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Proposing a framework for industry 4.0: An Asian perspective

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Abstract

In this paper, a framework was presented for implementing Industry 4.0 in an Asian context. Industry 4.0, also known as the fourth industrial revolution, is a concept that described the inclusion of cutting-edge technologies such as automation and artificial intelligence into the manufacturing process. To successfully implement Industry 4.0 in the Asia region, the authors argued that it was necessary to take into account the region's specific cultural and socioeconomic backdrop. The authors argued that the successful implementation of Industry 4.0 in Asia was contingent on the effective management of six crucial elements, which were outlined in the suggested framework. Examples of these variables included the organizational structure, the matrix structure, the project teams, the flat hierarchy, the decentralization, the leadership style, and the human resource practices. The authors suggested that governments, industry leaders, and academics take into account the listed elements while establishing and implementing plans for Industry 4.0. The word "organizational structure" referred to an organization's overall architecture, whereas "matrix structure" referred to the use of cross-functional teams to address specific projects or initiatives. Project teams were temporary teams formed for a specific project or task, and a flat hierarchy was an administrative structure with fewer levels than standard hierarchies. Decentralization referred to the process of delegating decision-making authority to lower levels of an organization, whereas leadership style referred to the approach managers took when it came to inspiring and guiding employees. Lastly, when referring to human resource practices, the authors were talking about the rules and processes that aided in the recruitment, development, and retention of employees. The proposed framework provided a starting point for researchers to investigate how Industry 4.0 could be successfully adopted in Asian nations. If organizations considered the aforementioned characteristics, they would be able to build strategies that were more suited to the region's unique cultural and social milieu.

Keywords: Asian, human capital and education, policy and regulation, sustainability and ethics.

BACKGROUND

In every economy, industry is one of the key constituents. Innovations and technological changes have led to several shifts in the paradigm and such shifts in paradigms are referred as industrial revolutions, such as, in first industrial revolution, mechanization was introduced, whereas in second industrial revolution, the use of electrical energy is increased, followed by the introduction of automation and electronics in the third industrial revolution. In the recent era, industry is experiencing fourth industrial revolution resulting from economic, political, social, and technological changes (Poór et al.,2019).

This industrial revolution is named as Industry 4.0 and is defined as the digital transformation of current processes and business as it integrates digital computer structures and replace them with the manual business functions. Figure 1 presents the economic and social factors of industry 4.0 (Butt,2020).

Figure 1 suggests that aging society, lack of skilled workers, clean and efficient urban production, shorter product life cycle, product variability, pressure of cost reduction, volatile markets, mass customization, and dynamic value chain are the critical factors of Industry 4.0 (Deniz,2020). Therefore, specialized management of these factors is required to deal with the challenges in recent era. All economies small or big are experiencing such challenges, such as China is dealing with high pollution and is faced with the challenge of clean urban production. Another challenge faced by China and Japan is the workforce aging (Wankhede & Vinodh,2021). Moreover, cost reduction and customization targets cannot be achieved at the same time since additional cost is required to initiate product customization. With the continuously changing market trends, the product life cycle becomes shorten, therefore, short term innovation must have given more emphasis. Industry 4.0 aims to apply the Cyber Physical Systems (CPS) to the production, such as, integrating machine in the value chain, integrate sensors and actuators, and create a microcomputer network. Industry 4.0 also involves product reengineering and digital enhancement of products. Production style of Industry 4.0 is presented in Figure 2(Currie et al. 2020). Industry 4.0 production style is characterized as a combination of well-coordinated products and services, customized and differentiated products, and value-added product and services. Simply put, Industry 4.0 is assumed to be equipped with smart production facility, machines, and storage system.

Under volatile business environment, businesses face several challenges in terms of selecting management approaches, such as, innovative business models. Innovation capability is one of the key factors to achieve success in the recent technological world (Ismail,2021). Furthermore, motivated employees also play a significant role in such environment by contributing to the organization's process of learning and innovative (Sodiq et al.,2019). Moreover, firms under such environment need to become more responsive towards the needs of industry 4.0 and must develop learning and innovation climate as it facilitates in exhibiting creative behavior and on the job learning environment (Suvarna et al.,2020).

