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Neutrosophic Assessment of Legal Certainty in the Digital Transformation of Logistics in Callao: A Comparative Study Based on SVNN and the Neutrosophic Analytic Hierarchy Process (AHP).

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Abstract. The digitalization of the logistics sector in Callao challenges the notion of legal certainty. The implementation of new technologies such as electronic signatures and smart contracts generates uncertainty, exposing individuals and legal entities to greater risks if adequate legal protection is not in place. Although prior research on regulatory compliance exists, little has been done to certify legality over time and in the present. To address legal ambiguity and contradictions, this study proposes a neutrosophic approach. A model is constructed by applying the logic of Single Valued Neutrosophic Numbers (SVNN) and weighting through the Neutrosophic Analytic Hierarchy Process (AHP). By investigating two groups of logistics companies—one highly digitized and one with low digitalization—and focusing on the triads of truth (T), indeterminacy (I), and falsity (F), the comparison of information leads to the results. It is determined that greater technological maturity is associated with a higher perception of legal certainty, although ambiguity persists in areas such as criminal liability and uncertain legislation. This research enhances the concept of legal certainty in virtual environments with a theoretical contribution—a methodology to assess a hybrid complex—and a practical contribution—recommendations for companies and regulators seeking assurance of compliance and effective regulation, respectively, in the digital area of Callao.

Keywords: Legal Certainty, Digital Transformation, Callao Logistics, Neutrosophic Logic, SVNN, AHP, Regulatory Compliance, Legal Uncertainty.

1. Introduction

The digital transformation of the logistics sector in Callao, Peru's main port hub, has revolutionized operations through the integration of advanced technologies such as electronic signatures, smart contracts, blockchain, and traceability platforms, optimizing efficiency and competitiveness in global trade. This phenomenon, crucial for the Peruvian economy, where Callao manages more than 70% of national maritime trade, poses significant challenges in terms of legal certainty, an essential pillar for building trust among economic actors and ensuring regulatory compliance in digital environments [1].

The relevance of this issue lies not only in its economic impact, but also in the need to align technological innovations with solid regulatory frameworks capable of mitigating legal and ethical risks that affect the adoption of these tools in port contexts [2]. The absence of clear regulations can generate mistrust, limiting the potential of digitalization to transform logistics in a strategic sector such as Callao.

Over the past few decades, the Port of Callao has transitioned from predominantly manual logistics processes to semi-automated systems, a shift driven by port reforms initiated in the 2000s [3]. The introduction of disruptive technologies, such as artificial intelligence for data management and blockchain for ensuring the traceability of goods, has marked a new era in port logistics [4]. However, this rapid technological advancement has outpaced the capacity of local regulations to adapt, generating ambiguities in the application of laws and legal responsibilities [5]. For example, the use of smart contracts raises questions about their legal validity and the allocation of responsibilities in the event of disputes, while digital platforms face challenges related to data protection and privacy [6]. These tensions reflect a gap between technological innovation and regulatory frameworks, which affects the perception of legal certainty among logistics companies.

The central problem addressed by this study is the legal uncertainty arising from the implementation of digital technologies in logistics in Callao. How do logistics companies perceive legal certainty when adopting digital tools, considering the regulatory ambiguities, legal contradictions, and associated ethical tensions? This research question arises from the need to understand not only the technical aspects of regulatory compliance but also the subjective perceptions of legality and risk, which directly influence companies' trust in digital systems. The lack of a comprehensive approach that addresses these complex dimensions represents a significant gap in the current literature, especially in port contexts in emerging economies such as Peru.

The main objective of this research is to evaluate legal certainty in logistics companies in Callao using a neutrosophic model based on single valued neutrosophic number (SVNN)[7] and expert-based weighting using the Neutrosophic Analytic Hierarchy Process (AHP) [8], comparing companies with advanced and initial levels of digitalization. Secondarily, the study seeks to identify the main sources of legal uncertainty, such as contractual clarity, data protection, and trust in regulatory frameworks, in order to propose strategies to strengthen regulatory environments in the logistics sector. These objectives are designed to answer the research question, offering both a theoretical contribution, by advancing the application of neutrosophic approaches to legal problems, and a practical one, by providing applicable recommendations for regulators and companies in the context of digital transformation.

