SEM Model for Investigating Factor of an Accident Affecting Safety Performance in Construction Sites in Nepal

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Abstract— **The main objective of this research work is to identify critical accident causing factor, which affects the improvement of safety performance in the construction enterprise. Besides, an evaluation matrix was considered to identify the present state of safety performance on a different category of construction enterprise. Conceptual SEM-PLS path model is designed, 192 complete respondents are collected from professional technical manpower in the construction project by questionnaire survey in Nepal. The inadequate setting of safety level by the contractor (ISSC) impact hugely to safety performance than other accident causing factors with a path coefficient of 0.299 and the t-value of 8.068. Both private and public construction enterprises are in IV (high impact) level and INGOs construction is in III (fair impact) level to improve safety performance as per maximum degree of membership (MDM) principle. The practical implication of this research is, results will motivate future research in this region and also increase the profile of critical accident causing factors mainly in developing countries.**

Keywords: **accident-causing factor, Nepal, safety performance, SEM-PLS model**

I. INTRODUCTION

The construction firm is among one of the most probable sectors for hazardous incidents. Various construction hazard edge to loss of life, disease, injuries and permanent disability. Such hazards not only affect the employees but it also has direct impact on employers as the employees suffering from disease or injury cannot work. In some cases, the employers may lose the competent employees in case of permanent disables [1]. Occupational Safety and Health Administration (OSHA) is always concentrated in concern to construction firms, especially regarding high number of accidents in comparison to other firms. These accidents has impact not only to the employer but also to their future life of the whole family, and it is also one of the main cause of losses of construction firm [2]. The previous researcher claims that people who spend life in construction site, one in 300 had the chances of death at the site while 10 out of 1000 employers face injuries annually. Probability of serious casualties and disability only from onsite accident is high in the construction industry than another industry sector [3]. Issue of accidents not only delays the project activity and deliverables but also indirectly or directly obtains cost [4]. Insufficient or absence of Occupational Safety and Health (OSH) management and unfollowed OSH management system are the prime cause of high injury rate in a construction sites [5].

The occupational safety and health management system is a proactive method having a well-managed set of elements which facilitate an organization to achieve a goal. Management body generally concentrates on uniform progress using the plan-do-check-act model [6]. Neglecting safety in the site will issue accidents or ill health which results not only in financial losses but also results in crippling of the company. Similarly, giving a safe and healthy workplace is efficient action for controlling the cost of construction works. Various occupational health and safety experts accept that the implementation of well-organized education mediate on OSHA escort for better safety performance [7].

Although for social and economic progress of any developing country, construction industry plays a vital role but safety measures are not much a matter of high consideration. Nepalese contractors are unconcerned about the procedure of safety rules and regulations. With an intention of cost minimization, they lower the standard safety procurement, but in reality, it leads to a high loss in future through accidents. For instance, the construction site engineers, managers, supervisors and employers lack sufficient training on occupational safety and health which leads to higher rates of accidents in construction sites. Besides, only a limited number of researches were held in Nepal which elaborate issues of safety in Nepalese's construction firm[8]. The health and safety of employers during construction is a major factor, as it impacts the project directly since the accidents and injuries cost to the project will be very high. The ratio of serious injuries, death and ill health around the world in construction firms remain too high compared to other sectors [9]. It is necessary to understand the construction health and safety problems in order to determine the factors that affects the procedures regarding the health and safety of workers. To improve safety performance, safety standardization is considered as a promising solution to engineers and foreman in any construction project [10]. Moreover, safety behavior of worker in work place is considered as critical aspect for improvement of safety performance of construction sites [11].

Rahim (2008) defined an accident as an event which is out of any planning, expectation, desirable, or controlled [12]. Similarly, the researcher explained that the accident is directly proportional to an unsafe state and unsafe activities in the site. Generally, an accident takes place under specific

Manuscript submitted June 18th 2019; Revised on April 17th 2020.
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cause which can be reduced. The major factors that causes an accident in the construction site are pointed by many previous researchers which includes workers related, worker team related, workplace related and equipment and material related causes [12-17]. The causes of accidents are varied but the major causes of accident in Nepal are identified as– workers and work team, workplace material and equipment, lack of leadership from the government [18]. Construction industry utilizes 7.5 percent of the world workers but it turns over 16.4 percent of the total occupational injuries and fatalities.

The major aim of this research is to identify the main critical factors that impacts on upgrading safety performance in construction enterprises, in developing country, by using SEM-PLS model and focused to minimize those identified critical factors which has huge impact and is a barrier to improve safety performance. Besides, this research also tries to determine the present condition of various construction enterprise in terms of safety performance by using evaluation matrix implementing Maximum Degree of Membership (MDM) principle.

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

A. *Influential factor*

An accident is a greatly meaningful or considerable injurious event [19, 20]. The earlier researchers from various part of the world express various aspects as a major cause of the accident on the site. In the USA, factors causing accident include insufficient training, unsafe work site condition, weak attitude in safety, insufficient safety material and equipment [21]. In China, two prime contributing factors for construction accident are the issue of workers and management [12]. In Taiwan, cause of the accidents are working in a height without PPE, not enough experience of workers, worker contact with movable thing or structure in the sites[22]. In UK prime factor for high potential injuries are classified in three factors: macro (concern to stockholder), mezzo (project manager, organization etc.) and micro (worker, working site, supervision problem etc.) [23]. In UK, key aspects of potential injuries were: worker and work team (70%), equipment related (56%), material related (27%), worksite related (49%) and lack of risk management (84%) [13]. In Pakistan, cause of the accident in the sites are weak application of safety rules by the government, not enough execution of safety budget and safety incentive by the client and lack of enough safety training PPE by the contractor in the site [13]. In Malaysia, key aspects for injuries were: negligence of labor, the inability of labor to follow work process, using equipment absence of safety device, labor attitude, insufficient skill, and education level of labor [12]. In addition, major factor of an accidents were also associated to worker's element, improper site management, unsafe equipment and unable to use PPE [16].

Worker team related

The teamwork-related factor is pointed as a major cause of the accident in the construction site [13, 15, 17, 20]. Many researchers have pointed out many indicators related to work team factor for an accident in the construction sites. Lack of proper communication, application of safety rules and regulation in a team are pointed as a critical aspect of an accident causing in the site [24]. Similarly, the inadequate experience of safety management personnel is marked as a major indicator for worker team [25]. Lack of concentration to coworker's safety play vital role in occurring of accident in the site [26]. Besides, the earlier study pointed out that the poor experience of the foreman is also a cause of the accident [24]. Misunderstanding of safety requirements by workers or subcontractors [27] are some critical aspects that invite accident in the construction industry.