LITERATURE REVIEW

A firm's innovation capability serves as the success driver in Industry 4.0. The innovation capability can be in the form of product reengineering, CPS (sensors, actuators, computer networks), or product differentiation. Thus, in order to become smart, an organization needs to develop innovation and learning climate, implement appropriate management practices, and hire intelligent employees (Leng et al.,2020). Industry 4.0 management is an important issue, however, there is dearth of available research in this area. Figure 3. shows that Industry 4.0 require firm to develop various capabilities relevant to different organizational dimensions. Therefore, to achieve successful management of business model, organizations are required to develop organizational capabilities, and create product portfolio for getting access to the customers and market as well as for enhancing the organization's value chain systems and processes (Lim et al.,2020).

How organizations can enhance innovative capabilities is of prime importance since it helps the enterprise to keep aligned with the Industry 4.0 requirements. Therefore, this study aims to integrate logical beliefs and relevant literature and propose management practices that aim to fulfill the Industrial 4.0 requirements, by establishing innovation and learning climate within the organization. Such climate is assumed to enhance the capabilities of organization(Liu et al.,2020). The discussion of these practices are as follows:

Organizational Structure

In current business environment, the organizational structures are changing with a greater pace. Such acceleration in the change in organization's structure significantly contributes to the creation of organizational climate that is favorable to innovation and learning (Huang et al.,2020). Broadly speaking, the design of organization can range from mechanistic to the organic design, where mechanistic design comprises of specialized tasks, set of rules and formalities, centralized structure, strict authority, and vertical communications. Such design is favorable for the rigid culture and stable business environment however, this might not be favorable for the Industry 4.0 since Industry 4.0 refers to an unstable and volatile environment to which organic design seems to be appropriate. On the other hand, organic design is characterized by features like horizontal communication, empowerment, collaborative teamwork, decentralization, and fewer formalities and rules(Sima et al.,2020). Organic design is suitable for continuously changing environments and works well with the implementation of innovation strategy. Therefore, a manager in Industry 4.0 must consider an organic design paradigm while developing its organizational structure.

For industry 4.0, no single structure can be suitable, since organizations are expected to assess both the situation and needs of their organization to design a structure that is suitable and flexible (Javaid et al.,2020). Although, a design suitable for one organization may not be suitable for the other as each design has advantages and disadvantages. Thus, some of the options that are suitable for the industry 4.0 are:

Matrix Structure

Matrix structure is a form of organizational structure, where organizational activities are managed by multiple lines of authority (Demir et al.,2020). In this structure, dual reporting system is used for grouping resources and people based on their product and function. One of its key features is its flexibility and quick response or adaptability to change. Each employee in the matrix structure is required to work under various functional managers, one product manager, and two bosses. Matrix structure also allows firm to keep pace with the industry 4.0.

Project teams

In a team-based group, a single group is formed by combining different organizational functions and processes, with an aim of achieving common goals or objectives. Project teams stimulate the decision-making process, supports organizational learning, and breaks the organization's departmental and functional obstacles (Jiménez López et al.,2022). Under volatile environment characterized by frequent changes, the key success factor is innovation and project-based teams facilitate and improve organizational innovation and learning. Besides, new routines and knowledge are the key to improve the process of innovation (Nicoletti,2020). For a firm to achieve technological developments, reusing existing solutions as well as creating new technical solution is important. In a learning environment, project teams facilitate in reusing and sourcing knowledge, however, it entirely depends on the goal orientation of the group member (Dolgin, 2020). Thus, managers must adopt capability-oriented management or supervision, or motivate their team members by tolerating their mistakes.