2. Preliminaries

2.1. Legal Security in Digital Transformation.

Digital transformation has reshaped the landscape of global logistics operations, introducing tools such as electronic signatures, smart contracts, and traceability platforms that optimize efficiency, but also generate significant challenges in terms of legal certainty [9]. In contexts such as the Port of Callao, Peru's main logistics hub, the adoption of these technologies is crucial to maintaining competitiveness in international trade. However, the implementation of digital solutions raises questions about regulatory compliance, data protection, and contractual clarity, essential aspects to ensure the trust of companies and regulators. Legal certainty, understood as the certainty in the application of legal norms in digital environments, emerges as a fundamental pillar to mitigate risks and foster innovation in this sector.

Historically, logistics systems have evolved from manual processes to highly technological environments, especially in key ports like Callao, where reforms in the 2000s marked the beginning of modernization [10]. The introduction of technologies such as blockchain has enabled unprecedented traceability, while artificial intelligence optimizes real-time data management [11]. However, these advances have outpaced the capacity of regulatory frameworks to adapt, generating legal ambiguities that affect the perception of security among logistics actors. The lack of clarity regarding the validity of electronic contracts or criminal liability in digital disputes is a clear example of these tensions.

The challenge of legal certainty in digital transformation lies in the difficulty of aligning rapid technological evolution with regulations that, in many cases, are obsolete or insufficient. How can logistics companies ensure regulatory compliance in an environment where laws have not kept pace with technology? This question highlights the need to address not only technical aspects but also perceptions of legality, which directly influence trust in digital platforms. Legal uncertainty can discourage companies from adopting innovative technologies, limiting the transformative potential of digitalization [12].

A promising approach to addressing this problem is the application of neutrosophic models, such as single valued neutrosophic neutrosophic numbers (SVNN)[13] and Neutrosophic Analytic Hierarchy Process(NAHP) [14] . These methods allow for modeling the uncertainty and contradictions inherent in the perception of legal certainty, capturing dimensions such as truth, indeterminacy, and falsity. By comparing companies with different levels of digitalization, this approach reveals how technological maturity impacts trust in regulatory frameworks. For example, highly digitalized companies tend to perceive lower legal risk, although ethical dilemmas related to liability in digital environments persist.

Assessing legal certainty in the digital transformation of Callao's logistics sector requires understanding both technical factors and the subjective perceptions of stakeholders, particularly regarding challenges like data protection and the validity of electronic contracts. While clear regulatory frameworks can drive innovation and enhance port competitiveness, implementation is hindered by institutional fragmentation and resistance to change. In this context, neutrosophic models provide a comprehensive approach by integrating regulatory compliance with perceived risks, enabling practical recommendations such as guidelines for electronic contracts and cybersecurity standards. Strengthening legal certainty demands joint efforts from the public and private sectors, positioning the Port of Callao as a benchmark in digital logistics supported by clear and adaptive regulatory environments.

2.2. Neutrosophic Logic

Neutrosophic Logic is a formal extension of fuzzy logic that enables reasoning with incomplete, inconsistent, and ambiguous information, making it suitable for contexts where uncertainty, contradiction, and partial knowledge are present. It was introduced by Smarandache to overcome the binary and even fuzzy limitations by incorporating a three-component system: truth (T), indeterminacy (I), and falsity (F) [15,16].

Each situation, statement, or evaluation is expressed as a neutrosophic triplet [17,18]:

$$P = (T, I, F) \tag{1}$$

Where:

$T \in [0^-, 1^+]$: Degree of truth (certainty in legal interpretation)

$I \in [0^-, 1^+]$: Degree of indeterminacy (regulatory ambiguity)

$F \in [0^-, 1^+]$: Degree of falsity (perceived contradiction or legal risk)

Unlike classical logic systems, Neutrosophic Logic allows these values to be evaluated independently and without the constraint of summing to one[19]:

$$\mathbf{0}^- \leq \boldsymbol{T} + \boldsymbol{I} + \boldsymbol{F} \leq \mathbf{3}^+ \quad \textbf{(2)}$$

This feature allows for the modeling of complex phenomena with overlapping, contradictory, or insufficient information, such as those commonly found in emerging regulatory frameworks or evolving legal interpretations.