Worker related

Worker related factor has been the focus of many previous researchers as the cause of the accident [13, 15]. Worker action or behavior, worker health and fatigue and worker capabilities including knowledge and skill are some indicator factor related to worker [13]. Similarly, workers lack the capability to recognize hazard and their negligence of hazard are highlighted as an aspect that invites accident in the site [28]. Moreover, the low skill level of the workers and the effect of alcohol or drugs among workers are identified as the cause of accident under worker related factor [29].

Workplace related

Unsuitable worksite condition and the environment are the major factor for the cause of the accident in construction [12-14, 16, 17, 30]. Site congestion or Site condition excluding material, equipment and weather are indicators for factor related to workplace [13, 15]. Similarly, working under extreme temperature, poor ventilation and light arrangement are major cause of the accident [13, 14, 31]. Besides, restricted worksite and poor housekeeping on the site are pointed as cause of the accident [13, 16, 32]. Low level of ergonomic consideration of workspace is also one of the cause of the accident [33]. Moreover, lack of mitigation of hazardous site environments e.g. noise is pointed out as indicator factor of the accident [31]. Inadequate safety guards or barriers [34], unclear emergency procedure [25], inadequate site information [29] are some important indicator of workplace-related factor which may cause an accident in the site.

Equipment and material related

The equipment and material can be a critical factor for an accident on the construction site [12-17]. Suitability, usability and condition of material and equipment play a vital role in causing an accident in the site [13, 24]. An accident can take place due to the use of defective, substandard and incorrect working tools, inadequate temporary support structure like scaffolding, work platform, grill guard etc.[14]. Similarly, inadequate use of PPE is pointed as a critical cause of the accident in the site[26]. Moreover, workers' exposure to hazardous material and inadequate use of heavy equipment are listed as the cause of the accident in the site [29, 35].

Inadequate setting of safety level by the contractor

The previous studies focused on inadequate setting of safety level by the contractor as a factor that drags accident in the site [14]. Safety precautions are not considered while selecting the subcontractors [36, 37], inadequate reporting and investigation of accidents and near misses [38], lack of safety ownership by the contractor and his staff [39], insufficient provision of safety training and resources by the contractor including PPE [40, 41], poor employment practices, that is, transient and unskilled workforce, high turnover of workers, insufficient manpower employed, unfavorably high supervisor-worker ratio [42-44] and insufficient staff for safety supervision and inspection [40, 41] are key aspects of accident caused due to inadequate setting of safety level by the contractor.

Lack of leadership from government

Poor enforcement of safety rules and regulations by the government agencies [40, 42, 43, 45-47]. Non-existence of any mechanism to maintain accident statistics at industry level [16, 42, 43, 46, 47], poor contracting practices like competitive bidding, safety not included as a BOQ item [42, 43, 46, 47] and non-existence of a safety certification system for construction stakeholders at industry level [42, 46, 48] are critical indicators under lack of leadership from government that causes accident in site.

Lack of proper safety commitment

Lack of proper safety commitment is a secondary cause of the accident. Proper participation and commitment of both worker and management is the prime requirement to ensure the improvement of safety policy [16]. Similarly, previous researchers focused that increases in safety performance with an increase in safety commitment [49]. Besides, the owner commits to focus on the choice of safe contractor, showing safety in design and involvement in safety management. Similarly, when subcontractor commits to safety, subcontractor automatic adheres with the safety mechanism stated by the contractor [25]. Moreover, the management group commits to spend for safety, stating safety program and maintaining pressure to labor [15]. Side by side, when a management group focuses safety over schedule, the management group can't adjust safety even when the schedule is lagging and when the cost is overrun [31, 50, 51].

III. METHODOLOGY

The usage of Structural Equation Modeling (SEM) in construction management related studies is increasing nowadays. In this research, we used Partial Least Square Structural Equation Modeling (PLS-SEM) as suggested by some previous literature [52] when the goal of the study is to forecast & describe a target construct and also help to recognize its predecessors. Smart PLS (v.3.2.8) software, IBM SPSS statistic v.23, AMOS v.23, G- power (3.0.10) and Excel were used to do analysis. Moreover, safety performance evaluation uses the quantitative relationship between the latent variable and observed variable from SEM-PLS model as a basis for making comparative study in different types of construction namely private, public and INGOs construction enterprise to measure impact level of accident factor in safety performance.

A. Questionnaire design

From the previous literature review, we tried to enlist 41 indicators on seven constructs on accident causing relevant factor and one construct was to measure safety performance. Most of the items were investigated by Likert scale from 1 (totally agree) to 5 (totally disagree). All 41 items used in the model are shown in table 1:

TABLE I
LATENT FACTORS ALONG WITH ITS CORRESPONDING INDICATORSINDICATORS

Latent factor	Code	Indicator factor	Supporting sources
Work team related	WT1	Lack of communication /application of safety rules and regulation in a team	[24]
	WT2	Inadequate experience of safety management personnel	[25]
	WT3	Lack of concentration of coworker's safety	[26]
	WT4	Poor experience of foreman	[24]
	WT5	Misunderstanding of safety requirements by workers or subcontractors	[27]
Worker related	W1	Workers failure to identify the hazard	[28]
	W2	Worker negligence of hazard	[28]
	W3	Worker health and fatigue	[13, 26]
	W4	Worker capability including skill and knowledge	[29]
	W5	A worker under the influence of drugs or alcohol	[29]
Work place related	WP1	Site congestion or site condition excluding material, equipment, and weather	[13, 15]
	WP2	Working under extreme temperature, poor ventilation and light arrangement	[13, 14, 31]
	WP3	Restricted worksite and poor housekeeping in site	[13, 32, 53]
	WP4	Low level of ergonomic consideration of workspace	[33]
	WP5	Inadequate safety guards or barriers and unclear emergency procedure	[25, 34]
Equipment and material related	EM1	Suitability, usability and condition of material and equipment	[13, 24]
	EM2	Use of defective, substandard and incorrect working tools, Inadequate temporary support structure (like scaffolding, work platform, grill guard etc.	[14]
	EM3	Inadequate use of PPE	[26]
	EM4	Workers exposure to hazardous material	[35]
	EM5	inadequate use of heavy equipment	[29]
The inadequate setting of safety level by the contractor	ISSC1	Safety not considered while selecting the subcontractors	[37, 38]
	ISSC2	Inadequate reporting and investigation of accidents and near misses	[38]
	ISSC3	Lack of safety ownership by the contractor and his staff	[39]
	ISSC4	Insufficient provision of safety training and resources by the contractor (including PPE)	[40, 41]
	ISSC5	Poor employment practices (transient and unskilled workforce, high turnover of workers, insufficient	[42, 44]

