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IMPACT OF INFORMATION TECHNOLOGY ON LEAN PRODUCTION SYSTEM: ANALYTICAL STUDY AT THE STATE ELECTRIC POWER TRANSMISSION COMPANY/MIDDLE EUPHRATES PROJECT IMPLEMENTATION BRANCH

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Abstract:

This research reviews impact of information technology on realization of principles of lean production system. We analyze relationship between information technology and lean production system. Lean production system is studied according to degree of use of information technology and type of information technology used. Research results have shown that all dimensions of information technology variables have a positive impact on lean production system. Information technology was fully applicable to lean production system. All five hypotheses were positive and supportive, thus achieving results of desired objectives.

Research attempted to provide a modern theoretical framework on research variables as well as an analytical working framework for views of a sample of senior and middle administrations of state electric power transmission company/middle euphrates project implementation branch, representing independent information technology variable in following dimensions. (physical components, software, human resources, databases and communication networks) variable adopted is lean production system with its four

dimensions. (organization of 5s workplace, overall production maintenance, production on time and continuous improvement).

Introduction:

The recent period has seen rapid developments in various aspects of life. One of most notable developments currently taking place is information technology because of its intensive use, increased reliance and strong employment in various aspects and productive activities.

Information technology enabled organizations to manage more information better, more flexibility, more functions and more features. Information technology can facilitate implementation of principles and practices of lean production system since two sets of tools (information technology and lean production system) complement each other. However, it and lean production may compete with each other at management level for two reasons. First, source of organizational expertise required for each tool is quite different, and second, financial resources and senior management attention required by each of these initiatives often prevent organizations from making widespread use of information technology and lean production system at same time (fuentes et al.,2012:133).

The principles of lean production system have enabled organizations in manufacturing and services sectors to significantly improve their competitiveness. Application of graceful principles derived from toyota production system has enabled many organizations to improve productivity, quality and customer service at same time. Similar benefits have been achieved through application of information technology. Claims that application of it principles is interrelated and complementary; others felt that curriculum was against (riezebos et al.,2009:237).

First part: Research Methodology

First: - Research problem

The subject of information technology and lean production system is a recent topic, as production organizations have become a well-known information technology-intensive organization and in recent years have faced new challenge of continuous product improvement through adoption of lean production systems to reduce waste.

The problem with research is following questions:

1. How does use of information technology affect lean production system of state electric power transmission company?
2. What are dimensions of information technology and are they applied in state electric power transmission company?
3. What are dimensions of graceful production system and are they applied in state electric power transmission company?
4. Is there an impact relationship on dimensions of information technology in dimensions of lean production system?

Second: importance of research

The following points illustrate importance of research:

1. importance of variables discussed, as research has focused on variables (information technology and lean production system) through a clear definition of their concepts and how to respond to them.

2. To identify concept and dimensions of information technology and explain its impact on application of lean production system.
3. Recognize concept and dimensions of lean production and extent to which it contributes to continuous improvement of state electric power transmission company.
4. To recognize reality of productive organizations and extent to which they keep up with technological developments by drawing on global experiences towards modern production management systems and lean production processes.

Third: search objectives

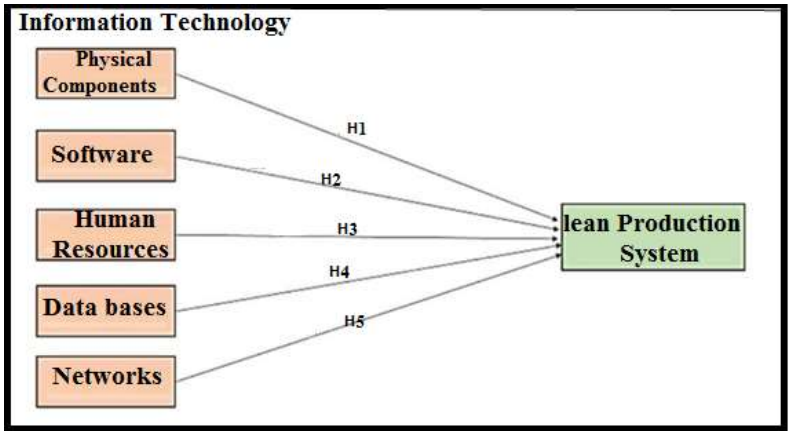
research aims at several points that can be summarized as follows:

1. Clarify nature of relationship and type of impact between information technology and lean production dimensions.
2. Identify and clarify impact of information technology on lean production system.
3. Develop a set of conclusions and recommendations that may assist organizations in applying principles of lean production and thereby improve their performance.