In this research, Neutrosophic Logic is applied to evaluate the perceptions and conditions related to legal certainty in the digital transformation of logistics companies in Callao, considering that these aspects present inherent degrees of uncertainty. Business perceptions, regulatory frameworks, and legal dilemmas are translated into neutrosophic values, allowing for inferences that integrate different levels of legal and technological certainty.

The use of Neutrosophic Logic facilitates the integration of fragmented information on emerging regulatory frameworks, offering more reliable and representative inferences of legal reality in digitalized contexts. Furthermore, it encourages a flexible analysis that reflects regulatory complexity and the multiplicity of business perspectives, consolidating more responsible and contextualized decisions and improvement proposals for the port logistics sector [20].

While standard Neutrosophic Logic allows for the complete independence of Truth (T), Indeterminacy (I), and Falsity (F), this study adopts a pragmatic simplification for its application in the legal domain. It is posited that in the context of legal certainty, the perception of actors is primarily polarized between what is "legally certain" (Truth) and what is "clearly risky or illegal" (Falsity). Under this assumption, any aspect not falling into these two categories is naturally perceived as "ambiguous or uncertain" (Indeterminacy). Therefore, this research defines indeterminacy using the formula I = 1 - T - F. This constraint aligns the model with the structure of Intuitionistic Fuzzy Sets [21], allowing it to adequately capture the psychological and operational reality of the participants in this specific field while simplifying the data collection and analysis process.

3. Materials and Methods

Research Context and Participants

The study was conducted among logistics companies operating in the Port of Callao during an eight-week evaluation period in 2024. The research aimed to empirically assess perceptions of legal certainty, opportunities, and legal dilemmas surrounding digital transformation using a neutrosophic evaluation model.

Forty-four logistics companies from Callao participated, divided into two groups according to their level of digital maturity:

- **Control group**: 20 companies with low digitalization (operating with traditional methodologies)
- **Experimental group**: 24 highly digitalized companies (using advanced digital tools)

The companies were selected based on criteria such as uniformity in operational size, years of operation in the port, and types of logistics services offered.

Evaluation Procedure

The evaluation process was structured in three phases over the eight weeks:

Phase 1 (Weeks 1-2): Initial diagnosis

- Assessment of knowledge on digital regulatory frameworks
- Analysis of documentation systems and contracts used
- Identification of perceptions on data protection

Phase 2 (Weeks 3-6): Operational Monitoring

- Monitoring of legal risk management processes
- Documentation of conflict resolution procedures
- Analysis of trust levels in digital vs. traditional systems

Phase 3 (Weeks 7-8): Final Evaluation

- Measuring perceptions of global legal security
- Comparative analysis between groups
- Application of the complete neutrosophic model

Neutrosophic Model of Legal Security Assessment

Input Variables

Single Valued Neutrosophics (SVNN), with their corresponding triplets (T , I, F), where:

- $\boldsymbol{T} \in [\mathbf{0}, \mathbf{1}]$:Degree of perceived legal truth or certainty
- $\boldsymbol{I} \in [\mathbf{0}, \mathbf{1}]$:Degree of uncertainty or regulatory ambiguity
- $\boldsymbol{F} \in [\mathbf{0}, \mathbf{1}]$:Degree of perceived legal falsity or distrust

The sum is not limited to $T + I + F = 1$,what allows for more realistic management of legal uncertainty in contexts of digital transformation.