		manpower employed, unfavorably high supervisor-worker ratio)	
Lack of leadership from government	LLG1	The non-existence of any mechanism to maintain accident statistics at the industry level	[42, 46]
	LLG2	Poor contracting practices (competitive bidding, safety not included as a BOQ item	[42, 46]
	LLG3	Poor enforcement of safety rules and regulations by the Government agencies.	[42, 46, 48]
	LLG4	Complex designing causing difficulty in the firm (Safety is not concerned in the project)	[14]
	LLG5	Nonexistence of a safety certificate system for construction firm stakeholders	[14]
Lack of proper safety commit-ment	LPSC1	The owner commits to focus on the choice of safe contractor, showing safety in design and involvement in safety management.	[25]
	LPSC2	When subcontractor committed to safety, subcontractor automatic adheres with the safety mechanism stated by the contractor.	[25]
	LPSC3	Management group commit to spending for safety, stating safety program and maintaining pressure to labor	[15]
	LPSC4	management group focus safety over schedule, the management group can't adjust safety even when the schedule is lagging	[31, 50]
	LPSC5	management group focuses safety over schedule, the management group can't adjust safety even when the schedule is a cost overrun.	[33]
Safety Performance	SP1	Pathways of workplaces are neat and tidy in my company	[54, 55]
	SP2	Machinery is equipped with good safeguard in my company.	[54, 55]
	SP3	Electrical equipment is with good safeguard in my company.	[54, 55]
	SP4	Hazardous workplaces are equipped with good ventilation in my company	[54, 55]
	SP5	My company provides employees with Personal Protective Equipment (PPE).	[54, 55]
	SP6	My company implements measurement of hazardous environment periodically.	[54, 55]

B. Questionnaire response profile

All the responses were collected from province no. 3, 4 & 5 of Nepal, where construction firms are highly available; survey report (70% of the questionnaire) and through emails & telephone interview (30% of the questionnaire). Out of 400 questionnaires distributed, 233 responses were received. Among 233, only 192 responses were fully filled and those complete data were used for analysis. Out of 192 respondents, 63 respondents were from the public construction firms, 54 respondents were from INGO construction firms and 75 respondents were private construction firms, where respondents were the front-line staff and manager of a construction project having better knowledge of safety in site.

C. Hypothesis

Based on previous literature and theoretical examination, seven reasonable hypotheses are generated, which is very vital for modeling in SEM. Our hypothesis majorly based on accident causing factors: worker team, worker, worker place, equipment & material, the inadequate setting of safety level by the contractor, lack of leadership from government and lack of proper safety commitment affect the safety performance in the construction site to develop theoretical research model.

Hypothesis H1:
Inadequate setting of safety level by the contractor have a positive impact on safety performance in a construction firm.
Hypothesis H2:
Equipment and Material have a positive impact on safety performance in a construction firm.
Hypothesis H3:
Lack of leadership from the government has a positive impact on safety performance in a construction firm.
Hypothesis H4:
Lack of proper safety commitment has a positive impact on safety performance in a construction firm.
Hypothesis H5:
Worker has a positive impact on safety performance in a construction firm.
Hypothesis H6: Work place has a positive impact on safety performance in a construction firm.
Hypothesis H7:
Worker Team have a positive impact on safety performance in a construction firm

IV. PLS-SEM MODEL TESTING AND RESULT

PLS-SEM is preferred as it is flexible in terms of normally distributed and small sample size. Besides, the benefit of PLS-SEM has higher statistical power which is best to use in the exploratory study [56, 57]. The PLS path model includes two-part namely measurement model and structural model. The measurement model confirms the measurement quality of the model's latent variable. Since this research used reflectively specified constructs, the measurement quality analyzed according to consistency reliability, indicator reliability, discriminant validity and convergent validity. Moreover, a structural model was used to analyze multi-collinearity issue, coefficient of determination (R2) of the endogenous construct, effective size (f2), cross-validity redundancy(Q2) and hypothesis were evaluated.

A. Validity and reliability of the measurement model

Table II-IV show the evaluation of the validity and reliability of the construct in SEM-PLS model. In table II, all the indicator loading of the corresponding construct was above 0.7 which shows that reliability level is satisfactory

[58]. Composite Reliability (CR) values and Cronbach's Alpha (CA) values were above 0.7 demonstrates the internal consistency reliability [59]. Besides, the Average Variance Extracted (AVE) value was above 0.5 that represents the existence of convergent validity [60, 61]. In Table III, the Fornell and Larker criteria showed that the square root of AVE is greater than their correlation coefficient within the latent variable, which shows discriminant validity [60]. Similarly, each indicator loading was in the highest value to the corresponding construct as shown in Appendix A also demonstrated discriminant validity [62, 63]. Moreover, table IV showed that the Heterotrait-Monotrait Ratio (HTMT) value is below the threshold of 0.9 representing the strong evidence for the validity of discriminant [64].

TABLE II
MEASUREMENT QUALITY OF THE MODELS' CONSTRUCT

Construct	Indicator Items	Indicator loading	Cronbach's Alpha (CA)	Composite Reliability (CR)	Average Variance Extracted (AVE)
WT	WT1	0.897	0.916	0.937	0.747
	WT2	0.855			
	WT3	0.878			
	WT4	0.826			
	WT5	0.865			
W	W1	0.866	0.912	0.934	0.739
	W2	0.867			
	W3	0.858			
	W4	0.857			
	W5	0.85			
WP	WP1	0.885	0.914	0.936	0.745
	WP2	0.85			
	WP3	0.884			
	WP4	0.84			
	WP5	0.855			
EM	EM1	0.85	0.908	0.931	0.73
	EM2	0.876			
	EM3	0.88			
	EM4	0.825			
	EM5	0.84			
ISSC	ISSC1	0.835	0.899	0.925	0.712
	ISSC2	0.856			
	ISSC3	0.858			
	ISSC4	0.825			
	ISSC5	0.844			
LLG	LLG1	0.84	0.896	0.923	0.706
	LLG2	0.807			
	LLG3	0.852			
	LLG4	0.81			
	LLG5	0.89			
LPSC	LPSC1	0.832	0.897	0.922	0.701
	LPSC2	0.848			
	LPSC3	0.831			
	LPSC4	0.861			
	LPSC5	0.815			
SP	SP1	0.853	0.900	0.923	0.667
	SP2	0.838			
	SP3	0.741			
	SP4	0.826			
	SP5	0.815			
	SP6	0.821			

Note: This table shows indicator items loading, average variance extracted (AVE), composite reliability (CR) and Cronbach alpha (CA) values for evaluating the measurement value of the construct's indicator in the model. An indicator loading value larger than 0.5 shows the indicator reliability [58]. A set of indicators to measure each construct is found from the loading relevant test [65]. CR and Cronbach's alpha values larger than 0.7 show the internal consistency reliability [59]. The AVE value greater than 0.5 signifies the convergent validity [60, 61].