Fourth: default search scheme

Based on problem and objectives of search, and in order to complement search requirements in its application, a virtual model has been designed to show logical relationship between independent variable. Information technology (it) and dependent variable (lean production system/lps) lean production system, which was size of sample selected (195) employees and employees of state electric power transmission company/middle euphrates project implementation branch. Independent variable consists of five dimensions:

Physical components (pc), software software (SO), human resources (HR), data base databases (DB), communication networks (N). As in figure 1, which gives preliminary answers to research hypotheses:



Form (1) Hypothetical Diagram of Research

Fifth: Search Hypotheses

There is a morally significant impact relationship between information technology and lean production system, from which following sub-hypotheses emerge:

- There is a morally significant effect of dimension of physical components in lean production system.
- There is a morally significant impact of software dimension in lean production system.

- There is a morally significant impact of human resources dimension in lean production system.
- There is a morally significant impact of database dimension in lean production system.
- There is a morally significant impact on distance of communication networks in lean production system.

Two Part: Conceptual Framing of Information Technology and Lean Production

First: concept of information technology

According to (neyazi, 2016:153) technology represents industry-specific practical or methodological knowledge and different types of programs and devices, while information is process of transmitting knowledge, data and reports collected from reading, observing and searching for others. Information is foundation and important incentive that limits uncertainty in regulatory environment. Information represents all kinds of knowledge, ideas, facts, data and mental acts that are formally or informally communicated in any form. Information represents all that an individual possesses in his or her work, research, structure and requirements (murthy, 2019:1). It is extremely difficult to identify a comprehensive concept of term information technology because of differing views among researchers, writers and practitioners on this concept, and table (1) shows what information technology is easily accessible.

Table 1: Views of some researchers on concept of information technology

N	Researcher / year	Concept
1	Naghsh & Farajolahi,2018:2	A set of tools and methods that provide for production, processing and delivery of data to users
2	Rasheed et al.,2018:2	Technology for development, development and use of computer systems, software and networks for data processing and distribution
3	Sujith& Sanu,2018:16	Study, design, development, application, implementation and support of management of computer information systems
4	Alkinzawi,2019:11	Beneficial and optimal investment in various aspects of knowledge that enable organization to access as much information as possible quickly enough
5	Danladi,2019:66	A tool for achieving competitive advantage in organization because it enhances efficiency and effectiveness of organizational processes
6	Frimpong, 2019:3	Data collection, processing, storage and retrieval
7	Gargvanshi & Kumar,2019:4	Study, design, development, implementation and support of functions through management of computer information systems and computer applications, software and hardware
8	Hanum,2019:6	Extent to which diffusion of technology in regulatory process becomes an integral part of tasks associated with organization
9	Morrar et al.,2019:13	Study, design, development, implementation, support and management of computer-based information systems and other applications and programmers
10	Witczak-	A set of procedures, tools and techniques that serve overall

	Roszkowska,2020:513	use of information

Second: Information technology dimensions

Information technology consists of several components and table 2 shows these dimensions as agreed by researchers.

Table 2: views of some researchers on dimensions of information technology

N	Researcher / year	O'Brien& Marakas2010	Jabbouri et al.,2016	Ibrahim& Huimin,2017	Januhari et al., 2018	Adult & Indian, 2019	Osman, 2019	Kabanda 2019	Utami et al., 2020
1	Physical Components	*	*	*	*	*	*	*	*
2	Software	*	*	*	*	*	*	*	*
3	Human resources		*			*			*
4	Databases	*	*		*	*			*
5	Communication networks	*	*	*	*				*
6	Storage technology						*		
7	Long-range communication & communications technology						*		
8	Perception							*	
9	Technical knowledge							*	

Through above, five dimensions of information technology will be relied upon:

1. Physical components.
2. Software.
3. human resources.
4. Databases.
5. Communication networks.

Fourth: concept of lean production system

Before discussing concept of agility, it is necessary to mention what groover said about terms production and manufacturing are usually used interchangeably and that they give same meaning and vice versa. As a result, many researchers have begun to call (lean production) instead. From (lean manufacturing). In other words, this does not make a difference between two terms, because production or manufacturing processes mean processing under (groover, 2002: 21). Table 3 shows view of some researchers on concept of lean production system:

Table 3: Concepts Of Lean Production System

N	Researcher / year	Concept
1	Wickramasinghe & Wickramasinghe, 2017:536	Lean production is a system that uses less of everything when compared to large production, half human effort in plant, half manufacturing space, half investment in tools and half engineering hours to develop a new product at half time. It also needs to maintain less than half of required on-site stock, lead to fewer defects, and produce larger and more diversified products.
2	Ustundag & Cevikcan,2018: 43,44	It can be described as a multifaceted production approach that incorporates a variety of industry practices geared towards identifying value-added processes from point of view of customer and to enabling flow of these processes to attract customer through organization.
3	(Jacobs& Chase, 2018:351)	Integrated activities designed to achieve high-volume and high-quality production using minimum stockpiles of raw materials, operational work and finished goods
4	UlHuq & Mitrogogos, 2018:12	A set of principles, tools and techniques that many industrial organizations or companies choose to implement in order to enhance efficiency of production and overall value of customers while eliminating waste
5	Nicholas,2018:87	Lean production represents a range of methods for producing small batches, reducing preparation time, boiling, pulling production, etc., as well as a production planning and control system.
6	Nwanya& Oko,2019:3	Lean production can be defined as an alternative integrated production model because it combines distinct tools, methods and strategies in product development, processing management and process management as a whole in a coherent manner.
7	Yahya et al., 2019: 2	Lean production is defined as manufacturing without waste.
8	Saett a& Caldarelli,2020:498	Industrial solution to maximize added value by identifying and eliminating eight loss types (inventory, overproduction, defects, waiting, movement, transport, oversupply and human resources)
9	Skobleva et al., 2020:230	Effective management of production processes through waste disposal, that is, processes that do not add value and are not necessary
10	Pushina et al., 2020:1	Lean production is a business management philosophy based on ongoing effort to eliminate all waste known as "muda," namely loss of surplus production "wait/time lost," loss during unnecessary transport, loss resulting from unnecessary additional processing stages, loss of excess supply, loss due to unnecessary proposals, loss due to defects, etc.

Fifth: Dimensions Of Lean Production System

Lean production system aims to achieve high product diversification and productivity, while synchronizing production and demand. In order to achieve these objectives, dimensions have been developed, which are part of concept of lean thinking that focuses on waste or elimination of "muda" (moreira et al., 2017:2). Table 4 shows these dimensions:

Table 4: Views Of Some Researchers On Dimensions Of Lean Production System

N	Researcher / year	Greene 2002	Basha&Toweny 2012	Schlash& El-Hasnawi,,2014	Dombrowski et al., 2016	Folding & Shelby, 2017	Wesenberg 2017	Wagner et al., 2017	Schroeder& Goldstein 2018	Sarayrah& 2020others,
1	Organization of workplace 5S		*	*		*		*		*
2	Continuous Improvement/Kaizen		*	*	*	*		*		*
3	JIT		*	*		*		*		
4	Universal Productive Patience			*		*				*
5	Kanpan			*						
6	Automation		*					*		
7	Production adjustment							*		
8	Consolidation		*		*			*		
9	Reduce Waste							*		
10	Customer Value	*					*		*	
11	Value Stream	*		*			*		*	
12	Flow	*			*		*		*	
13	Perfect	*					*		*	
14	Zero Defects				*					
15	Managing by Goals				*					
16	Value flow map									*
17	Individuals and collective action							*		
18	Drag	*			*		*	*	*	
19	Drag/ Canpan System									*
20	Completion Time							*		
21	Orientation of posts				*					
22	Distinction between Man and Machine							*		

Through above, we will rely on four dimensions of lean production:

1. Regulation of workplace 5S.
2. Overall production maintenance.
3. Production on time.
4. Continuous improvement.

Third Part: Statistical description (presentation of results, analysis and interpretation of hypotheses)

Researcher has two parts: first is standard model that explains validity and reliability of respondents. Second is structural model that illustrates relationship between independent variable and that of final acquired sample of 195 employees and employees of pec/middle euphrates project implementation branch.

First: Standard model (standard relationship)

According to (amaro & duarte, 2015) it is necessary to evaluate data before final analysis of results. This research analyses standard model to verify reliability and validity of results obtained from data analysis. Table 1 shows statistical analysis of data using sps (social science statistical package for social) and smart-pls method. Highest percentage reached for all variables in this research according to sps and smart-plss analysis is 0.834 and lowest is 0.774.

Reliability assessment of all variables has been determined and positive results have been achieved for all five hypotheses (p-value <0.05), which in statistical analysis means p-value value is probability of obtaining at least extreme results such as observed results of statistical hypothesis test, assuming that zero hypothesis is true.

