International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 05 Issue: 01 | Jan – 2026 DOI: 10.55041/ISJEM05433
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Charting The Route to Logistics 4.0: Unpacking Adoption Drivers in the Indian Context.

S Lakshmidevi, Research Scholar, University of Madras

Dr. Manjula P S, Assistant Professor , University of Madras

Abstract

This study is an attempt to explore the critical factors affecting the logistics 4.0 implementation in the Indian context, spotlighting on organisational preparedness, competitive landscape, and regulatory frameworks. As you all know, logistics 4.0 integrates the latest technologies like Internet of Things(IoT), Artificial Intelligence(AI) and blockchain methodologies in the supply chain management processes hence its successful adoption hinges on many key factors. Technological infrastructure and workforce capabilities are the key influencers as far as organisational readiness is concerned. These are very vital for the successful leveraging of logistics 4.0 like innovations effectively.The competitive landscape is urging the firms to continuously evolve, innovate and strategically position themselves to take the lead with their competitive advantages.The regulatory environment should foster and support new and innovative technologies while ensuring compliance and favouring overall growth.This study is an attempt to comprehensively analyse and identify these factors there by limelighting the opportunities and challenges faced by Indian logistics sector in the context of logistics 4.0 implementation.The findings of the study offer valuable insights for the stakeholders aiming at the enhancement of efficiency and effectiveness of logistics operations in the rapidly evolving logistics 4.0 scenario.

Key words: Logistics 4.0, Organisational Preparedness/ Readiness, Regulatory frameworks, competitive landscape.

Introduction

The current era is characterised by rapid changes in technological advancements and especially the logistics industry is facing unforeseen significant transformation namely logistics 4.0. This new paradigm shift evolved from industry 4.0 which integrates advanced technologies like IoT, Big data Analytics and AI to create a well interconnected logistics ecosystem.The adoption of logistics 4.0 in industry setting involves a comprehensive overhaul of current processes, systems and even organisational culture. (Sony 2021). The paper delves deep into the major critical factors that affect successful implementation of logistics 4.0 in the Indian context, a market featured with unique challenges and opportunities in its logistics sector. The Indian logistics sector is characterised by infrastructural bottlenecks, regulatory challenges and fragmented market conditions. Despite these issues and challenges, India has a lot of potential for the successful adoption of Logistics 4.0, given its stride in the digital economy and government initiatives like Digital India and burgeoning investments in infrastructure development. Analysing the critical factors that affect logistics 4.0 implementation in Indian context will help the various stakeholders like policy makers, industry leaders and technology providers to leverage its full potentiality and foster sustainable growth. (Culottes, 2020)

This study is focusing on the effective implementation of Logistics 4.0, encompassing the following factors namely technological preparedness, regulatory frameworks, market dynamics and organisational readiness. Technological readiness was studied in terms of availability of competent and efficient technology and also in terms of ability of the organisations to integrate these new technologies into their daily operations. (Javaid, 2021) Regulatory frameworks are the repositories of policies, rules and regulations that can either foster or hinder the adoption of advanced logistics technologies and solutions. Market dynamics involves competitive environment, customer expectations and the demand requirements for a more effective and efficient as well as transparent logistical services. Organisational preparedness factor incorporates internal components of the organisation such as workforce skills and abilities, change management practices and proper aligning of strategic goals in line with technology advancements. (Ali, 2021)

By pouring light into the critical factors in Indian context, this research paper dives deep to provide a comprehensive understanding of the enablers and barriers to the implementation of Logistics 4.0. The learning output provided by the paper will be handholding the industry stakeholders to make well informed decisions, fostering innovation and spearheding the transition of Indian logistics sector towards more agile and responsive horizons. Logistics 4.0 adoption

© 2026, ISJEM (All Rights Reserved)

will be helping the county in achieving long term economic resilience and to become more competitive as we continue to integrate into global supply chain networks. (Choudhury, 2021).

Literature Review

The literature on Logistics 4.0 is very vast and extensive, showcasing the genuine interest in understanding and leveraging the transcending digital technologies and their power to transform the logistics sector. Industry 4.0 is the root of the logistics 4.0 concept, which emphasises the integration of latest technologies such as IoT and AI into industry set up. Numerous studies have spotlighted the transformative potential of these innovative technologies in increasing operational efficiency, transparency and responsiveness in logistics operations (Markov, 2020).

Various researchers have investigated the conversant impacts of Logistics 4.0 upon supply chain management in different global contexts. For instance , the study by Bag (2020) and Rosin (2019) emphasises the potential of Internet of Things and Big data analytics in optimising logistics processes. Their studies have explored the various capacities of these emergent technologies like real time tracking, predictive maintenance and enhanced decision making capabilities. These technologies found to be enabling a shift from traditional reactive approaches to problem solving to proactive strategies that anticipate and mitigate possible disruptions in a better way. Furthermore, the new logistics 4.0 is characterised by advanced data analytics features powered by the integration of machine learning algorithms and AI and this will pave the way for improved demand forecasting and better inventory management and precise route optimisation.