TABLE III
DISCRIMINANT VALIDITY (FORNELL AND LARKER CRITERIA)

	EM	ISSC	LLG	LPSC	SP	W	WP	WT
EM	**0.85**							
ISSC	0.13	**0.84**						
LLG	0.31	0.23	**0.84**					
LPSC	0.22	0.07	0.14	**0.84**				
SP	0.47	0.45	0.44	0.42	**0.82**			
W	0.28	0.19	0.23	0.29	0.50	**0.86**		
WP	0.31	0.16	0.26	0.20	0.47	0.37	**0.86**	
WT	0.23	0.09	0.07	0.33	0.37	0.33	0.33	**0.87**

Note: This table represents that diagonal item which is printed boldly is higher and it is the square root of the Average Variance Extracted (AVE) latent variable which indicates highest in any column and row. The non-diagonal numbers signify correlations of the construct with other constructs [60].

TABLE IV
DISCRIMINANT VALIDITY: HETEROTRAIT-MONOTRAIT RATIO (HTMT)

	EM	**ISSC**	**LLG**	**LPSC**	**SP**	**W**	**WP**	**WT**
EM								
ISSC	0.15							
LLG	0.34	0.24						
LPSC	0.24	0.12	0.18					
SP	0.50	0.49	0.47	0.43				
W	0.29	0.20	0.24	0.31	0.52			
WP	0.33	0.17	0.29	0.20	0.49	0.39		
WT	0.25	0.10	0.08	0.35	0.39	0.35	0.35	

Note: This table shows that Heterotrait-Monotrait Ratio (HTMT) value is under the threshold of 0.9 [64]

B. Evaluation of structural model

The coefficient of determination (R^2) for endogenous construct SP was 0.606 which was higher than cutoff value 0.26 [66, 67]. All the hypothesis were supported at 1% level of significant except construct WT which was supported at 5% level of significant by using 5000 bootstrap subsampling method [57], as shown in table V. Among all relationship, the inadequate setting of safety level by the contractor (ISSC) showed high barrier to improve safety performance in construction firms with path coefficient 0.299 and t-value 8.068**. The effective size of a particular predictive construct within an endogenous construct is in the cutoff limit. The value of f^2 was 0.02 for small, 0.15 for medium and 0.35 for large structural level [9, 62, 68, 69]. The cutoff value of VIF was less than 5 and tolerance value was greater than 0.1, which indicates that there was absent of multi-collinearity as shown in table VI [64]. Table VII shows that all the Q^2 value was greater than 0 by blindfolding method with omission distance seven, which support predictive relevance of structural model [70].

TABLE V
TESTING THE HYPOTHESES IN THE STRUCTURAL MODEL

Hypothesis	Relation	T Statistics	P Values	Decision	f^2
H1	ISSC -> SP	8.068**	0	Supported	0.209
H2	EM -> SP	3.831**	0	Supported	0.084
H3	LLG -> SP	3.372**	0	Supported	0.068
H4	LPSC -> SP	4.381**	0	Supported	0.100
H5	W -> SP	3.456**	0	Supported	0.071
H6	WP -> SP	3.390**	0	Supported	0.052
H7	WT -> SP	1.909*	0.028	Supported	0.016

Note: t-value >= 1.96 at p = 0.05* level, t-value >= 2.58 at p = 0.01** level, t-value >= 3.29 at p = 0.001 level, The value of f2 is 0.02 for small, 0.15 for medium and 0.35 for large structural level [9, 62, 68, 69].

TABLE VI
RESULT OF COLLINEARITY ASSESSMENT

Exogenous construct	**Collinearity Statistics**	
	Tolerance	**VIF**
WT	0.784	1.275
W	0.763	1.311
WP	0.767	1.303
EM	0.809	1.237
LLG	0.835	1.198
LPSI	0.848	1.180
ISSC	0.932	1.073

Note: Dependent Variable: SP, the cutoff value of VIF is less than 5 and tolerance value is greater than 0.1 [64].

TABLE VII
PREDICTIVE RELEVANCE Q^2

Predictor endogenous	Q-sq included	Q-sq excluded	Predictive relevance (Q^2 value)
ISSC -> SP	0.362	0.358	0.006
EM -> SP	0.362	0.345	0.027
LLG -> SP	0.362	0.35	0.019
LPSC -> SP	0.362	0.342	0.031
W -> SP	0.362	0.312	0.078
WP -> SP	0.362	0.345	0.027
WT -> SP	0.362	0.338	0.038

Note: All the Q^2 value is greater than 0 by blindfolding method with omission distance seven, which support predictive relevance of structural model [70].

C. Evaluation process

Earlier data that we have used in SEM-PLS modeling was reused by categorizing respondent into three different construction enterprises namely private, public and INGO construction enterprise. Among total respondents 65 respondents were from public enterprise, 75 respondents were from private and 54 respondents were from INGO construction enterprises which helped in making comparative study in different types of construction to measure impact level of accident factor in safety performance.

Evaluation matrix

We implemented the same number of judgments as per the questionnaire of each indicator of each latent construct factor, which is represented by:

$$M_{ij}^{ln} = (i=1, 2, j=1, 2, 3, 4, 5, 6; h=1, 2, 3; d=1, 2, 3, 4, 5) \quad (1)$$

Where i represents a number of exogenous construct and j, symbolizes the number of indicators in each construct as shown in table I. Similarly, h symbolizes different types of construction enterprise and d stands for judgment level from 1(fully agree) to 5 (fully disagree). To measure the impact level of accident factors on different construction enterprises, the study was fragmented in 5 levels namely "I (very less impact), II (less impact), III (fair impact), IV (high impact) and V (very high impact)". Proportion distribution of each indicators in each construct was symbolized as by M_{ij}^{ln} and calculated by eqn (2). The evaluation matrix for fraction distribution of ith phase with hth type construction enterprise was symbolized by M_i^h as shown in eqn (3). The vector M^h represents evaluation data for all aspects on the basis of hth types of construction enterprises.