P-value value is used as an alternative to rejection points to provide smallest level of importance through which infinitesimal hypothesis is rejected. A smaller probability value implies stronger evidence in favour of alternative hypothesis, a positive and supportive result because all analysis results of statistical data are higher than 0.05. Table 5 shows reliability statistics for all variables (karpen et al., 2015).

Table 5: Reliability Statistics For All Variables

Variables	Cronbach's Alpha	Composite Reliability	Average Variance Extracted	Number of questions
LPS	0.830	0.881	0.601	5
DB	0.900	0.928	0.723	5
HR	0.748	0.829	0.696	5
NE	0.774	0.845	0.527	5
PC	0.812	0.869	0.570	5
SO	0.834	0.883	0.605	5

Power of discriminatory validity lies in emphasizing difference between elements or measurement of concepts, as well as emphasis on importance of such research. It also focuses on ships between standards of overlapping structures. Table (6) shows that all smart-pls-distinguished validity results are higher than all results below privileged validity rating. Thus, privileged validity of this search results in support of five search hypotheses, as shown in figure (2) and table (6) of privileged validity (maynes & podsakoff, 2014).

Table 6: Privileged Validity

Variables	LPS	DB	HR	NE	PC	SO
LPS	**0.775**					
DB	0.581	**0.850**				
HR	0.480	0.387	**0.704**			

NE	0.478	0.418	0.256	**0.726**		
PC	0.229	0.477	0.452	0.262	**0.755**	
SO	0.322	0.237	0.314	0.318	0.427	**0.778**

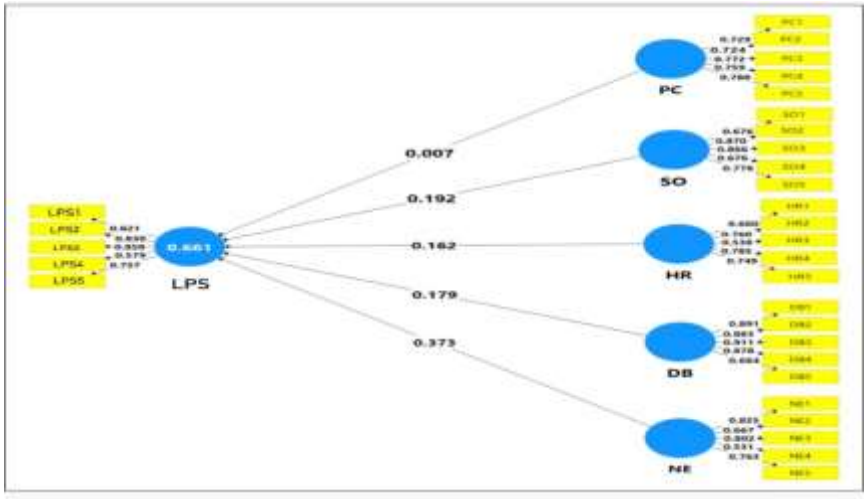


Figure (2) Standard SmartPLS

Second: Exploratory Factor Analysis

Exploration Factor Analysis (efa) is used in research to gather information on ships of a range of variables. Efa is used to create a tool scale in complex sets of statistical data to determine correlation between variables. Prior to efa procedure, adequacy of data for this test must be assessed. Recommends that kaiser-meyer-olkin measure of sufficient sampling be higher than 0.5, and that bartlett's test of speed value should be large at 0.05 or less to show that data set is suitable for factor analysis. Table (7) shows loading of relevant data by indicators using smart-pls method in "efa" exploration factor analysis of variables (awang, 2016).

Table 6: Exploratory Factor Analysis

Items	LPS	DB	HR	NE	PC	SO
LPS1	**0.821**					
LPS2	**0.830**					
LPS3	**0.858**					
LPS4	**0.579**					
LPS5	**0.757**					
DB1		**0.891**				
DB2		**0.883**				
DB3		**0.911**				
DB4		**0.878**				
DB5		**0.664**				
HR1			**0.660**			
HR2			**0.760**			
HR3			**0.538**			
HR4			**0.785**			

HR5			**0.749**			
NE1				**0.825**		
NE2				**0.667**		
NE3				**0.802**		
NE4				**0.531**		
NE5				**0.763**		
PC1					**0.729**	
PC2					**0.724**	
PC3					**0.772**	
PC4					**0.759**	
PC5					**0.788**	
SO1						**0.676**
SO2						**0.870**
SO3						**0.866**
SO4						**0.676**
SO5						**0.778**