The Indian logistics sector, however, possesses unique challenges and opportunities in the context of logistics 4.0 implementation and successful adoption of the same. If we survey literature specific to the Indian context, we will come across unique critical factors specific to the country influencing the digital transformation towards logistics 4.0. One of such predominant and critical influencers is the infrastructural bottlenecks that pose hindrance to seamless and efficient logistics operations.

According to a study conducted by (Khan , 2018) India's logistics costs are far much higher compared to that of developed countries. This is attributed to sub- optimal infrastructural facilities and fragmented logistics networks. The studies by Sufiyan (2019) and Joshi (2021) emphasised the need for governmental intervention for substantial investments in infrastructural developmental projects to support the adoption of emerging advanced technologies in the field of logistics.Regulatory frameworks and government initiatives has a key role in shaping the conducive climate in India towards logistics 4.0 adoption. Indian logistics landscape should have more embracing features to attract the digital transformation. Goods and Services Tax implementation in 2017, has been a significant landmark towards creating a unified national market and thereby reducing logistics related inefficiencies caused by state level taxes and various check points.

According to the research conducted by Jagtap (2020) and Rejeb (2020) GST positively impacts logistics operations and it facilitates smoother interstate movements of goods and fosters a more integrated logistics network. Apart from this the new initiatives like Smart Cities and Digital India Campaign provides a conducive environment for the adoption of latest initiatives like logistics 4.0.

The growing E commerce sector and ever evolving consumer expectations has modified the market dynamics into a greater height driving the need for more advanced logistics solutions in India. Studies by Rahman (2020) and Kumar (2021) highlights the need for reliable, faster and transparent logistics services. The last mile delivery has been ever challenging since the introduction of E commerce ordering platforms has mushroomed the internet space.The challenges in last mile delivery can be effectively off-setted by the deployment of drones, autonomous vehicles and use of advanced robotics technologies.

Javaid (2021) in his study has explored the criticality of internal factors viz. organisational readiness and workforce capabilities in the effective implementation of logistics 4.0. This study pointed out that successful adoption of logistics 4.0 requires substantial changes in the organisational culture, organisational processes and workforce skillsets. The current workforce may require reskilling or upskilling to fit themselves into the changing logistics 4.0 like advanced logistics systems. This study identified the need for better change management practices as well as the realignment of strategic goals with the advancements in technologies for the effective implementation of logistics 4.0.

Many global studies on implementation of logistics 4.0 describes the benefits of adopting the same to their logistics processes, meanwhile the studies specific to Indian context sheds light on the unique challenges and opportunities of adopting logistics 4.0 into its operations. Infrastructural development, technology friendly regulatory frameworks, market dynamics and organisational readiness are observed to be the critical factors in shaping a successful logistics landscape in India favouring the implementation of logistics 4.0.

Objectives of the study

- To analyse the role of organisational preparedness in impacting the implementation of Logistics 4.0 in the Indian scenario
- To evaluate the impact of the competitive landscape in the implementation of Logistics 4.0 in the Indian scenario
- To understand the nature of regulatory frameworks in the successful implementation of Logistics 4.0 in the Indian scenario

Research Methodology

The study used convenience sampling method for collecting the respondents from the entire population. Primary data were collected through structured questionnaire and Google forms. The collected data were analyzed using quantitative methods in SPSS Software. AMOS software was used for SEM analysis. Quantitative data collected from surveys are statistically analyzed to determine the significance and correlation of various factors and to arrive at valuable conclusions.

Data analysis

This section involves presenting the critical data analysis regarding the study, the researcher has used SPSS and SEM model for preparing the analysis.

Demographic analysis

Table 1: Demographic profile of the sample

Gender	Frequency	Percentage
Male	91	65.90
Female	47	34.10
Age groups	Frequency	Percentage
Less than 25 years	43	31.20
26 - 30 years	46	33.30
31 - 35 years	18	13.00
35 - 40 years	31	22.50
Place of Residence	Frequency	Percentage
Urban	63	45.70
Semi Urban	51	37.00
Rural	24	17.40
Family type	Frequency	Percentage
Nuclear family	81	58.70
Joint family	57	41.30
Management levels	Frequency	Percentage
Lower Level Management	105	76.10
Middle Level Management	33	23.90
Work experience	Frequency	Percentage
Less than 5 years	38	27.50
5 - 10 years	38	27.50

10 - 15 years	24	17.40
15 - 20 years	27	19.60
Above 20 years	11	8.00

The sample consisted of 91 males and 47 females. The higher proportion of male respondents in the logistics industry is the reason behind the sample distribution being not balanced in terms of gender. However, the age distribution of respondents shows very equal expressions in different age categories, with the largest group being people aged 26-30, a 33.30% sample (n = 46). The group of people under the age of 25, 31.20% (n = 43), follows immediately.From the sample, 13.00% (n = 18) consisted of respondents aged 31-35, and 22.50% (n = 31) were between 35-40 years old.Since most respondents are under 30 years of age, the distribution of the sample primarily indicates younger demographics. This means that this study probably reflects the ideas and experiences of the young population that could influence the prospects studied.