Flat Hierarchy

Hierarchy refers to the chain of command in organization, which indicates the managers' authority at different organization levels. Flat structure involves wide span of control, and fewer hierarchical levels, thereby suggesting fewer staff and managerial levels and large number of employees that report to a single manager (Hussain, 2019). Flat structure reduces gap among top management and employees, and facilitates communication within the organization, which thus improves employee participation in the decision-making process as well as in discussions, that may increase employee learning and faster response from the top management, that can possibly be achieved through horizontal communication(Wang et al.,2019). Thus, it can be stated that flat structure seems compatible and suitable for the Industry 4.0.

Decentralization

In decentralized system, the decision-making authority in organization is passed on to lower-level employees. In this system, it is the employees who have the knowledge and authority of organizational activities, and top management and supervisor cannot control these activities. Both non-managerial staff and managers take decisions without top management's consent, for instance decisions regarding the use of resources (Talitha et al.,2020). Since situations continuously change under uncertain environment, therefore, it is preferable for the organizations to adopt decentralized system. Decentralized system enables timely decision-making and assists the employees in changing business environment as well as in changing the direction of the business. It thus allows quick learning and decision-making among employees (Abimbola et al.,2019). Hence, decentralization improves compatibility among organization and Industry 4.0.

Role of Leadership style as A Mediator

Leadership style

The term leadership refers to the skill of a leader to inspire, influence, direct, and motivate others to achieve certain organizational goals and objectives. The path goal theory of leadership suggests that the appropriate selection of leadership style enables the leaders to motivate their fellows to perform activities in order to achieve desired organizational goals. Such as, Apple Inc. ranks as one of the top innovative companies in the world (Asgari et al.,2020). Majority of the case studies on Apple Inc. suggest that the success of the company is not solely because of the CEO's technical skills, rather the leadership skills of Steve Jobs. Similar is the case with Microsoft Corporation, where Bill Gates leadership style is often considered as the reason for the company's success (Guterresa et al.,2020). Therefore, in Industry 4.0, a specialized leadership style is needed to stimulate the organization's process of learning and innovation. Transformation leadership style is the common style that is often adopted by organizations for learning and innovation. Transactional leadership and authentic leadership are some of the other styles that discuss learning, knowledge, and innovation. Transformational leadership alone is not sufficient for the industry 4.0 and requires something more in context to innovation and learning. It is due to the fact that transformation leadership mainly revolves around inspirational motivation, idealizing influence, providing vision, and intellectual stimulation (Shkoler & Tziner,2020). Therefore, industry 4.0 is required to focus more on the learning, innovation, and knowledge. So, a knowledge-oriented leadership construct was developed with a combination of transactional and transformational leadership styles. Although, knowledge-oriented leadership particularly emphasizes on innovation and learning, still this construct can further be extended by including supportive behavior, knowledge diffusion, innovative role modeling, mentoring, consulting, and delegation to the construct and adopt in the Industry 4.0. The extended knowledge-oriented leadership construct may facilitate in stimulating the pace of learning and innovation and enhance organizational compatibility with Industry 4.0.

Human Resource Practices as A Mediator

Human resource (HR) practices is the key source for shaping the employees' capabilities, skills, attitudes, and behaviors to achieve desired organizational goals and objectives (Boon et al.,2019. Employees learning, innovativeness, and knowledge management capacity can be enhanced by designing and implementing appropriate HR practices, since HR practices significantly contribute to gaining competitive advantage by the organization, particularly in case of knowledge-based economy (Amrutha & Geetha,2020). Some of the key HR practices that need to be implemented by organizations include staffing, training, compensation, job design, and performance appraisal (Anwar & Abdullah,2021).