LPS1...LPS5... Number of questions by resolution * *
Note: * * Physical Components (PC), Software (SO), Human Resources (HR), Databases (DB), Communication Networks (NE)

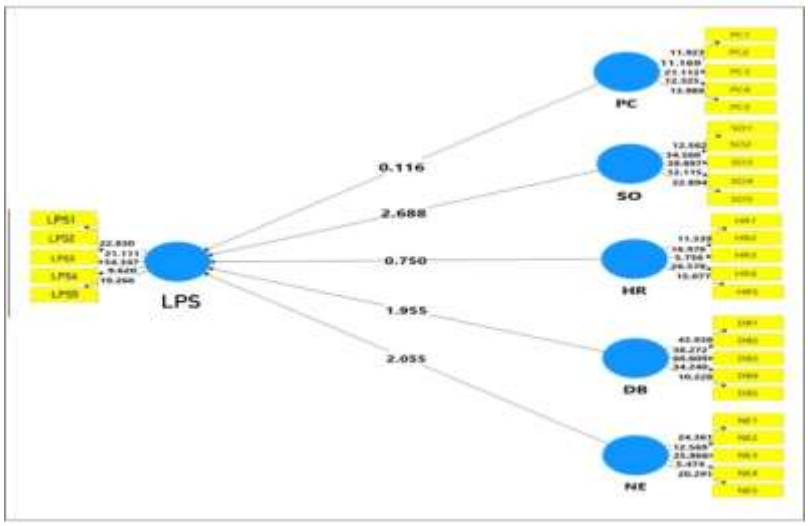
- Structural model (structural relationship)

According to (henseleret et al., 2016) structural relationship in this research is achieved through result of five hypotheses, which were all positive and supportive. Table 8 shows that all dimensions of information technology variables (physical components, software, human resources, databases, communication networks) have a positive impact on lean production system. This relationship is important at 0.05. Research suggests first that external and internal environment affects implementation of information technology in lean production system. This confirms fact that goals of information technology dimensions are to support lean production system, to improve output more efficiently, and this research, after compiling and analyzing results of statistical data, found that information technology is fully applicable to lean production system. Table (8) and figure (3) show relationship between t-value variables. This test means evidentiary statistics are used to determine whether there is a significant difference between two group modes, which may be associated with certain advantages. T-value test is used as a test tool for hypotheses if they are supportive or vice versa (hair et al., 2017).

Table 8: Standard And Structural Relationship Of Results

Hypotheses	Relationship between hypotheses			t-value	Path Coefficient, β	p-value	results
H1	LPS	--->	PC	0.003	0.007	0.116	supporting
H2	LPS	--->	SO	0.001	0.192	2.688	supporting
H3	LPS	--->	HR	0.002	0.162	0.750	supporting
H4	PS	--->	DB	0.001	0.179	1.955	supporting
H5	LPS	--->	NE	0.003	0.373	2.055	supporting

Note: level of importance is $p < 0.05$



Form (3) Structural Method (Compositional) Content In Smart-Pls

Third: Square (R2) R-squared

Square r-squared (r^2): A statistical measure represents variation ratio of a dependent variable explained by a variable or independent variables, while correlation explains strength of relationship between independent variable and dependent variable, and r^2 has provided amounts of variation with number of variables in this research. After researcher evaluated standard model in which all five hypotheses appeared supportive. Positive value of standard model and structural model has been verified in research through use of pls-smart statistical data analysis method. R^2 result represents amount of variation in composition by standard model. R^2 value is vital in research although there are differences with respect to satisfactory level of r^2 value according to (hair et al.,2017), r^2 value between 0.19-0.33 is low, 0.33-0.67 is moderate, and 0.67 and above is high. R^2 value is presented in table (9).

Fourth: Predictive relevance (Q^2)

Predictive relevance: it is a predictive sample that reuses technique known as q^2, focusing on its application as a predictive significance criterion along with size of r^2. In this research, this technique represented a combination of function and excellence validation, bearing in mind that prediction of potential observations was more important than estimate obtained in this research, and this measure (q^2) focused on assessing predictability of research model. This approach in pls-smart confirms a sample procedure by deleting part of inappropriate data in statistical analysis. Q^2evaluates predictive state of model determination via smart-pls. $Q^2$is generally estimated using deletion of 5-10 distance in smart-pls. Q^2values were greater than zero, indicating that external structures are of predictive importance for internal construction. Table (10) shows value of $q^2$and r^2, which is greater than zero for any internal variable. Table (10) indicates predictive importance of path model in standard model (jimha et al., 2017).