45.70% (n = 63) of respondents lived in urban areas, while 37.00% (n = 51) lived in semi-cost areas and 17.40% (n = 24) in rural areas.The data at the residential location show the advantages of respondents under urban and semi-cooking conditions, with limited number of respondents in rural areas.The prevalence of urban participants in the sample may indicate that the outcomes are primarily urban or semi-urban outlooks and may differ from rural outcomes due to various socioeconomic conditions, resource availability and lifestyles.Of the total number of respondents, 41.30% (n = 57) belong to joint families, and most respondents have 58.70% (n = 81) belong to nuclear families. These results show that nuclear housing is more common as part of this demographic.The type of family structure can affect the respondent's perspective, particularly in areas related to the balance between work and personal life, financial responsibility, and social support systems.

From the sample, only 23.90% (n = 33) belonged to the moderate level of management, with the majority of respondents, 76.10% (n = 105) coming from the low level of management.This study primarily reflects the outlook of people at the operational level, as evidenced by the majority of participants at the lower level of management, and does not reflect the views of people at the higher management positions.This can affect commercial solutions, leadership outlook, and interpretation of facts related to adoption of administrative issues.Distribution of practical experience.

The distribution of work experience among respondents varies completely in several categories.In particular, 27.50% (n = 38) have experience under 5 years of age, while the same number has 5-10 years of experience.Of the 24 people with 10-15 years of experience, this accounts for 17.40%.Similarly, out of 27 people aged 15 to 20, it represents 19.60%.Only 8.00% (n = 11) have over 20 years of professional experience.The answers showed a wide range of professional experience, but most were in the beginning of their careers.Different work experiences can provide unique opinions about the opportunities and issues people face at different stages of their careers, perhaps revealing trends in occupational growth, career and sensitivity in the industry.

Table 2: Reliability analysis

S. No	Constructs	No. of variables	Cronbach Alpha
1	Organisational Preparedness	3	0.957
2	Competitive Landscape	3	0.946
3	Regulatory Frameworks	3	0.921
4	Implementation of Logistics 4.0	3	0.934

The data presented in this study were subjected to reliability analysis using Cronbach's Alpha to measure the reliability of four independent constructs. This statistical metric is commonly used to assess the consistency or internal reliability of a set of scales or test items. Values close to 1.0 indicate high reliability.Organization Preparedness consists of three elements, with Cronbach Alpha 0.957.Very high alpha value shows that the components of this construct are very reliable and effectively measure a single underlying dimension. From a practical standpoint, this means that the

problems or variables linked to organizational preparedness are clearly defined to accurately assess the extent to which the company can solve a particular problem or implement innovative concepts.The high reliability of this construct ensures that the obtained results accurately reflect the actual state of organizational preparation, minimizing the likelihood of measurement error.

The "Regulatory Frameworks" construct has a Cronbach's Alpha of 0.921 and is made up of three variables. Despite being marginally lesser value, this alpha number shows a high degree of reliability. It is likely that the factors in this framework will be useful in evaluating the regulatory environment, which includes the effects of legislation, rules, or standards that regulate the particular industry or sector being studied. This design's great reliability guarantees that the regulatory components are continuously evaluated, allowing for a thorough examination of how they affect organizational goals or results.

The "Implementation of Logistics 4.0" construct, which has three variables, has a Cronbach's Alpha coefficient of 0.934. The strong internal consistency indicates that the variables effectively capture the complexities of implementing advanced logistics operations involving the integration of automation, data analytics, and real-time tracking technologies pertinent to Industry 4.0. The reliability of this construct is crucial to ensure that the study accurately portrays the extent of Logistics 4.0's implementation, along with its potential benefits or downsides. Reliable judgments about the impact, readiness, or effectiveness of modern logistics methods on organizational performance can be drawn with a high level of dependability in this sector.

All four constructs exhibit relatively high Cronbach's Alpha values, indicating strong internal consistency and reliability in measuring their respective concepts. The validity of the results of the study relies on the accuracy of the measurements, as this minimizes the chance of error and enhances confidence in the conclusions drawn from the data.

Chi-square analysis

Null hypothesis : There is no statistical difference between the role of organizational preparedness and the implementation of Logistics 4.0 in the Indian context.