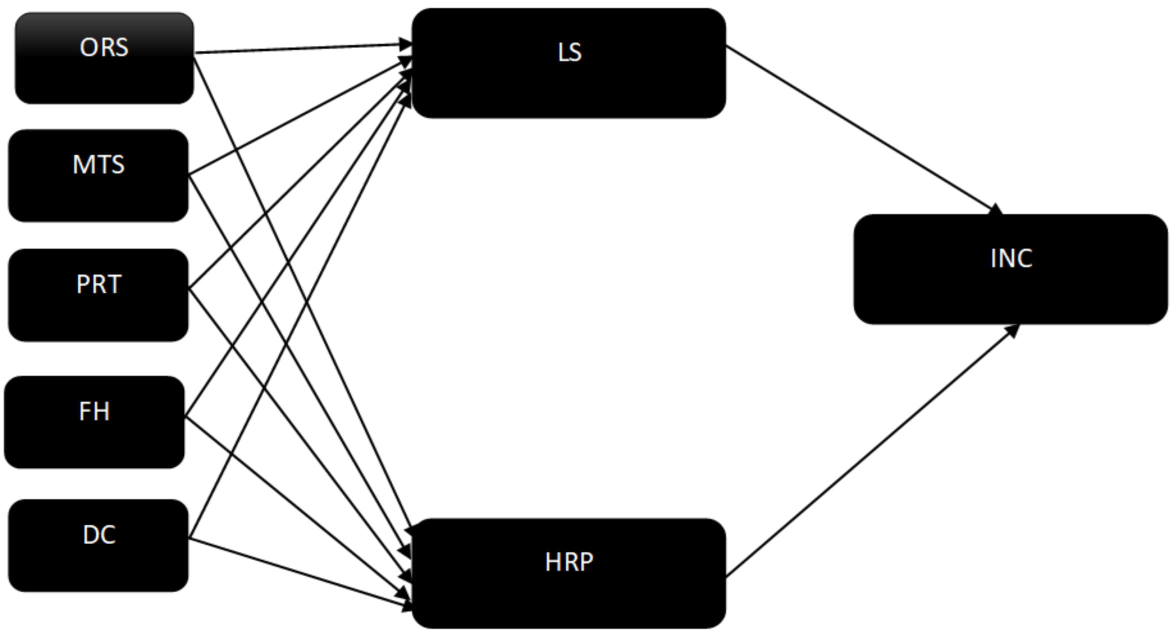

Figure 1.
Conceptual framework

RESEARCH METHODOLOGY

The purpose of this research was to develop a theoretical underpinning for Industry 4.0 that is sensitive to Asian cultural norms. We employed a survey-based strategy, with a response rate of 30% (n=300). There were a total of 265 questions on the survey questionnaire, all of which were designed to gauge various factors of interest. Organizational determinants included a matrix structure, project teams, a flat hierarchy, decentralization, a leadership style's ability to mediate conflict, and human resource practices; innovation capacity was the independent variable. Those with expertise in both the Asian market and Industry 4.0 were asked to fill out the poll. All of these people came from relevant work backgrounds. For this survey, we selected participants using a method known as convenience sampling.

Statistical tools like structural equation modeling were employed in the data analysis (SEM). We mapped out the interdependencies among the factors and provided a framework inspired by Industry 4.0. Using the outer loading values, we estimated the PLS-SEM model's structural equations to find out how much of an effect the latent variables have on the observables. To evaluate PLS-dependability, SEM's we used both the Composite Reliability (CR) and Average Variance Extracted (AVE) techniques. Discriminant validity was shown via the correlation matrix.

Several characteristics, including organizational structure, matrix structure, project teams, flat hierarchies, and decentralization, were discovered to improve innovation skills. In addition, the company's Leadership Model and HR Policies & Procedures played key mediating roles in this association. It is possible that the industry 4.0 framework could assist Asian companies in enhancing their innovative capabilities and maintaining their global competitiveness.

In conclusion, the findings of this study shed considerable light on the elements that influence the innovative potential of Asian organizations. The proposed framework can assist firms in implementing organizational and leadership changes, as well as refining their human resource policies and processes, in order to boost their innovation potential. This research may pave the way for future studies on Industry 4.0 in Asia.