Formal Definition of Variables

Knowledge of digital regulatory frameworks:$Kp = (T_k, I_k, F_k)$

Where:

$$T_k = \frac{N(correct\ regulatory\ concepts)}{N(evaluated\ concepts)} \quad (3)$$

$$I_k = 1 - |T_k - F_k| \quad (2)$$

$$F_k = \frac{N(normative\ interpretative\ errors)}{N(evaluated\ concepts)} \quad (4)$$

Trust in digital documentation systems: $Pd = (Tp, Ip, Fp)$

Where:

$$T_p = \frac{N(reliable\ digital\ processes)}{N(total\ documentary\ processes)} \quad (5)$$

$$I_p = 1 - |T_p - F_p| \quad (6)$$

$$Fp = \frac{N(questioned\ processes)}{N(total\ documentary\ processes)}$$

Data protection perception :$Da = (T_d, I_d, F_d)$

Where:

$$T_d = \frac{Score(data\ security)}{Score(maximum\ possible)} \quad (7)$$

$$I_d = 1 - |T_d - F_d| \quad (8)$$

$$F_d = \frac{N(reported\ security\ incidents)}{N(evaluated\ operations)} \quad (9)$$

Quality of legal risk management: $Rc = (Tr, Ir, Fr)$

Where:

$$Tr = \frac{(Identification\ score + Mitigation\ score + Resolution\ score)}{Maximum\ score} \quad (10)$$

$$Ir = 1 - |Tr - Fr| \quad (11)$$

$$Fr = \frac{N(unmanaged\ risks + procedural\ errors)}{N(total\ evaluated\ situations)} \quad (12)$$

Global Composition: Effectiveness of Legal Security

$$E_l = w_1 \cdot K_p + w_2 \cdot P_d + w_3 \cdot D_a + w_4 \cdot R_c \quad (13)$$

The neutrosophic evaluation E = (Te, Ie , Fe) is calculated as:

$$T_e = \sum_{i=1}^{n} w_i \cdot T_i$$
$$I_e = \sum_{i=1}^{n} w_i \cdot I_i \quad (14)$$
$$F_e = \sum_{i=1}^{n} w_i \cdot F_i$$

Weights established by Neutrosophic AHP:

$w(Kp) =$ 0.25(Regulatory knowledge)

$w(Pd) =$ 0.20(Contractual trust)

$w(Da) =$ 0.25(Data protection)

$w(Rc) =$ 0.30(Legal risk management)

The weights were established through expert analysis in digital law and port logistics using the Neutrosophic Analytic Hierarchy Process (Neutrosophic AHP) technique. A pairwise comparison matrix $M = [aij]$was constructed, where aij represents the relative preference of variable i over variable j.

Normalization was carried out by:

$$w_i = \frac{\sum_{j=1}^{n} \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}}}{n} \quad (15)$$

Consistency was checked by: $CR = \frac{CI}{RI}$, $I = \frac{\lambda_{max} - n}{n-1}$, where $CR < 0.1$indicates acceptable consistency.

Interpretation of Results

The neutrosophic model assesses the effectiveness of legal certainty in logistics digital transformation processes. The final score $El = (Te, Ie, Fe)$represents each company's neutrosophic perception of legal certainty:

You close to 1: High degree of trust and legal certainty in digital processes

High Ie: Significant degree of regulatory ambiguity or uncertainty that requires regulatory clarification

High faith: Signs of mistrust or perceived legal limitations in the digital transformation

Complementary Statistical Analysis

To validate the neutrosophic results, traditional statistical tests were applied:

Analysis of variance (ANOVA) to compare means between groups

Post-hoc tests to identify specific differences

Correlation analysis between neutrosophic variables

Calculation of effect sizes (η^2) to assess practical significance

Statistical significance criteria were established in $p \leq 0.05$, complementing the neutrosophic interpretation with conventional statistical validation.

4. Results

With the aim of empirically analyzing the perceptions of legal certainty, opportunities, and legal dilemmas surrounding digital transformation in logistics companies in Callao, an intervention was designed based on a neutrosophic evaluation model that employs Single- Valued Neutrosophic Numbers (SVNN) logic and AHP (Analytic Hierarchy Processing) weighting. This intervention was applied over an eight-week evaluation period to logistics companies with different levels of digital maturity operating in the port of Callao. The experience sought to evaluate the effects of digitalization on the perception of legal certainty through a comparative approach with two different groups: companies with high digitalization (experimental) and companies with low digitalization (control).