$$M_{ij}^{ln} = \frac{a_{ij}^{ln}}{\sum_{n=1}^{5} a_{ij}^{ln}} \text{ i= 1, 2, 3, 4, 5, 6, 7; j=1, 2, 3, 4, 5; h=1, 2, 3; d= 1, 2, 3, ….5} \quad (2)$$

$$M_i^h = \begin{bmatrix} M_{i1}^{h1} & M_{i1}^{h2} & M_{i1}^{h3} & M_{i1}^{h4} & M_{i1}^{h5} \\ M_{i2}^{h1} & M_{i2}^{h2} & M_{i2}^{h3} & M_{i2}^{h4} & M_{i2}^{h5} \\ M_{i3}^{h1} & M_{i3}^{h2} & M_{i3}^{h3} & M_{i3}^{h4} & M_{i3}^{h5} \\ M_{i4}^{h1} & M_{i4}^{h2} & M_{i4}^{h3} & M_{i4}^{h4} & M_{i4}^{h5} \\ M_{i5}^{h1} & M_{i5}^{h2} & M_{i5}^{h3} & M_{i5}^{h4} & M_{i5}^{h5} \end{bmatrix} \quad (3)$$

Weight calculation

We used path coefficient and indicator loading of validity SEM-PLS modeling where σ_{ij}= (i=1, 2…7 j=1, 2, 3, 4, 5) shows the value of loading indicator of j^{th} indicator in i^{th} form (table II and V). The j^{th} indicator weight in the i^{th} indicator is denoted by β_{ij}, gained by eq^n (IV). All indicator in i^{th} form is specified by eq^n (5). Likewise, let x_i (i=1, 2, …7) symbolize the value of path coefficient in i^{th} form, i^{th} form weight represented by w_i can be gained by eq^n (6). All the aspect of weight can be gained by eq^n (7).

$$\beta_{ij} = \frac{\sigma_{ij}}{\sum_{j=1}^{5} \sigma_{ij}}, \text{ i=1, 2...7; j=1, 2...5} \quad (4)$$

$$\beta_i = [\beta_{i1}\ \beta_{i2}\ \beta_{i3}\ \beta_{i4}\ \beta_{i5}] \quad (5)$$

$$w_i = \frac{x_i}{\sum_{i=1}^{7} x_i}, \text{ i=1, 2 ………7} \quad (6)$$

$$W= [w_1\ w_2\ w_3\ w_4\ w_5\ w_6\ w_7] \quad (7)$$

Calculation and result

Proper measurement of the impact of accident causing factor helps in making the decision to improve safety performance level in construction sites. With the base of evaluation matrix M and weight matrix W, the extensive evaluation vector of the i^{th} indicator with reference to h^{th} types construction enterprise, denoted by M_i^h was calculated by eq^n (8). Likewise, extensive evaluation vector of the h^{th} construction stands as M^l which was calculated by eq^n (9). Maximum Degree of Membership (MDM) principle [71] was applied where the level of the impact of accident factor on safety performance were recognized in such a way that maximum value within five level was taken as the final result. For example, P^1 with spreading (0.2, 0.34, 0.29, 0.27, 0.28) as (very poor, poor, fair, good, excellent) impact, it was evaluated as II (Poor) impact level.

$$Q_i^l = \beta_i \, x \, M_i^h = [P_i^{h1}\ P_i^{h2}\ P_i^{h3}\ P_i^{h4}\ \ P_i^{h5}], \text{ i=1, 2…5; l=1, 2, 3} \quad (8)$$

$$P^l = W \text{ x } \begin{bmatrix} Q_i^{h1} \\ Q_i^{h2} \\ Q_i^{h3} \\ Q_i^{h4} \\ Q_i^{h5} \\ Q_i^{h6} \\ Q_i^{l7} \end{bmatrix} \quad (9)$$

From the above procedure and eqn (9), we evaluated all types of construction enterprises with an impact level of accident factor on safety performance in construction enterprise as shown in table VIII. From the output, in public and private construction enterprise accident causing factor had IV (highly impact) safety performance of project whereas in INGO construction it had III (fair impact) of accident factor on safety performance in the construction site.