RESULTS

In order to find the relationships between organizational structure, leadership style, human resource practices, and innovation capabilities in the context of Industry 4.0, we realized we required a comprehensive analytic tool. Using Sem-pls, a dynamic two-step approach, we were able to delve deeply into the data and draw pertinent conclusions. We painstakingly crafted a series of questions to capture the nuances of each variable and distributed them to a large sample of 300 individuals along with the measurement model. Then, we delved into the structural model, utilizing the collected data to construct a strong framework that would assist us in comprehending the complex interplay of these vital components. At each point of the process, we were able to gather new insights and a deeper knowledge of the relationships at play. It was a thrilling journey with many twists and turns, but with Sem-pls as our guide, we were able to successfully traverse it and emerge with a comprehensive understanding of the factors driving innovation in the world of Industry 4.0.

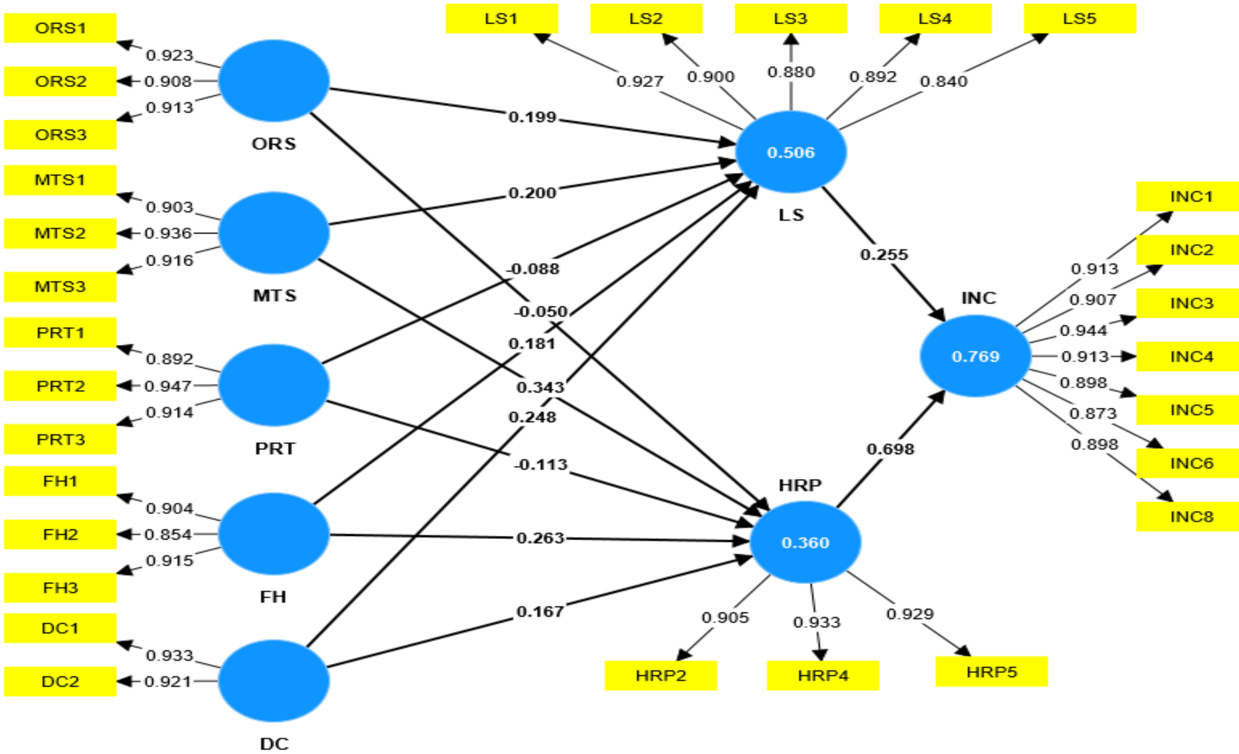

Figure 2.

Measurement Model

According to the PLS-SEM methodology, the "outer loadings" are the regression coefficients that reflect the correlations between the latent variables and the observable variables.

Table 1.