Research intervention

The intervention consisted of comparing the impact of different levels of digital transformation on logistics companies' perceptions of legal certainty. The control group (companies with low digitalization) operated using traditional documentation methodologies, physical contracts, manual process verification, and conventional traceability systems without advanced technological integration. The experimental group (companies with high digitalization), on the other hand, used various digital tools such as electronic signatures, smart contracts, blockchain traceability platforms, digital document management systems, and legal risk analysis algorithms, which they actively employed to structure and manage their logistics operations. These tools facilitated the automation of legal processes, regulatory compliance analysis, and the generation of risk reports, improving the perception of legal certainty and transparency.

The variables analyzed to evaluate the effects of digital transformation on legal security included:

Level of knowledge about digital regulatory frameworks and regulatory compliance

Level of trust in digital documentation and contract systems

Perception of data protection and privacy in logistics processes

Quality of legal risk management and conflict resolution procedures

Table 1. Variables considered

Variable	Description	Symbol	Guy
Regulatory knowledge	Assessment of knowledge on digital legal frameworks	Kp	input
Contractual trust	Level of confidence in digital documentation systems	P.S	input
Data protection	Perception of security in the handling of sensitive information	Give	input
Legal risk management	Quality of procedures to identify and mitigate legal risks	Rc	input
Effectiveness of Legal Security	Global assessment of legal security in digital operations	El	expected result

Each input variable is represented as a neutrosophic triplet. $xi = (Ti, Ii, Fi)$. Taking one of the companies in the case study as an example, for the variable Regulatory Knowledge Kp , it would be:

$$Kp = (0.8,0.1,0.1)$$

Where:

Ti: degree of truth (high level of regulatory knowledge)

II: degree of indeterminacy (uncertainty in the normative application)

Fi: degree of falsehood (absence of knowledge or negative perception)

The weights assigned to each variable (according to expert analysis using Neutrosophic AHP) would be as follows:

$$\boldsymbol{w(Kp) = 0.25, w(Pd) = 0.20, w(Da) = 0.25, w(Rc) = 0.30}$$

Application of the Neutrosophic Model

The neutrosophic evaluation is calculated according to equation (13). Continuing with the same example, the neutrosophic triplet of a company in the experimental group is defined as follows:

Input data:

- Kp: $(0.8, 0.1, 0.1)$- Regulatory knowledge
- Pd: $(0.7, 0.2, 0.1)$- Contractual trust
- Da: $(0.6, 0.3, 0.1)$- Data protection
- Rc: $(0.75, 0.2, 0.05)$- Legal risk management

Calculation according to equation (14):

Neutrosophic Evaluation:

Truth Component (Te): $Te = (0.25)(0.8) + (0.20)(0.7) + (0.25)(0.6) + (0.30)(0.75)$

$$Te = 0.2000 + 0.1400 + 0.1500 + 0.2250 = \mathbf{0.7150}$$

Indeterminacy Component (I_e): $Ie = (0.25)(0.1) + (0.20)(0.2) + (0.25)(0.3) + (0.30)(0.2)$

$$Ie = 0.0250 + 0.0400 + 0.0750 + 0.0600 = \mathbf{0.2000}$$

Falsehood Component (F_e): F_e = (0.25)(0.1) + (0.20)(0.1) + (0.25)(0.1) + (0.30)(0.05) F_e = 0.0250 + 0.0200 + 0.0250 + 0.0150 = **0.0850**

Bottom line: $\boldsymbol{El = (0.7150, 0.2000, 0.0850)}$

Interpretation of the result:

For this specific case, the results are interpreted as follows:

There is a **71.50%** positive effectiveness (T) in the perception of legal security with high digitalization

There is **20.00%** ambiguity or uncertainty about digital legal frameworks

8.50% of potential negative effects are presented, which suggests a favorable implementation but with legal aspects to monitor.