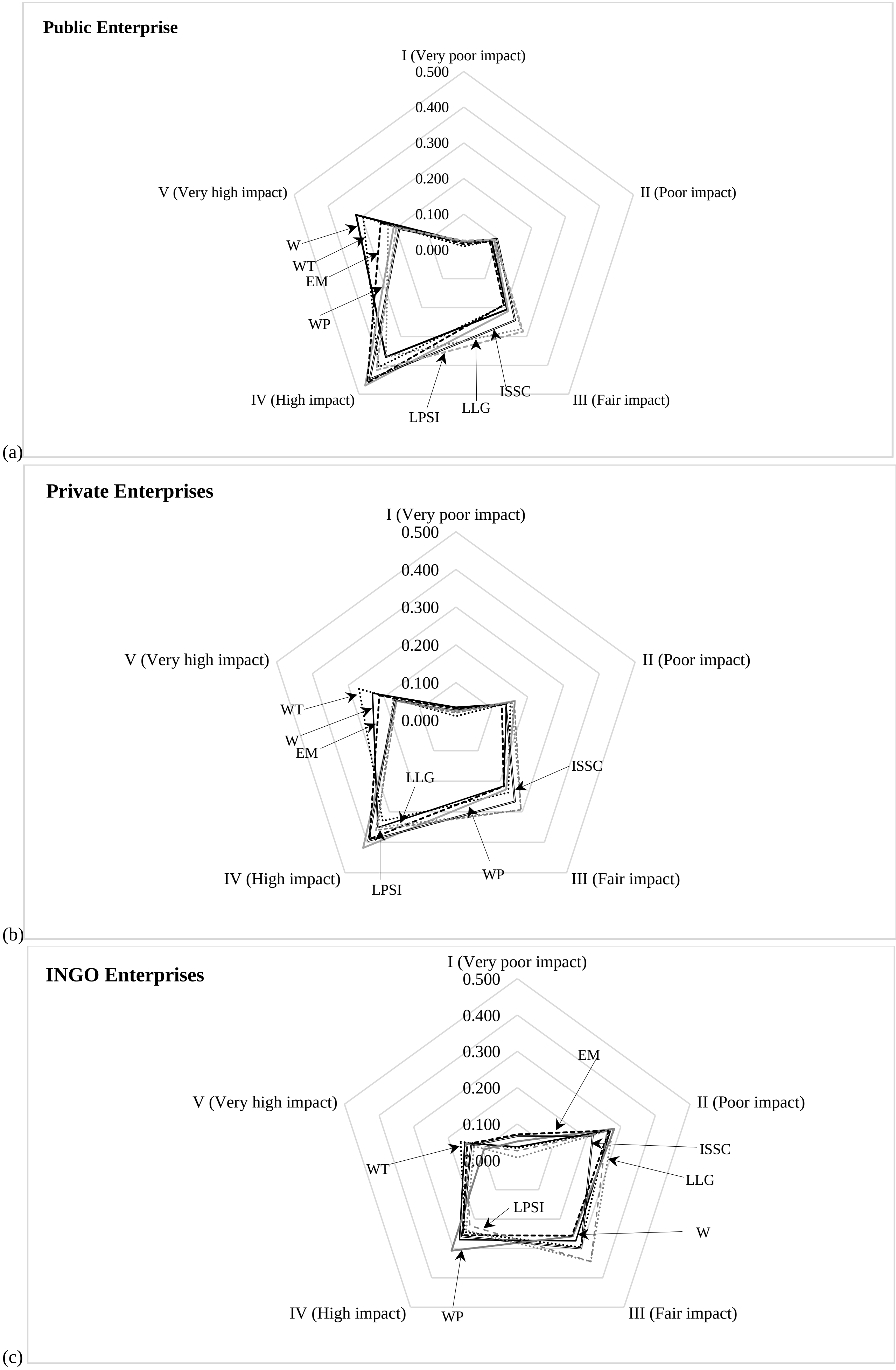

Fig. 1. Evaluation result for an accident causing factor impact on safety performance

TABLE VIII
FINAL OUTPUT OF IMPACT OF AN ACCIDENT CAUSING FACTOR ON SAFETY PERFORMANCE WITH RESPECT TO 3 VARIOUS CONSTRUCTION ENTERPRISES

Category	Evaluation distribution				
	I (Very Less Impact)	II (Less Impact)	III (Fair Impact)	IV (High Impact)	V (Very High Impact)
Public construction	0.0209	0.0889	0.2335	**0.4233**	0.1994
INGO construction	0.0447	0.2579	**0.2973**	0.2564	0.1125
Private construction	0.0262	0.1478	0.2528	**0.3753**	0.1914

Note: Maximum Degree of Membership (MDM) principle [71] is implemented to compare the impact on safety performance in different category construction enterprises by accident causing factor.

D. KMO, BARTLETT'S test and model fit verification in structural Equation Model by using SPSS AMOS

TABLE IX
RESULT ON KMO AND BARTLETT'S TEST

Kaiser-Meyer-Olkin (KMO)		0.786
Bartlett's Test of Sphericity	Approx. Chi-Square	6609.583
	Df	820
	Sig.	0.000

Note: KMO<0.7 and Bartlett's Test of Sphericity (>0.05)[72].

During Exploratory Factor Analysis, KMO value should be greater than 0.7 and Bartlett value should be significant with p-value less than 0.005. Here, KMO (0.786>0.7) indicated sufficient items for each factor in model and Bartlett's Test of Sphericity($p<0.001$) indicated that the correlation matrix was significantly varied from an identify matrix[72].

TABLE X
RESULT OF MODEL FIT VERIFICATION IN STRUCTURAL EQUATION MODEL

Indicators	Value	Threshold
CMIN/DF	2.502	<3 good
CFI	0.845	>0.8 permissible
RMSEA	0.089	0.05-0.10 moderate
SRMR	0.067	<0.09

*Note: SRMR(<0.08 excellent), RMSEA(<0.06 good,0.05-0.1 moderate), CMIN/DF(>3acceptable, >1 excellent) and CFI(>0.9 excellent,>0.8 permissible)[73, 74].

Here, CMIN/DF stands for likelihood ratio chi-square goodness of fit statistic, standardized root mean square residual (SRMR) are perfectly fit and Conformity Fit Index(CFI), root mean square error of approximation (RMSEA) are moderate or permissible fit as per threshold value given[73, 74]. Overall, the model fitness was in good range. The goodness of model fit is inversely interrelated to number of construct items in a model, so, as we have more numbers of construct some fit indices were moderate or permissible [74]. The previous authors used the same common fit indices to measure model fit in their research so it was used for analysis of model fit [75].

E. Power Analysis

Power analysis in PLS model is essential to confirm the steadiness of model with respect to implication of sample sizes. We used G-power(3.0.10) software to test power analysis of model as earlier authors used in their research [9]. Implementation of this software at 5% level of significance, with effective size of 0.30 as highest path coefficient along with 7 predictors construct from model, we achieved 100% with a sample size of 120 as shown in fig.2. Hence, it is evident that sample size used in study is sufficient for achieving adequate power.