Outer Loadings

	DC	FH	HRP	INC	LS	MTS	ORS	PRT
DC1	0.933							
DC2	0.921							
FH1		0.904						
FH2		0.854						
FH3		0.915						
HRP2			0.905					
HRP4			0.933					
HRP5			0.929					
INC1				0.913				
INC2				0.907				
INC3				0.944				
INC4				0.913				
INC5				0.898				
INC6				0.873				
INC8				0.898				
LS1					0.927			

LS2					0.900			
LS3					0.880			
LS4					0.892			
LS5					0.840			
MTS1						0.903		
MTS2						0.936		
MTS3						0.916		
ORS1							0.923	
ORS2							0.908	
ORS3							0.913	
PRT1								0.892
PRT2								0.947
PRT3								0.914

According to Table 2, the CR and AVE coefficients for the study's latent variables fall within acceptable limits, indicating that they can be relied upon. Table 3 displays the results of an examination of discriminant validity using the Fornell-Larcker criterion; the bold loadings on all variables indicate a high level of discriminant validity. Using a set of structural equations derived from the measurement model, the PLS-SEM structural model was developed by estimating the external loadings applied to the model. We were able to examine undiscovered correlations between latent variables and test our data-driven hypotheses due to the structural model (Hair et al., 2022). All of the hypotheses were validated with a high degree of certainty, suggesting the validity and dependability of the data, as shown in Table 4. The table serves to illustrate these outcomes.

Table 2.

Reliability Analysis

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
DC	0.836	0.841	0.924	0.859
FH	0.870	0.874	0.921	0.795
HRP	0.912	0.913	0.945	0.851
INC	0.964	0.964	0.970	0.822
LS	0.933	0.934	0.949	0.789
MTS	0.907	0.910	0.942	0.843
ORS	0.902	0.903	0.939	0.837
PRT	0.907	0.916	0.941	0.843

Table 3 below demonstrates the discriminant validity of the present study.

Table 3.

Discriminant validity

	DC	FH	HRP	INC	LS	MTS	ORS	PRT
DC	0.927							

FH	0.882	0.891						
HRP	0.567	0.572	0.922					
INC	0.682	0.702	0.853	0.907				
LS	0.681	0.671	0.604	0.677	0.888			
MTS	0.898	0.881	0.581	0.684	0.685	0.918		
ORS	0.853	0.860	0.532	0.652	0.671	0.902	0.915	
PRT	0.863	0.865	0.516	0.667	0.628	0.873	0.855	0.918

Discriminant Validity:

The term "discriminant validity" describes the extent to which two variables in an investigation are distinct and unrelated. It is essential to verify that the measurements used in a study do not overlap, as this could lead to inaccurate or misleading results if not strictly regulated. Statistical approaches such as confirmatory component analysis are widely used to evaluate discriminant validity. This type of study compares the relationships between variables to determine whether there are significant differences between them.

Structural Model:

The structural model extends the measurement model with a set of structural equations. What these reveals are connections between parts that were previously hidden..

