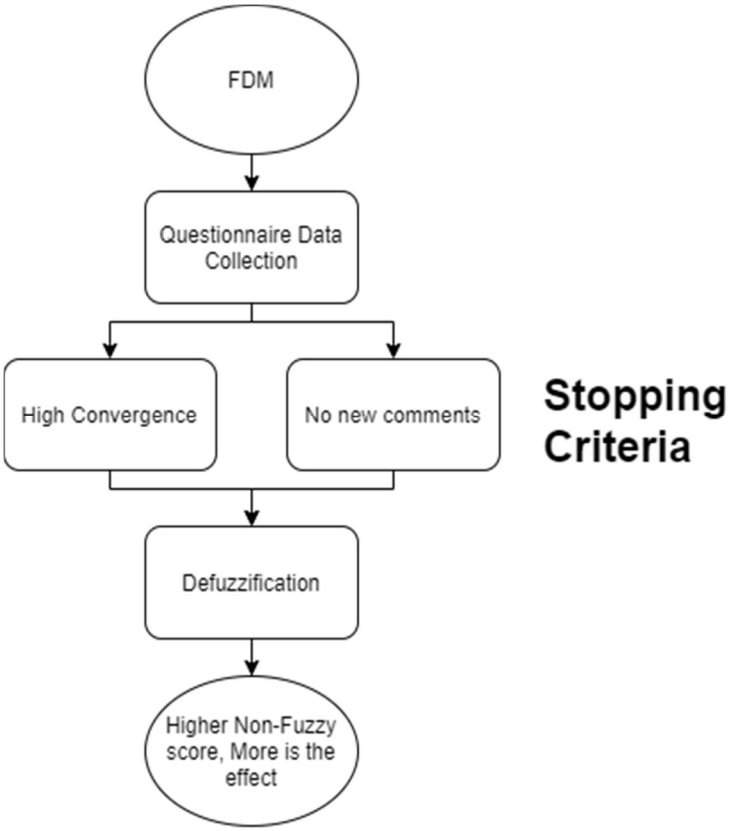
Fuzzy Delphi Method Implementation:

1. The survey begins with an extensive review of the literature followed by problem identification and formulation, data collection, data processing, analysis and conclusion.
2. Data obtained from a randomly chosen crane operator and the questionnaire includes a nominal scale of 5 points (No or quite small, low,

moderate, large, quite large).

3. Stopping criteria for data collection was when there are no new comments from the respondents then we can stop the survey as well as when there was high convergence among variables of the operators then we can stop the survey.

Flow chart of Fuzzy Delphi Study:



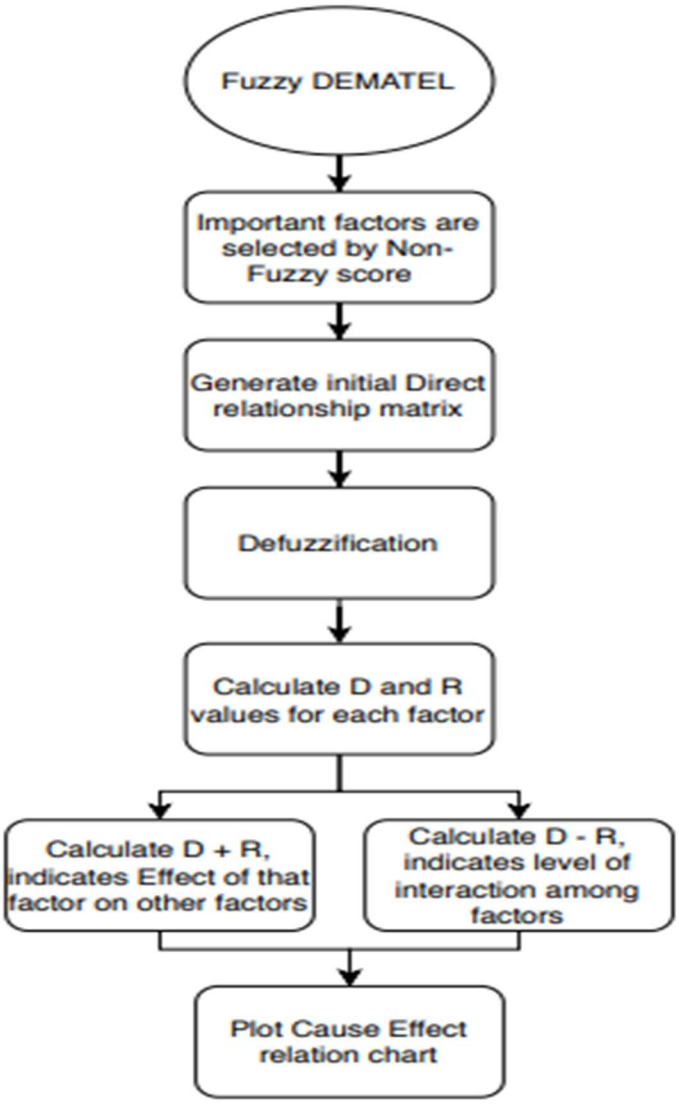
Implementation of Fuzzy DEMATEL Method:

1. After computing the non-Fuzzy score for all variables, important variables are selected depending on their scores. Highest score variables from each category was selected for later study.
2. Initial Direct relation matrix was generated from the selected variables and

again we convert the fuzzy integers into non-Fuzzy score for comparing the relations among variables.

3. Calculate D and R values for every factor and then compute (D + R) and (D – R) values for each factor to find cause and effect relationship
4. The following flow chart shows the Fuzzy DEMATEL method implementation.

Flow chart of Fuzzy DEMATEL Method:



Finding interactions among variables

The next step is to calculate D and R values.

1. The total of every row (D) shows the factor's effect on other factors.

$$D = \sum_{j=1}^{n} t_{ij}$$

2. The total amount of one column (R) refers to each factor's effect of other factors.

$$R = \sum_{i=1}^{n} t_{ij}$$

3. The total amount of every row (D) implies that factor has an effect on other factors.

4. The total amount of every column (R) has shown the influence of the various factors on each factor.

5. D - R for each factor reflects the type of relationship (cause or effect).

6. D + R indicates the degree of interaction between variables.

7. Final step is to draw cause effect relationship between variables.

Experimental Design:

Data collected from 10 crane operators using VR-Simulation. The simulation is of 2 types: Low Hazard and High Hazard.

5. DATA DESCRIPTION:

The following table contains the questionnaire data collection and their description

WI – Weakly Important
VSI– Very Slightly Important
SI - Slightly Important
MI - Moderately Important
AI – Absolutely Important

VL– Very Low
L – Low
ML – Moderately Low
M – Moderate
MH – Moderately High
H – High
VH – Very High

Questionnaire Direct Relation Evaluation Matrix:

	MD	**PD**	**TD**	**F**	**E**	**P**
Mental Demand (MD)	EI	MI	VSI	SI	WI	SI
Physical Demand (PD)	VSI	EI	SI	WI	SI	MI
Temporal Demand (TD)	SI	MI	EI	SI	MI	EI
Frustration (F)	SI	VSI	SI	EI	VSI	WI
Effort level (E)	MI	VSI	SI	MI	EI	SI
Performance (P)	VSI	SI	MI	WI	SI	EI

Questionnaire Direct Relation Rating Matrix:

	MD	PD	TD	F	E	P
Mental Demand (MD)	VH	ML	H	L	MH	VL
Physical Demand (PD)	MH	VH	VL	H	L	MH
Temporal Demand (TD)	MH	L	H	ML	H	VH
Frustration (F)	H	M	MH	ML	VH	H
Effort level (E)	VH	L	MH	ML	VL	L
Performance (P)	VL	H	VL	H	MH	H

Linguistic Terms and their Fuzzy Numbers:

i. Trapezoidal Fuzzy integers for Evaluation matrix:

	A	B	C	D
EI	0	0	0.1	0.2
VWI	0.1	0.2	0.2	0.3
WI	0.2	0.3	0.4	0.5
MI	0.4	0.5	0.5	0.6
SI	0.5	0.6	0.7	0.8
VSI	0.7	0.8	0.8	0.9
AI	0.8	0.9	1	1

ii. Triangular Fuzzy integers for Rating matrix:

	A	B	C
VL	0	0	0.1
L	0	0.1	0.3
ML	0.1	0.3	0.5
M	0.3	0.5	0.7
MH	0.5	0.7	0.9
H	0.7	0.9	1
VH	0.9	1	1

6. *RESULTS:*

Defuzzification:

Triangular fuzzy integers can be converted into non-Fuzzy number (Z) using following formula: $Z = (a + 2*b + c) / 4$