Table 3: Chi-square analysis – Impact of the role of organizational preparedness on the implementation of Logistics 4.0

Organisational Preparedness	Value	df	p value
Pearson Chi-Square	286.646a	16	0.00
Likelihood Ratio	207.718	16	0.00
Linear-by-Linear Association	102.83	1	0.00

For the analysis of the data for "Organizational Preparedness," several statistical tests are used in order to provide useful insights into the correlations. With a value of 286.646 and 16 degrees of freedom (df), the Pearson Chi-Square test is extremely significant, as evidenced by the p-value of 0.00. This outcome points to a clear link between the relevant factors. The fact that the p-value is well below the acceptable threshold of 0.05 demonstrates that the association is not just due to chance. In practical terms, this implies that the model effectively captures the interrelationships between the variables that affect an organization's preparedness, which is probably crucial. Along with the results of the Pearson Chi-Square test, the Likelihood Ratio test has 16 degrees of freedom and a value of 207.718. The Pearson test and the Likelihood Ratio test both produce a p-value of 0.00, demonstrating a statistically significant connection between the components related to organizational preparedness. The similarity between the two tests increases the trustworthiness of the results since it implies that the underlying framework of the data is strong and that the variables are likely measuring features of organizational preparedness in a consistent and trustworthy manner.

The results of the prior tests are supported by the Linear-by-Linear Association test, which has a score of 102.83 and a p-value of 0.00. In this test, the link between two ordinal variables is specifically explored, and in this case, the data show a strong linear relationship. With p-values of 0.00, the Pearson Chi-Square, Likelihood Ratio, and Linear-by-Linear Association tests all provide statistically significant findings, demonstrating the importance of this experiment in illustrating how related variables may affect the concept of organizational readiness when one variable rises or falls.

This suggests that the connections between the factors pertaining to organizational preparation are not due to chance. These findings imply that the data is well-organized and that the variables utilized in the study adequately represent the multifaceted aspect of organizational preparedness. The validity of the measured structures is supported by the importance of all tests, which in turn increases the reliability of any conclusions made from this data regarding the degree of organizational preparedness.

Null Hypothesis: There is no statistical difference between the impact of the competitive landscape and the implementation of Logistics 4.0 in the Indian context.

Table 4: Chi-square analysis 2 - Impact of the competitive landscape on the implementation of Logistics 4.0

Competitive Landscape	Value	df	p value
Pearson Chi-Square	284.151	16	0.00
Likelihood Ratio	194.903	16	0.00
Linear-by-Linear Association	102.92	1	0.00

Various tests that explore the "Competitive Landscape" concept yield noteworthy statistical results, which point to a strong and significant connection between the variables being studied. The Pearson Chi-Square test, which has a value of 284.151 and 16 degrees of freedom (df), yields a p-value of 0.00. The small p-value suggests that the observed correlations between the components related to the competitive environment are quite improbable to be the result of chance. The variables show statistically significant correlations, which suggests that the observed competing elements are likely linked in a meaningful manner. This could cover the complexity and interdependence of several aspects of the sector or industry being studied. In a similar vein, the Pearson Chi-Square test's results are supported by the Likelihood Ratio test, which has a value of 193.903 and 16 degrees of freedom. With a p-value of 0.00, the possibility of these connections being attributable to chance is quite low. The close resemblance between the Pearson Chi-Square and Likelihood Ratio tests increases the trustworthiness of the findings, indicating that the model employed to evaluate the competitive environment is capable of reflecting the complex dynamics of competition inside the study's framework. The idea that the variables reflect separate but related elements of the competitive environment, thereby offering a full picture of the competitive landscape, is further supported by the valid Likelihood Ratio test.

The Linear-by-Linear Association test, which has a score of 102.92 and a p-value of 0.00, offers compelling support for a linear correlation between the variables. This test is especially helpful for examining the link between two ordinal variables because it reveals a distinct and linear trend in the data. The correlation between competitive variables is highlighted by the low p-value, which shows that changes in one variable related to the competitive environment are related to changes in another. This linear relationship reinforces the idea that the competitive landscape is shaped by several elements that are likely to shift simultaneously, thus reaffirming the overall construct validity. The "Competitive Landscape" construct shows noteworthy outcomes in the Pearson Chi-Square, Likelihood Ratio, and Linear-by-Linear Association tests, with all p-values being 0.00. The findings show significant and statistically significant correlations between the variables, indicating that the data accurately captures the competitive dynamics. These tests' reliability and validity are encouraged by their consistent and relevant character, which supports the notion that the competitive environment is a well-defined idea with clear links between its several components.