General results of the case study

The results obtained from applying the neutrosophic model described above are presented below. The analysis was organized into two parts: first, a description of the results by group (experimental and control), and second, a comparison between the two groups in relation to the key study variables.

Results of the Experimental Group (High Digitalization)

Table 2. Average neutrosophic values for the experimental group (n=24 companies)

Variable	T (Truth)	I (Indeterminacy)	F (Falsehood)
Regulatory knowledge (Kp)	0.78	0.15	0.07
Contractual trust (Pd)	0.82	0.11	0.07
Data Protection (Da)	0.74	0.17	0.09

Legal risk management (RC)	0.80	0.13	0.07
Perceived legal security (The)	**0.79**	**0.14**	**0.07**

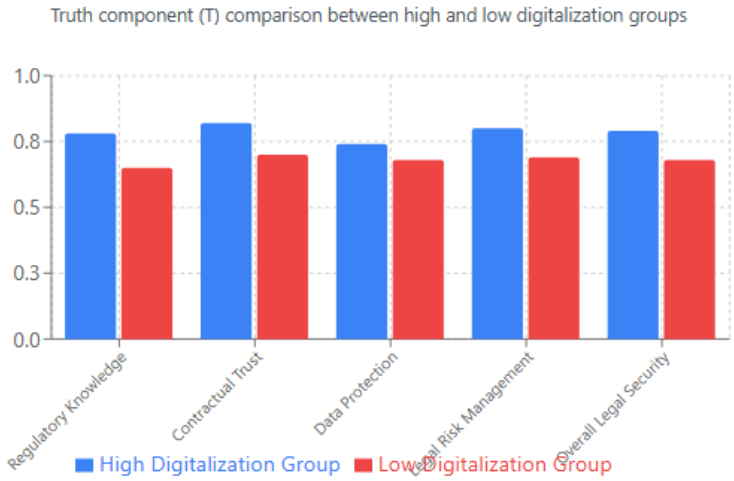

Figure 1: Comparative Analysis of Legal Security Variables.

These results indicate that companies in the experimental group showed a high positive perception of legal certainty (T = 0.79), moderate indeterminacy (I = 0.14) and low perceptions of risk or disagreement (F = 0.07) regarding the digital transformation in their logistics operations.

Control Group Results (Low Digitalization)

Table 3. Average neutrosophic values for the control group (n=20 companies)

Variable	**T (Truth)**	**I (Indeterminacy)**	**F (Falsehood)**
Regulatory knowledge (Kp)	0.65	0.23	0.12
Contractual trust (Pd)	0.70	0.20	0.10
Data Protection (Da)	0.68	0.22	0.10
Legal risk management (RC)	0.69	0.23	0.08
Perceived legal security (The)	**0.68**	**0.22**	**0.10**

Comparatively, the control group presented a lower level of positive perception (T = 0.68) and greater indeterminacy (I = 0.22), which suggests greater legal ambiguity and less confidence in traditional regulatory frameworks compared to the experimental group.

Comparative Analysis

Table 4. Comparison between the experimental and control groups

Cluster	You (Truth)	Ie (Indeterminacy)	Faith (Falsehood)
Experimental (High Digitalization)	0.79	0.14	0.07
Control (Low Digitalization)	0.68	0.22	0.10
Difference (Δ)	**+0.11**	**-0.08**	**-0.03**

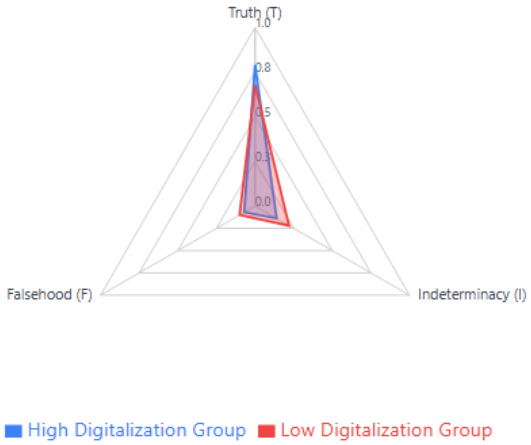

Figure 2: Neutrosophic Triplet (T, I, F) Radar Analysis.