	A	B	C	Non-Fuzzy number
VL	0	0	0.1	0.16
L	0	0.1	0.3	0.35
ML	0.1	0.3	0.5	0.55
M	0.3	0.5	0.7	0.71
MH	0.5	0.7	0.9	0.84
H	0.7	0.9	1	0.94
VH	0.9	1	1	0.99

Direct-Relation Non-Fuzzy score matrix:

	MD	PD	TD	F	E	P
Mental Demand (MD)	0.06	0.42	0.75	0.61	0.33	0.64
Physical Demand (PD)	0.75	0.06	0.64	0.33	0.64	0.42
Temporal Demand (TD)	0.54	0.47	0.06	0.54	0.47	0.06
Frustration (F)	0.61	0.67	0.54	0.06	0.75	0.33
Effort level (E)	0.49	0.75	0.61	0.42	0.06	0.61
Performance (P)	0.75	0.54	0.49	0.33	0.61	0.06

Calculate D and R values:

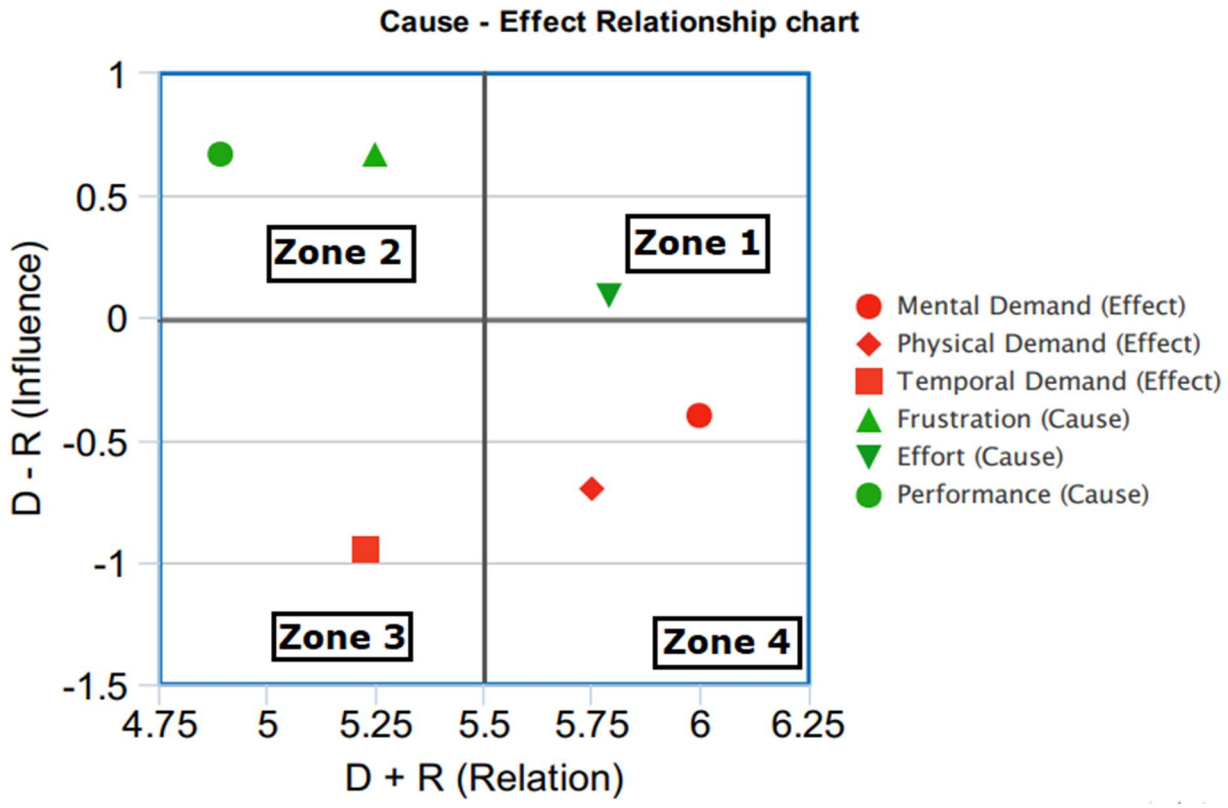
1. D - R for each factor reflects the type of relationship (cause or effect).
2. D + R indicates the degree of interaction among factors.