Null hypothesis : There is no statistical difference between the nature of regulatory frameworks and the implementation of Logistics 4.0 in the Indian scenario

Table 5: Chi-square analysis 3 - Impact of the nature of regulatory frameworks on the implementation of Logistics 4.0

Regulatory Frameworks	Value	df	p-value
Pearson Chi-Square	286.416	16	0.00
Likelihood Ratio	181.855	16	0.00
Linear-by-Linear Association	94.97	1	0.00

The statistical examination of the "Regulatory Frameworks" construct yielded consistent and statistically significant results, indicating strong relationships among the variables being investigated across several tests. The Pearson Chi-Square test yields a value of 286.416 with a p-value of 0.00 when there are 16 degrees of freedom (df). The extremely low p-value suggests that the connections between the variables related to regulatory frameworks are highly unlikely to occur by chance. In practical terms, this means that the variables measuring regulatory elements are statistically significant. The variables in this study capture different but interconnected features of the regulatory landscape. The findings highlight the importance of regulatory frameworks in shaping the business environment. The Likelihood Ratio test produces a p-value of 0.00, a test statistic value of 181.855, and has the same 16 degrees of freedom as the Pearson Chi-Square test. The concurrence of these two tests suggests that the model utilized to assess regulatory systems is robust and effective in capturing the complex dynamics of legislation. The significant p-value provides strong evidence that the variables used accurately represent the underlying regulatory environment. This indicates that the likelihood of these interactions occurring by chance is relatively low. The consistency observed in these tests increases confidence in the findings, suggesting that the regulatory structure is a clearly defined framework with important connections between its components.

With a value of 102.92 and a p-value of 0.00, the Linear-by-Linear Association test offers significant proof that the variables have a linear connection. Because it demonstrates a clear and linear pattern within the data, this test is especially useful for evaluating the link between two ordinal variables. Because it shows that a change in one variable connected to the competitive environment is related to a change in another, the large p-value reflects the relationship between competitive variables. This linear link, which reiterates the overall validity of the model, supports the idea that the competitive landscape is shaped by a number of factors that are likely to fluctuate in unison. The "Competitive Landscape" construct produces noteworthy outcomes in the Pearson Chi-Square, Likelihood Ratio, and Linear-by-Linear Association tests, with all p-values equal to 0.00. The results show strong and statistically significant links between the variables, implying that the data adequately represents the competitive environment. The fact that these tests are consistently relevant gives cause for optimism about the study's validity and reliability, which supports the conclusion that the competitive environment is a well-defined idea with significant links between its components.

Factor analysis

Table 6: KMO test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.934
Bartlett's Test of Sphericity	Approx. Chi-Square	1817.13
	df	36
	p value	0.00

Valuable information about the appropriateness of the data for factor analysis is provided by Bartlett's Test of Sphericity and the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy, which evaluates the proportion of shared variation between the variables in a data set to determine its appropriateness for factor analysis, produces a value of 0.934. A KMO score closer to 1.0 suggests that the data is well-suited for factor analysis if the variables are likely to have common factors. It is clear from the KMO score of 0.934 in this instance that there is a strong correlation between the variables. Consequently, component analysis would be a suitable and practical way to lower the data's dimensionality and find its underlying structure.

The correlation matrix of the variables is tested to see if it is an identity matrix using Bartlett's Test of Sphericity. The Chi-Square value is 1817.13, and the p-value is around 0.00 with 36 degrees of freedom (df). Bartlett's Test is used to test the null hypothesis that the correlation matrix is an identity matrix, meaning that the variables are not intercorrelated. A p-value below 0.05 indicates statistical significance, which supports the use of factor analysis and confirms that the variables are actually related. The null hypothesis is firmly rejected by the very low p-value of 0.00, demonstrating that

the correlation matrix is not an identity matrix. This suggests strong relationships between the variables, which supports the importance of component analysis.

Table 7: Communalities and Total Variance Explained

Communalities	Initial	Extraction
Organisational Preparedness 1	1	0.931
Organisational Preparedness 2	1	0.911
Organisational Preparedness 3	1	0.88
Competitive Landscape 1	1	0.933
Competitive Landscape 2	1	0.913
Competitive Landscape 3	1	0.939
Regulatory Frameworks 1	1	0.897
Regulatory Frameworks 2	1	0.984
Regulatory Frameworks 3	1	0.928
Extraction Method: Principal Component Analysis.		

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.608	84.54	84.54	7.61	84.54	84.54	3.75	41.66	41.66
2	0.439	4.87	89.41	0.44	4.87	89.41	2.54	28.18	69.84
3	0.269	2.99	92.40	0.27	2.99	92.40	2.03	22.57	92.40
4	0.185	2.06	94.46						
5	0.165	1.83	96.29						
6	0.11	1.22	97.51						
7	0.092	1.03	98.54						
8	0.075	0.83	99.36						
9	0.057	0.64	100.00						
Extraction Method: Principal Component Analysis.									

The data's dimensionality is reduced in this study using Principal Component Analysis (PCA). "Organisational Preparedness," "Competitive Landscape," and "Regulatory Frameworks" are the three variables under investigation. By identifying key underlying components or factors, the study successfully condenses the variation in the observed variables. The communalities table shows the proportion of variability for each variable that can be explained by the generated components. Initially, each variable has a communality of one, which means that all variation is considered. The communalities demonstrate how much variance each variable identified by PCA explains after extraction.