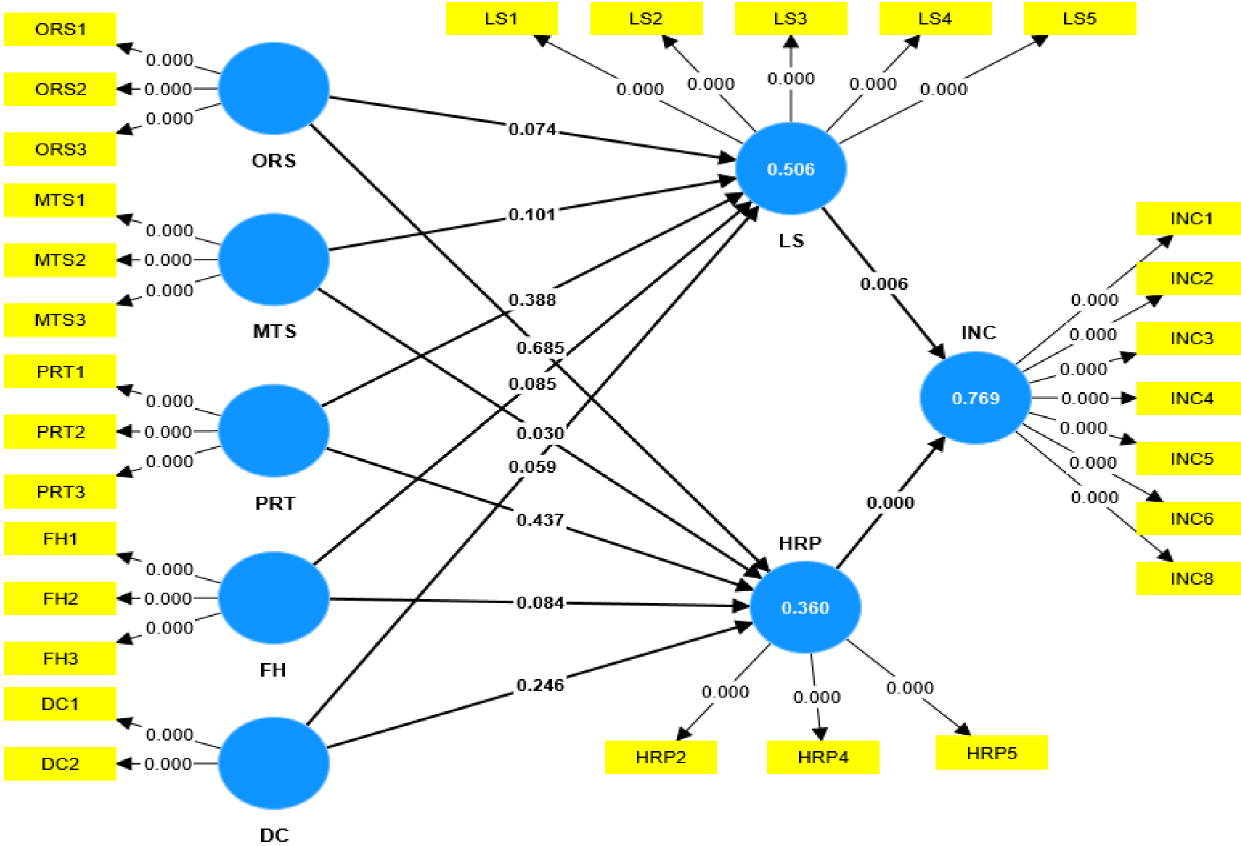

Figure 3.
Structural Model

In addition, the structural model captures the underlying causal structure of the data. Using observable data, this model is put to use to test hypotheses about the connections between latent variables. Calibrating the external loads on the structural model with the use of measurement model-retrieved structural equations is part of the model's scope. The measuring model serves as the foundation for this strategy. If the modeling approach is to produce a reliable and valid model, then this process must be repeated several times.

Table 4: Direct Results

	(O)	(M)	(STDEV)	(|O/STDEV|)	P values
DC -> HRP	0.167	0.164	0.144	1.161	0.246
DC -> INC	0.180	0.179	0.119	1.513	0.130
DC -> LS	0.248	0.254	0.131	1.892	0.059
FH -> HRP	0.263	0.267	0.152	1.731	0.084
FH -> INC	0.230	0.233	0.118	1.947	0.052
FH -> LS	0.181	0.173	0.105	1.721	0.085
HRP -> INC	0.698	0.700	0.086	8.167	0.000
LS -> INC	0.255	0.254	0.092	2.763	0.006
MTS -> HRP	0.343	0.347	0.158	2.169	0.030
MTS -> INC	0.291	0.292	0.119	2.441	0.015
MTS -> LS	0.200	0.206	0.122	1.642	0.101
ORS -> HRP	-0.050	-0.060	0.123	0.405	0.685
ORS -> INC	0.016	0.011	0.098	0.163	0.871
ORS -> LS	0.199	0.194	0.111	1.787	0.074
PRT -> HRP	-0.113	-0.106	0.146	0.777	0.437
PRT -> INC	-0.102	-0.094	0.111	0.915	0.360
PRT -> LS	-0.088	-0.086	0.101	0.864	0.388