The experimental group significantly outperformed the control group in terms of positive perceptions of legal certainty $(\Delta T = +0.11)$and showed lower regulatory ambiguity ($\Delta I = -0.08$), suggesting that advanced digital transformation had a favorable impact on the structuring of corporate legal trust. The difference in falsity $(\Delta F = -0.03)$also favored the experimental group.

Table 5. Statistical comparison of the study variables

Variable	Cluster	Average	Standard deviation	F	p	Comparison
Regulatory knowledge (Kp)	Control	0.65	0.18	4.25	0.045*	Exp > Control
	Experimental	0.78	0.15			
Contractual trust (Pd)	Control	0.70	0.16	5.18	0.028*	Exp > Control
	Experimental	0.82	0.12			
Data Protection (Da)	Control	0.68	0.19	2.89	0.096	
	Experimental	0.74	0.14			
Legal risk management (RC)	Control	0.69	0.17	6.12	0.017*	Exp > Control
	Experimental	0.80	0.13			

Variable	Cluster	Average	Standard deviation	F	p	Comparison
Perceived legal security (The)	Control	0.68	0.15	8.94	0.005*	**Exp > Control**
	Experimental	0.79	0.11			

*$p \leq 0.05$

The analysis of the results revealed that the group with the highest level of digitalization showed significant improvements in multiple dimensions of legal certainty. Trust in digital contractual frameworks was higher, reflecting a greater level of certainty in automated processes. Legal risk management, assessed through indicators of early conflict identification, dispute resolution procedures, and regulatory compliance, was clearly superior in the experimental group, demonstrating that technological assistance contributed to improving the quality of legal management and risk mitigation processes. Furthermore, companies stated that the use of digital technologies facilitated the documentation of complex processes and accelerated procedures that, under traditional methods, take more time and generate greater legal uncertainty.

These findings suggest that incorporating digital transformation tools into port logistics can have positive effects on the perception of legal certainty, the level of regulatory trust, and the efficiency of legal risk management. Technology does not replace critical legal analysis, but rather complements it, helping companies improve their compliance capabilities and overcome the limitations of conventional legal management methods.

The digital transformation of Callao's port logistics marks a profound shift not only in technology but also in legal, procedural, and ethical structures. Tools like smart contracts, blockchain, and automated documentation systems enhance transparency, compliance, and risk detection in complex, multi-actor operations. However, tensions remain around legal liability, data protection, and document validity. Neutrosophic analysis highlights these concerns while confirming that digitalization, when supported by updated regulations and legal training, improves perceptions of legal certainty—especially in contract trust, risk management, and regulatory adherence.

5. Conclusions

This research demonstrated that evaluating legal certainty in the digital transformation of Callao's logistics sector requires more than technological advancement—it demands a structured and context-sensitive analytical approach. By applying a neutrosophic model based on Single Valued Neutrosophic Numbers (SVNN) and expert-based weighting through the Neutrosophic Analytic Hierarchy Process (AHP), the study was able to identify and quantify perceptions of truth, uncertainty, and falsity regarding legal certainty in digital logistics environments.

The model proved effective in capturing the inherent ambiguity of regulatory interpretation, the legal risks posed by technology, and trust in automated systems. It successfully addressed contradictions between operational efficiency and legal responsibility, as well as between automation and human oversight. One of the most important findings was its capacity to represent the mixed perceptions logistics companies have about digitalization—highlighting both the benefits (such as traceability and efficiency) and the ongoing concerns (such as smart contract validity and liability in system failures).

Ultimately, the study concludes that the future of logistics must emphasize a deliberate and regulated integration of digital technologies aimed at enhancing legal certainty. This includes the

development of clear legal frameworks, risk management protocols, and legal support systems. The success of this transition depends not only on digital tools, but on institutional capacity, regulatory foresight, and ethically responsible innovation that fosters transparency and confidence in Callao's port logistics sector.

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