The extraction communalities of 0.931, 0.911, and 0.88 suggest that the organizational preparation variables account for a large proportion of the variation in these variables. According to the study, the variance in these variables may be explained by the underlying components by 93.1%, 91.1%, and 88%, respectively. The high degree of explained variance indicates that the retrieved factors effectively reflect the variables connected to organizational preparation, consistently providing informative signals of them. The Competitive Landscape variables have substantially greater communalities, with values of 0.933, 0.913, and 0.939. These figures show that the computed components account for 93.3%, 91.3%, and 93.9% of the variation in these variables. The close link between these values demonstrates that the identified elements are an accurate representation of the competitive landscape, suggesting that the variables are highly consistent and probably reflect the same underlying aspect of competition inside the study framework. The variables representing regulatory frameworks display communalities of 0.897, 0.984, and 0.928. The second variable, Regulatory Frameworks 2, accounts for between 89.7% and 98.4% of the variance and is accurately represented by the extracted components. It may be concluded from the strong correlation between the second variable and the underlying structures that the regulatory frameworks are also significantly impacted by the elements produced by the PCA.

The Principal Component Analysis (PCA) findings indicate that the complicated variables pertaining to regulatory frameworks, competitive environment, and organizational readiness may be adequately represented by three primary components. These components provide a reliable and meaningful representation of the underlying constructs, as evidenced by the significant similarities and differences they account for, suggesting that the variables are appropriate for factor analysis. The use of component rotation makes the analysis more understandable and allows for a more fair interpretation of the many factors at play. The data has been successfully simplified overall using the Principal Component Analysis (PCA), which has also revealed important factors that reflect the key elements of regulatory effects, competitive dynamics, and organizational preparedness.

International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 05 Issue: 01 | Jan – 2026 DOI: 10.55041/ISJEM05433
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