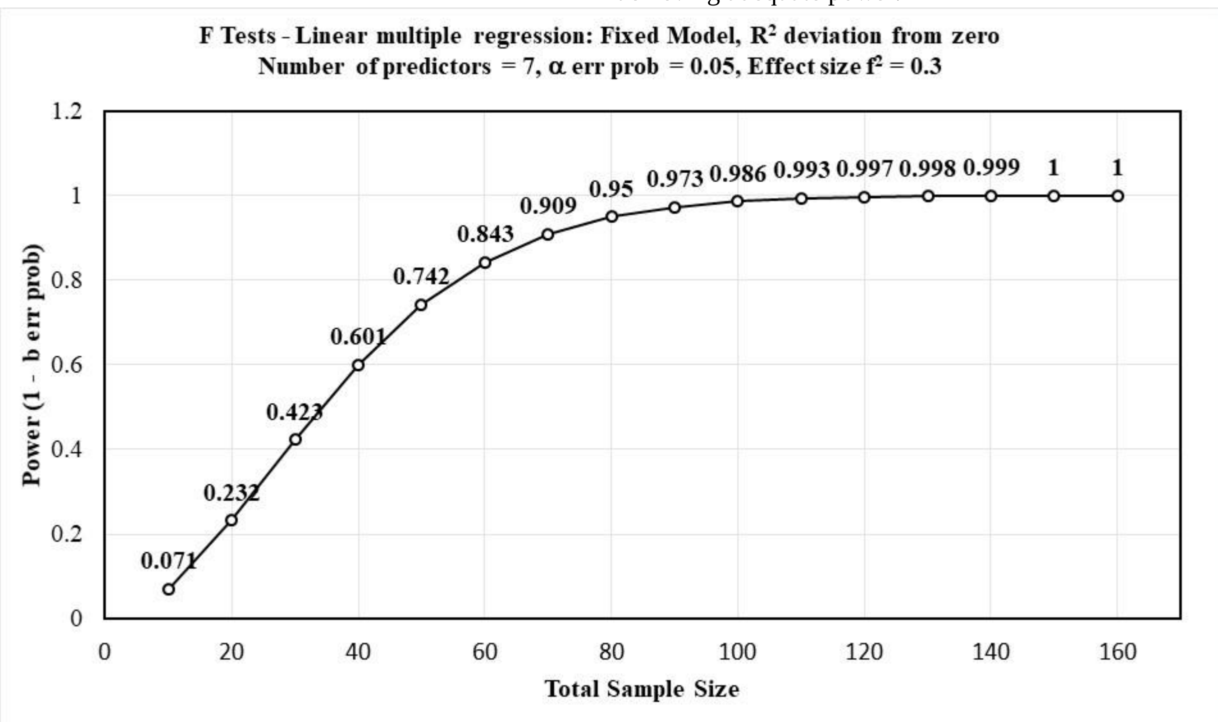

Fig. 2. Power Analysis for Adequacy of sample Size

F. Assessment of normality

Overall, kurtosis and skewness value meet the threshold value. In general, Kurtosis and skewness values must be within range of -1.96 to +1.96 for normal distribution [76]. Previous authors suggested that kurtosis is more relevant than skewness during SEM modeling as skewness only has huge impact on mean whereas kurtosis impact tests of covariance and variances[77]. Earlier researchers suggested that multivariate kurtosis values >±5 can be treated as symbolic of leaving from range multivariate normality[78]. As multivariate was not normal as soon in Appendix B, which showed the reason why we did bootstrapping by using smart PLS software for these data set[79]. In SEM analysis, the “maximum” and “minimum” standard deviation estimates are often not defined [80, 81].

G. Harmon's one- factor test

Common Method Bias (CMB) can be problematic when all data are collected from a single source at one point in a time[82]. With the implementation of Harmon’s one-factor test in SPSS to check CMB, outcome confirmed the absenteeism of CMB from our data set as the first factor described only 25.964% variance, which was less than the threshold value 50%.

V. DISCUSSION

All hypothesis relationship was supported at 1% level of significant except WP>SP which was significant at 5% level of significance. R^2 & Q^2 values of SP construct were 0.606, 0.362 respectively. These result display suitable level of PLS path model predictive accuracy and significance [56]. With the increase of one standard deviation of ISSC, EM, LLG, LPSC, W, WP and WT construct will increase 29.9%, 20.2%, 18%, 21.7%, 19.3%, 16.5% and 9% respectively to standard deviation of SP at (f^2= 0.209, $p<0.01$), (f^2=0.084, $p<0.01$) (f^2=0.068, $p<0.01$), (f^2=0.1, $p<0.01$), (f^2=0.071, $p<0.01$), (f^2=0.052, $p<0.01$) and (f^2=0.016, $p<0.05$) respectively. The inadequate setting of safety level by the contractor (ISSC) accident factor affected more than another construct to improve safety performance in the construction enterprise. Nepalese contractors are unconcerned about the procedure of safety rules and regulation. By lowering safety standard (inadequate reporting of an accident in the site, poor employment practices, safety not consider while selecting the subcontractor, etc.), they are supposed to save costs but in reality, they are losing costs because of accidents. The construction site engineers, managers, supervisor and employer are not given sufficient training and resources on occupational safety and health. The health and safety of employers during construction is a major factor, as it has impact on the project directly since the accidents and injuries cost to the project would be very high.

From the evaluation matrix, it was identified that accident factor is highly impacting in private and public construction enterprises with IV (highly impact) level which is barrier to improve the safety performance of construction. These results showed that private and public construction enterprises need to identify such accident factor and need to eliminate or minimize to negligible level to improve safety performance in the project. Moreover, INGO construction enterprise had III (fair impact) level with value 0.297351 which is barrier to upgrading safety performance. It shows that INGO construction has better safety performance or in other word less accident causing factor that has impact to upgrade in safety performance of the project. But they also need to identify major accident causing factor to upgrade safety performance in a project in excellent level.

Figure 1 shows each construct and its inclination level to impact safety performance. In public construction enterprise (a) EM, ISSC and WP constructs were inclined to IV (high impact) level along with W and WT constructs are inclined to V (very high impact) level. These graph outputs show that public construction sites need to concentrate a lot on the above construct that was in high and very high impact level to improve safety performance. Similarly, in private construction enterprise (b) constructs EM, ISSC, LPSI and WP were in IV (impact) level. So private construction enterprise needs to concentrate on these constructs to improve safety performance in private construction enterprise. Moreover, in INGOs construction enterprises, (c) construct W, ISSC, LPSI and LLG were in III (fair impact) level and WP construct were observed in IV (high impact) level. So, INGOs construction need to concentrate on all fair level impact with a high concentration on WP construct to improve safety performance.

VI. CONCLUSION AND IMPLICATION

To the best of our knowledge, this study is the first to show the link between accident causing factor and its impact to improve safety performance in construction enterprise by using SEM-PLS modeling. The entire hypothesis is positively affected by giving positive path coefficient in each relationship. Among all relation, we can say that ISSC constructs impact highly to improve safety performance with t-vale 8.068** and path coefficient 0.299. Similarly, LPSC constructs impact second higher to the barrier to improve safety performance with t-value 4.381** and path coefficient of 0.217. EM construct have third higher impact to improve safety performance in construction enterprises with t-value 3.831** and path coefficient 0.202. So, construction enterprises need to focus more on these constructs and need to study their indicators as they are a critical factor impacting safety performance of construction project.

Besides, from the matrix evaluation process by using MDM principle, INGO construction enterprise has better control on accident causing factor in comparison to public and private construction enterprises but still they are not yet able to gain excellent safety performance level. Similarly, Private and public construction enterprises are in high impact level and these constructions need to focus much in ISSC, LPSC and EM construct and its indicator so as to achieve good safety performance by minimizing the impact level.

VII. IMPLICATION

This research tries to supply a better understanding of opinion of professional technical labor in a construction project on critical accident causing factor, which impacts to improve safety performance. We believe that this study will encourage carrying out more research in safety in construction area in the future. Besides, it helps to draw a profile of critical accident causing factor that has been blockage in the upgradation of safety performance in developing countries. Moreover, evaluation matrix result gives ideas to a critical accident causing factors in different category construction enterprises. With proper concentration on these critical accidents causing factor, each category of construction enterprise can upgrade safety performance, mainly in developing country like Nepal.