Table (10) Production Significance Result ($Q^2$and) and R^2

Predictor	Endogenous	(p-value)	Q^2	R^2	Level R^2
PC	**LPS**	0.007	0.378	0.681	High
SO	**LPS**	0.192	0.378	0.681	High
HR	**LPS**	0.162	0.378	0.681	High

OB	**LPS**	0.179	0.378	0.681	High
NE	**LPS**	0.373	0.378	0.681	High

Fifthly: Hypothesis testing

Smart-plss and spss method for testing five hypotheses in this research was based on both standard and structural (structural) models. Accordingly, a complete model involving structural model of all phases has been identified, built and tested along with complementary pathways to examine p-value coefficients for standard model of model paths. Smart-pls not only takes measurement errors into account, but also generates estimates of standard regression coefficients. Smart-pls method can be used to assess relationship between latent variables (hair et al., 2017). Moreover, assumptions of measurement data and time lapse are not necessary. Wong recommended that prefix method be used as a basis, so that statistical significance of path coefficients can be estimated. This research has five hypotheses:

1. Is there a morally significant impact of dimension of physical components in lean production system?

First objective: explore challenges and implications to be faced in facilitating implementation of physical components in lean production system.

This section discusses analysis done to test direct effect of first hypothesis. There's a positive relationship between physical component variables in lean production system. Research found a statistically significant positive and supportive relationship as in table (11) standard and structural relationship (compositional) of results.

2. Is there a morally significant impact of software dimension in lean production system?

Second objective: explore challenges and implications to be faced in facilitating implementation of software in lean production system.

This section discusses analysis done to test direct effect of hypothesis two. There is a positive relationship between software variables in lean production system. Research found a statistically significant positive and supportive relationship as in table (10) standard and structural relationship (compositional) of results.

3. Is there a morally significant impact of human resources dimension in lean production system?

Third objective: explore challenges and implications to be faced in facilitating implementation of human resources in lean production system.

This section discusses analysis done to test direct impact of third hypothesis. That there is a positive relationship between human resource variables in lean production system. Research found a statistically significant positive and supportive relationship as in table (10) standard and structural relationship (compositional) of results.

4. There is a moral significance to distance of communication networks in lean production system.

Fourth objective: explore challenges and implications to be faced in facilitating implementation of databases in lean production system.

This section discusses analysis undertaken to test direct impact of hypothesis iv. There is a positive relationship between database changer in lean production system. Research found a statistically significant positive and supportive relationship as in table (4) standard and structural relationship (compositional) of results.

5. There is moral significance to dimension of databases in lean production system.

Fifth goal: explore challenges and implications to be faced in facilitating implementation of communication networks in lean production system.
This section discusses analysis done to test direct impact of hypothesis v. There is a positive relationship between communications network variable in lean production system. Research found a statistically significant positive and supportive relationship as in table (4) standard and structural relationship (compositional) of results.
A detailed description of data collection (non-response bias, response rate, common status bias) was provided in research. Descriptive statistics of variables have also been clarified. Apart from this, data were examined to ensure positive status because this is very important in spssu-smart-pls analysis results of analysis showed that all data results were supported by use of smart-pls analysis, reliability was achieved in standard model of discriminatory validity of all results. In addition, smart-pls was used for all search models (standard and structural). All five hypotheses were positive and supportive in achieving research objectives.

Fourth Part: Conclusions & Recommendations

First: Conclusions

1. Results have shown that all dimensions of information technology variables (physical components, software, human resources, databases, and communication networks) have a positive impact on lean production system.
2. This research found that information technology is fully applicable to lean production system.
3. All five hypotheses are positive and supportive, thus achieving research objectives.
4. Optimal use of information technology improves a company's performance by reducing costs and distinguishing its products and services, where it allows delivery of products that are unique in quality or value added.
5. Results of hypothesis test showed that there was a moral impact on extent to which dimensions of information technology were affected and reflected in each dimension of lean production system.

Second: Recommendations

1. Company needs to increase degree of use of information technology in order to increase level of lean production delivery and thus improve efficiency.
2. Train and engage company employees in specialized training courses to improve their levels of understanding and knowledge as well as their performance and skills development.
3. Emphasize need for adequate administrative and financial support for activation of information technology in Public Electric Power Transmission Company.
4. Management of public electric power transmission company should focus its attention on eliminating all forms of waste and at all stages of production process, since removal of waste is one of basic principles underlying lean production system.

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