SEM model

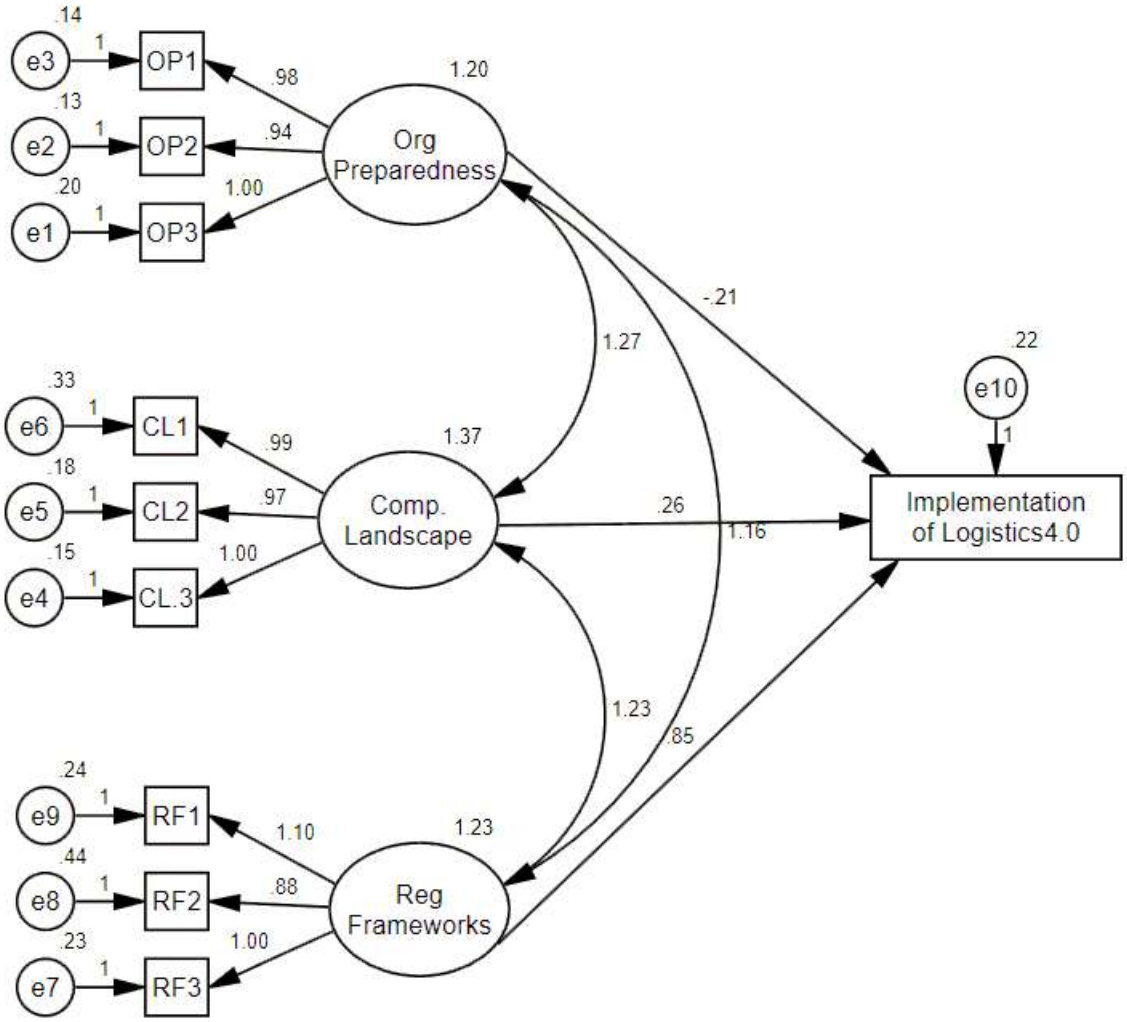

Figure 1: Confirmatory Factor Analysis

The Confirmatory Factor Analysis (CFA) model demonstrates the influence of three key latent constructs—Organizational Preparedness, Competitive Landscape, and Regulatory Frameworks—on the Implementation of Logistics 4.0. Each construct in the model is defined by three observed variables, which aim to represent how the underlying factors contribute to the effective implementation of advanced logistics systems within an organization. The first latent component, organizational preparation, is represented by three observable variables: OP1, OP2, and OP3. The standardized factor loadings for these indicators vary from 0.94 to 1.00, indicating that these variables are highly reliable and precise measures of the organizational preparedness construct. These observed indicators accurately indicate the level of readiness and capability of a company, reflecting its degree of preparation. The minimal error variances associated with these indicators further indicate that the model accurately represents the data for this construct, hence reinforcing the conclusion that organizational preparedness is a crucial element in the implementation of Logistics 4.0.

The direct impacts of these fundamental ideas on the implementation of Logistics 4.0 are also examined by the CFA model. A route coefficient of 1.20 indicates that organizational preparation has a significant and positive impact on the implementation process. This implies that companies are more likely to successfully adopt and incorporate Logistics 4.0 into their everyday operations if they are ready. The Competitive Landscape's path coefficient of 1.16 indicates that it has a significant positive impact. This illustrates how crucial a competitive environment is in encouraging businesses to develop and apply cutting-edge logistics solutions. Regulatory frameworks with a path coefficient of 0.85 also improve implementation, albeit not as much as other structures. Three observable variables, namely RF1, RF2, and RF3, are used to represent the third construct, Regulatory Frameworks. In general, these variables have significant factor loads; RF1 and RF3 show strong correlations with the underlying construct. RF2 plays a crucial role in the regulatory systems,

although having a slightly lower factor loading. Companies' implementation of Logistics 4.0 is heavily influenced by the regulatory environment, which includes regulations, policies, and laws. The small error terms associated with these indicators suggest that while the fit is adequate, there may be some variability in the interpretation or implementation of different components of regulatory systems.

The direct impacts of these fundamental ideas on the implementation of Logistics 4.0 are also investigated by the CFA model. A route coefficient of 1.20 suggests that organizational preparation significantly and favorably affects the implementation process. This implies that companies are more likely to successfully adopt and integrate Logistics 4.0 into their everyday operations if they are ready. With a path coefficient of 1.16, the Competitive Landscape shows a notable positive influence. This highlights how crucial a competitive environment is for encouraging businesses to develop and use cutting-edge logistics solutions. Regulatory frameworks with a path coefficient of 0.85 also have a favorable effect on implementation, albeit not as much as other structures. The CFA model also looks into the direct effects of these core concepts on the application of Logistics 4.0. The implementation process is significantly and favorably impacted by organizational preparation, according to a route coefficient of 1.20. This suggests that if businesses are prepared, they have a higher chance of successfully implementing and integrating Logistics 4.0 into their daily operations. The Competitive Landscape has a significant positive impact, as indicated by its path coefficient of 1.16. This demonstrates the importance of a competitive environment in motivating companies to create and implement innovative logistics solutions. Although not as much as other structures, regulatory frameworks with a path coefficient of 0.85 also have a positive impact on implementation.

Discussion

In the context of implementing Logistics 4.0 in India, the degree of organizational readiness is a critical factor in determining the adoption and integration of advanced logistics technologies. Logistics 4.0 is more likely to be adopted by Indian organizations that are highly prepared, as evidenced by their readiness, adaptability, and alignment with strategic objectives. This readiness includes having the required infrastructure, knowledgeable staff, and a clear vision that complements the objectives of digital transformation. Businesses are more likely to successfully negotiate the complexities of Logistics 4.0 implementation if they devote resources to these areas.

India's adoption of Logistics 4.0 is significantly impacted by the competitive environment. Businesses must innovate and use cutting-edge technologies to maintain a competitive edge in an increasingly competitive market. Businesses are being compelled to adopt Logistics 4.0 solutions as a result of competition and the need to meet customer demands. Greater flexibility, effectiveness, and transparency are offered by these solutions. Since the level of competition acts as both an incentive and an accelerator for the adoption of technology, it is crucial in determining the logistics transformation in this instance.