VIII. LIMITATION AND DIRECTION FOR FUTURE RESEARCH

The data are collected from a single nation as site data collection is laborious and it is costly, too. So, the output of this research may not be appropriate for all construction enterprises worldwide. Future studies need to be carried out in various countries from multi-level of technical professionalism by automatic data achievement created through online Group Decision Support System (GDSS)

APPENDIX A

CROSS LOADING TEST FOR DISCRIMINANT VALIDITY

	ISSC	**EM**	**LLG**	**LPSC**	**SP**	**W**	**WP**	**WT**
ISSC1	**0.835**	0.104	0.275	0.113	0.406	0.255	0.176	0.126
ISSC2	**0.856**	0.203	0.249	0.096	0.357	0.143	0.097	0.06
ISSC3	**0.858**	0.154	0.116	0.032	0.388	0.172	0.135	0.037
ISSC4	**0.825**	0.075	0.257	-0.072	0.379	0.139	0.147	0.125
ISSC5	**0.844**	0.017	0.045	0.107	0.365	0.087	0.105	0.011
EM1	0.173	**0.85**	0.254	0.129	0.362	0.291	0.213	0.227
EM2	0.048	**0.876**	0.307	0.289	0.457	0.333	0.322	0.178
EM3	0.111	**0.88**	0.349	0.162	0.414	0.222	0.32	0.221
EM4	0.119	**0.825**	0.141	0.099	0.374	0.183	0.182	0.171
EM5	0.124	**0.84**	0.276	0.217	0.39	0.151	0.268	0.198
LLG1	0.198	0.33	**0.84**	0.159	0.372	0.249	0.159	0.098
LLG2	0.188	0.245	**0.807**	0.13	0.323	0.223	0.275	0.035
LLG3	0.138	0.282	**0.852**	0.168	0.324	0.107	0.236	0.042
LLG4	0.177	0.223	**0.81**	-0.023	0.351	0.172	0.182	0.053
LLG5	0.232	0.246	**0.89**	0.156	0.438	0.199	0.258	0.071
LPSC1	0.134	0.118	0.089	**0.832**	0.416	0.297	0.235	0.322
LPSC2	0.049	0.19	0.204	**0.848**	0.454	0.246	0.154	0.319
LPSC3	0.002	0.119	0.044	**0.831**	0.261	0.212	0.069	0.182
LPSC4	0.027	0.243	0.041	**0.861**	0.298	0.185	0.168	0.234
LPSC5	0.017	0.261	0.189	**0.815**	0.235	0.271	0.161	0.267
SP1	0.361	0.473	0.434	0.426	**0.853**	0.536	0.467	0.257
SP2	0.499	0.368	0.347	0.415	**0.838**	0.502	0.426	0.294
SP4	0.405	0.321	0.344	0.177	**0.741**	0.365	0.351	0.219
SP5	0.357	0.414	0.429	0.295	**0.826**	0.302	0.321	0.286
SP6	0.248	0.243	0.291	0.364	**0.815**	0.316	0.22	0.345
SP7	0.3	0.44	0.266	0.361	**0.821**	0.374	0.438	0.399
W1	0.268	0.302	0.22	0.242	0.525	**0.866**	0.362	0.331
W2	0.157	0.229	0.25	0.241	0.454	**0.867**	0.352	0.3
W3	0.165	0.228	0.225	0.292	0.404	**0.858**	0.343	0.203
W4	0.089	0.223	0.131	0.252	0.39	**0.857**	0.295	0.235
W5	0.1	0.194	0.125	0.236	0.337	**0.85**	0.198	0.331
WP1	0.197	0.331	0.264	0.208	0.447	0.388	**0.885**	0.313
WP2	0.157	0.348	0.157	0.182	0.384	0.383	**0.85**	0.303
WP3	0.051	0.205	0.176	0.141	0.345	0.31	**0.884**	0.307
WP4	0.122	0.174	0.317	0.104	0.386	0.223	**0.84**	0.242
WP5	0.136	0.262	0.214	0.198	0.429	0.28	**0.855**	0.252
WT1	0.028	0.307	0.07	0.271	0.334	0.267	0.273	**0.897**
WT2	0.132	0.224	0.057	0.284	0.295	0.265	0.336	**0.855**
WT3	0.033	0.114	0.072	0.338	0.312	0.369	0.273	**0.878**
WT4	0.016	0.185	0.043	0.297	0.237	0.279	0.216	**0.826**
WT5	0.147	0.171	0.068	0.246	0.37	0.247	0.306	**0.865**

APPENDIX B

ASSEMENT OF NORMALITY

Variable	min	Max	skew	c.r.	kurtosis	c.r.
LPSI5	1.000	4.000	.008	.047	-1.005	-2.844
LPSI	1.000	5.000	.451	2.550	-.458	-1.294
LPSI3	1.000	5.000	.328	1.857	-.701	-1.984
LPSI2	1.000	5.000	.056	.318	-.764	-2.162
LPSI1	1.000	5.000	.103	.584	-.689	-1.948
LLG5	1.000	5.000	.271	1.534	-1.103	-3.121
LLG4	1.000	5.000	.327	1.849	-.163	-.460
LLG3	1.000	4.000	.079	.446	-1.137	-3.216
LLG2	1.000	5.000	.265	1.502	-.143	-.404
LLG1	1.000	4.000	.082	.464	-1.107	-3.132
WT5	1.000	5.000	.341	1.929	-.581	-1.644
WT4	1.000	5.000	.269	1.524	-.769	-2.176
WT3	1.000	5.000	.222	1.259	-.923	-2.610
WT2	1.000	5.000	.375	2.123	-.995	-2.814
WT1	1.000	5.000	.526	2.976	-.859	-2.431
EM5	1.000	5.000	.471	2.665	-.704	-1.992
EM4	1.000	5.000	.609	3.446	-.412	-1.166
EM3	1.000	5.000	.695	3.929	-.080	-.225
EM2	1.000	5.000	.357	2.022	-.816	-2.307
EM1	1.000	5.000	.233	1.317	-.870	-2.460
ISSC5	1.000	5.000	.569	3.220	-.544	-1.538
ISSC4	1.000	5.000	.260	1.470	-.651	-1.840
ISSC3	1.000	5.000	.339	1.919	-.638	-1.805
ISSC2	1.000	5.000	.295	1.668	-.656	-1.857
ISSC1	1.000	5.000	.292	1.650	-.585	-1.654
WP5	1.000	5.000	.440	2.491	-.609	-1.722
WP4	1.000	5.000	.422	2.385	-.534	-1.510
WP3	1.000	5.000	.524	2.965	-.218	-.617
WP2	1.000	5.000	.252	1.426	-.825	-2.333
WP1	1.000	5.000	.455	2.576	-.709	-2.007
W5	1.000	5.000	.369	2.088	-.794	-2.247
W4	1.000	5.000	.559	3.160	-.360	-1.018
W3	1.000	5.000	.358	2.027	-.662	-1.871
W2	1.000	5.000	.519	2.939	-.731	-2.067
W1	1.000	5.000	.322	1.824	-1.101	-3.115
Multi variate					-5.516	-.751

Note: C.R. is critical ratio

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