	MD	PD	TD	F	E	P	D - Value
Mental Demand (MD)	0.06	0.42	0.75	0.61	0.33	0.64	**2.80**
Physical Demand (PD)	0.75	0.06	0.64	0.33	0.64	0.42	**2.84**
Temporal Demand (TD)	0.54	0.47	0.06	0.54	0.47	0.06	**2.14**
Frustration (F)	0.61	0.67	0.54	0.06	0.75	0.33	**2.96**
Effort level (E)	0.49	0.75	0.61	0.42	0.06	0.61	**2.94**
Performance (P)	0.75	0.54	0.49	0.33	0.61	0.06	**2.78**
R –Value	**3.20**	**2.91**	**3.09**	**2.29**	**2.85**	**2.11**	-

Summary Table:

Factor	ID	D – Value	R – Value	D + R	D - R	Group
Mental Demand	**MD**	2.80	3.20	**6.00**	**-0.40**	**Effect**
Physical Demand	**PD**	2.84	2.91	**5.75**	**-0.07**	**Effect**
Temporal Demand	**TD**	2.14	3.09	**5.23**	**-0.95**	**Effect**
Frustration	**F**	2.96	2.29	**5.25**	**0.67**	**Cause**
Effort level	**E**	2.94	2.85	**5.79**	**0.09**	**Cause**
Performance	**P**	2.78	2.11	**4.89**	**0.67**	**Cause**

CAUSE – EFFECT RELATION CHART:



Decreasing order of D values: **F > E > PD > MD > P > TD**

Decreasing order of R values: **MD > TD > PD > E > F > P**

7. DISCUSSIONS AND CONCLUSION:

The results shows that the factors “Mental Demand (MD)” having 6.00 and “Effort (E)” having 5.79 (D + R) values, the level of interaction was high for these factors with other factors. Whereas, the factors “Performance” and “Temporal Demand (TD)” having least (D + R) values 4.89 and 5.23, the level of interaction was low for these factors with other factors.

In addition, the type of interactions for the factors “Mental Demand (MD)” are high (having high (D + R) value) but due to its high R-Value (3.20) it act as an effect factor and it almost entirely affected by all other factors even though, they only affect a few factors.

Mental Demand (MD) having low D value and high R value, it indicates low impact on other factors but high impact of other factors on Mental Demand. The dependencies can be explained using the cause-effect relationship chart using zones.

Factors in Zone 1 are most important and “Effort (E)” having higher D-value and lower R-value which indicates that high impact on other factors and low impact of other factors on Effort. The first line of corrective measures should be taken on this factors to improve.

Factors in Zone 2 are less important compared to zone 1. “Frustration (F)” having higher D-value and lower R-value, it indicates that high

impact on other factors and low impact of other factors on Frustration (F). In addition, for Performance (P) having low D and R values it can be considered as independent variable.

Zone 3 factors are influenced by zone 1 and zone 2 which influence zone 4. These factors are not so important and considered as independent variables.

Factors in Zone 4 are effect variables. Although all the factors are important but these factors should be least considered in corrective actions and these factors should generally improve indirectly by improving zone 1 and zone 2 factors.

Temporal Demand (TD) having low D and high R value, it indicates that low impact on other factors and high impact of other factors on TD.

Physical Demand (PD) having same range of D and R values, it can be considered as relatively independent factor.

Based on the above observed findings, Effort had the highest impact values and they identified as the effect factor with highest values among other factors. This indicates that the Effort (E) factor are the most important factor affecting the whole system.

The causal relationship among the factors can be studied using a variety of methods. DEMATEL is far more recommended among other methods because of certain features. Unlike other methods, such as AHP, which assume that the factors are independent, DEMATEL could well identify the interdependence between the factors. This performed to prepare the causal relationship between the variables in a digital manner, making

it much easier to interpret the effectiveness and assess the significance of the relationship. DEMATEL seeks to improve real applications in order to achieve research objectives and, furthermore, when this technique is often used in conjunction with fuzzy logic, it might yield more exact results. Previous studies proves the some similarity with uncertainty but by incorporating fuzzy methods, the results are more efficient results.

This study offers a framework for improving understanding and corrective behavior about circumstances. This study identifies the essential factors and their interaction which could be presented in a pictorial cause-effect relationship decision-making model. It therefore makes it possible to direct corrective actions towards the most effective variables that have a stronger impact and overcome resource constraints to improve safety performance. It is therefore a good guideline for the design of a strategic plan to improve safety performance and the results can be applied wherever possible.

This study identifies and ranks for the most important variables and their interactions on the basis of key findings. As it is a prerequisite for conducting field trials or designing predictive factors that the most significant factors are identified, the findings could be used as a guideline for future trials.

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