Conclusion

In India, implementing Logistics 4.0 is a complex process that is influenced by a number of important factors, including the company's readiness, the competitive environment, and the legal framework. Businesses must improve their technological readiness and flexibility in order to take full advantage of innovative logistical solutions. Sustaining a leading position in the competitive environment requires constant innovation and strategy alignment. Furthermore, in order to create an atmosphere that is favorable to the adoption of Logistics 4.0, a strong and encouraging legal framework is necessary. Logistics 4.0 may be successfully implemented in India by thoroughly addressing these elements, which would improve the logistics industry's productivity, competitiveness, and expansion.

The future course of Logistics 4.0 in India is anticipated to be influenced by a number of developing phenomena. Logistics operations will continue to be impacted by the swift pace of technological advancements like blockchain, IoT, and artificial intelligence, which will require constant organizational adaptation. The development of implementation strategies may be impacted by the growing emphasis on sustainability and environmentally friendly logistics, which may inspire creative ideas and legal requirements. Furthermore, the adoption of more adaptable and responsive regulatory frameworks is crucial to the logistics industry's capacity to meet its changing needs. As these variables change, businesses that actively welcome these shifts and devote resources to ongoing improvement will be better positioned to prosper in the future's changing logistics environment.

© 2026, ISJEM (All Rights Reserved)

References:

1. Ali, S.S.; Poksoy, T.; Torul, B.; Kaur, R. Reverse logistics optimization of an industrial air conditioner manufacturing company for designing sustainable supply chain: A fuzzy hybrid multi-criteria decision-making approach. Wirel. Netw. 2020, 26, 5759-5782
2. Bag, S.; Gupta, S.; Luo, Z. Examining the role of logistics 4.0 enabled dynamic capabilities on firm performance. Int. J. Logist. Manag. 2020, 31, 607-628.
3. Choudhury, A.; Behl, A.; Sheorey, P.A.; Pal, A. Digital supply chain to unlock new agility: A TISM approach. Benchmarking Int. J. 2021
4. Culot, G.; Nassimbeni, G.; Orzes, G.; Sartor, M. Behind the definition of Industry 4.0: Analysis and open questions. Int. J. Prod. Econ. 2020, 226, 107617
5. Jagtap, S.; Bader, F.; Garcia-Garcia, G.; Trollman, H.; Fadiji, T.; Salonitis, K. Food Logistics 4.0: Opportunities and Challenges. Logistics 2020, 5, 2
6. Javaid, M.; Haleem, A.; Singh, R.P.; Rab, S.; Suman, R.; Khan, S. Exploring relationships between Lean 4.0 and manufacturing industry. Ind. Robot. Int. J. Robot. Res. Appl. 2021.
7. Joshi, S.; Sharma, M. Digital technologies (DT) adoption in agri-food supply chains amidst COVID-19: An approach towards food security concerns in developing countries. J. Glob. Oper. Strat. Sourc. 2021.
8. Khan, S.; Haleem, A.; Khan, M.I.; Abidi, M.H.; Al-Ahmari, A. Implementing Traceability Systems in Specific Supply Chain Management (SCM) through Critical Success Factors (CSFs). Sustainability 2018, 10, 204
9. Kumar, A.; Choudhary, S.; Garza-Reyes, J.A.; Kumar, V.; Khan, S.A.R.; Mishra, N. Analysis of critical success factors for implementing Industry 4.0 integrated circular supply chain-moving towards sustainable operations. Prod. Plan. Control 2021, 1-15
10. Markov, K.; Vitliemov, P. Logistics 4.0 and supply chain 4.0 in the automotive industry. IOP Conf. Ser. Mater. Sci. Eng. 2020, 878, 012047.
11. Rahman, M.; Kamal, M.M.; Aydin, E.; Haque, A.U. Impact of Industry 4.0 drivers on the performance of the service sector: Comparative study of cargo logistic firms in developed and developing regions. Prod. Plan. Control 2020, 33, 1-16.
12. Rejeb, A.; Keogh, J.G.; Zailani, S.; Treiblmaier, H.; Rejeb, K. Blockchain Technology in the Food Industry: A Review of Potentials, Challenges and Future Research Directions. Logistics 2020, 4, 27.
13. Rosin, F.; Forget, P.; Lamouri, S.; Pellerin, R. Impacts of Industry 4.0 technologies on Lean principles. Int. J. Prod. Res. 2019, 58, 1644-1661
14. Sony, M.; Antony, J.; Mc Dermott, O.; Garza-Reyes, J.A. An empirical examination of benefits, challenges, and critical success factors of industry 4.0 in manufacturing and service sector. Technol. Soc. 2021, 67, 101754
15. Sufiyan, M.; Haleem, A.; Khan, S.; Khan, M.I. Evaluating food supply chain performance using hybrid fuzzy MCDM technique. Sustain. Prod. Consum. 2019, 20, 40-57