Structural Equation Modeling (SEM) with Partial Least Squares (PLS) can predict correlations between latent variables using a structural model that accounts for the causal structure of the data. This model offers a structural representation of the underlying data relationships. Combining principal component analysis (PCA) and structural equation modeling (SEM), this technique is sometimes known as "structural modeling" (Henseler & Schuberth, 2022).

The statistical importance of the path of mediation may be seen in the table below, which depicts the findings of the mediation study.

Table 5.

Mediation Analysis

	(O)	(M)	(STDEV)	(|O/STDEV|)	P values
DC -> HRP -> INC	0.117	0.114	0.101	1.157	0.247
ORS -> LS -> INC	0.051	0.050	0.036	1.403	0.161
MTS -> HRP -> INC	0.240	0.241	0.111	2.169	0.030
DC -> LS -> INC	0.063	0.065	0.043	1.474	0.140
FH -> HRP -> INC	0.184	0.187	0.109	1.678	0.093

ORS -> HRP -> INC	-0.035	-0.040	0.085	0.409	0.682
PRT -> LS -> INC	-0.022	-0.021	0.028	0.799	0.425
PRT -> HRP -> INC	-0.079	-0.073	0.102	0.779	0.436
MTS -> LS -> INC	0.051	0.051	0.036	1.412	0.158
FH -> LS -> INC	0.046	0.045	0.034	1.351	0.177

DISCUSSION AND CONCLUSION

Industry 4.0, often known as the Fourth Industrial Revolution, is currently altering how organizations compete on the global market. Organizational structures and human resource practices must be modified for businesses to adopt and implement Industry 4.0 effectively. This project aims to develop an Asian framework for the implementation of Industry 4.0. The article identifies organizational structure, project teams, leadership style, and human resource strategies as key components of the framework. Organizing Diagram: In modern enterprises, conventional hierarchical structures have no place; instead, matrix designs, which allow for greater flexibility and agility, should be utilized. Industry 4.0 necessitates cross-functional collaboration and the integration of diverse business processes in order to achieve shared objectives. Flat hierarchies and decentralization are also crucial factors to consider when it comes to empowering individuals and fostering quicker decision-making. Working Groups on Projects: Project teams are necessary for implementing Industry 4.0 since they enable agile and iterative development. As a result, teams can adjust rapidly to shifting market and technological conditions, paving the path for accelerated product development and innovation.

The Mediator Function of Leadership Style The leadership style is a crucial intermediary in the process of driving organizational change and facilitating the adoption of Industry 4.0. Leaders must be transformative and imaginative, guiding the organization and articulating its purpose. Also, they should be able to inspire and motivate staff to accept change and assume responsibility for their work. Methods of Human Resource Management as a Neutral Mediator: Human resource practices are essential for the development of the necessary skills and capabilities for Industry 4.0. This includes investing in employee training and development, building a culture of constant learning and innovation, and hiring and keeping the most talented individuals in the industry. As a dependent variable, innovation capacity: The ultimate objective of implementing Industry 4.0 is to enhance a company's capacity for innovation. In order to maintain a competitive advantage over rivals, businesses must cultivate the capacity for continual innovation through using developing technology and business concepts.

Conclusion:

The conclusion of this study puts out a model that is centered on Asia for implementing Industry 4.0. The framework places an emphasis on the requirement of human resource policies that encourage innovation and lifelong learning, as well as the advantages of flexible organizational structures, project teams, transformational leadership, and other notions of a similar nature. Companies that adhere to the concepts of Industry 4.0 work hard to keep a competitive edge in the global economy by acquiring capabilities that are on the leading edge of their fields.

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