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Implementation of Legal Informatics through Industry 4.0: A Fuzzy TOPSIS Approach

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ABSTRACT
Over the past decade legal informatics has expanded due to technological advancements and growing digitalization of legal processes. In the context of Industry 4.0, legal informatics plays an increasingly relevant role as it refers to how information technology is applied to law, that is, processing legal information in such a way as to enable better decisions and achieve outcomes under laws and regulations applicable to the specific situation. Also, Industry 4.0 is referring to the fourth industrial revolution that represents a fundamental change in industrial production through necessary integration of advanced information and communication technologies into traditional manufacturing processes. This integration has led to the emergence of smart factories and interconnected systems that enable enhanced efficiency, productivity, and flexibility in manufacturing operations. The purpose of this study is to understand the concealed relationship between Industry 4.0 and legal informatics systems in the Indian context. Therefore, the present study identify and prioritize the various implementation factor in the integration of legal informatics systems through Industry 4.0 based technologies. The study utilized multi-criteria decision-making approach such as Fuzzy TOPSIS for the illustration of the proposed methodology. The results of the study show that ICT law is the major alternative, while sustainable LI is the least prioritized. The findings will help scholars and policymakers to a detailed understanding of Industry 4.0 and legal informatics. Finally, the study presents current challenges and future research directions and tries to find out the integration of the important contemporary issues that currently remain scarce.

Keywords: Industry 4.0, Legal Informatics, Fuzzy TOPSIS, Internet of Things, Cyber Physical Systems, Big Data.

1. Introduction

The legal sector is undergoing a profound transformation with the advent of Industry 4.0, characterized as the Fourth Industrial Revolution. This transformation is evolving the old practices, increasing promptness, productivity as well as being economical and with better service quality. Successful Law Firms of the Future: Strategies for Embracing Industry 4.0 Descriptions of Industry 4.0 refer to digitization and intelligent robotics, all the way through to complete convergence between digital, physical and biological systems but so far in legal experiences are mainly been focused on the latter (Agrawal et al., 2022). Most notably, more and more advanced algorithms replace a number of traditional professions — mostly paralegals and legal assistants, as their work is extremely non-creative. As a result, law firms have started to invest in LegalTech solutions such as through third-party services or internal development initiatives driven by innovation hubs (Chourasia et al., 2023). Indeed, Silicon Valley eschews near-term profitability for visionary growth, whereas the legal industry's profit margins are solid even if they sit within a consolidating and fragmenting jurisdictional environment. However, the opportunities abound for law firms to tailor Industry 4.0 strategies to their essentials.

This includes creating and implementing corporate IT strategies, leveraging rolled-up technologies and partnerships with innovation hubs and LegalTech companies for smaller firms (Ladleif and Weske, 2019). On the other hand, larger law firms tend to invest more heavily in enabling & transformational technologies, using internal drives for innovation and having a VC-start up approach & mindset as related to LegalTech investments. This preventive approach readies firms for the future legal landscape when Industry 4.0 is gaining more and more prominence.

Legal informatics is the technology applied to legal data with the purpose of guaranteeing its correspondence with ordinary (offline) law as defined by any system in force, especially privacy rights, obligations and protections applicable on-line (Lloyd, 2020). It has been also describe as the intellectual discipline that related with the issues of computer and law (Akintunde et al., 2017).

The primary objective of this study is to explore the underlying connections between Industry 4.0 and legal informatics, shedding light on how advancements in information technology can be leveraged to enhance legal systems and processes. Through our findings, we seek to provide valuable insights for scholars and policymakers, enabling them to gain a deeper understanding of the implications of Industry 4.0 for legal informatics.

The remaining part of this article is structured as follows. Section 2 describes literature review related to Industry 4.0 and legal informatics. In Section 3, research methodology related to Fuzzy TOPSIS and sensitivity analysis explained. Results and discussion is discussed in Section 4. Conclusion along with future research directions are described in Section 5.

2. Literature review

In recent years, the demand for digital technologies in the field of law and jurisprudence has increased significantly. The integration of industry 4.0 technologies, including but not limited to quantum computing, the Internet of Things, cloud computing, artificial intelligence, and machine learning, into the legal systems of developing nations like India is essentially non-existent (Sahu et al., 2021). The legal system continues to operate in a conventional manner, which requires substantial resources and diligent effort. With the innovative notion of Industry 4.0 technologies, these stringent legal requirements can be circumvented (Agrawal et al. 2022; Zatarain et al., 2018). These technologies are capable of offering exceptional assistance to the current judicial system in lieu of undertaking massive, intricate tasks. The Indian legal system possesses boundless potential for enhancement, which can be realized through the integration of industry 4.0 technologies. Presently, the Indian legal jurisprudence system, which is typical of developing nations, is extremely sluggish and disorganized, with the greatest number of outstanding cases attributable to the lengthy court proceedings and the low judge-to-case ratio (Sharma and AL, 2021). Table 1 shows the critical success factors or criteria for the selection of best implementation decision alternative. It is found from the Table 1 that, there are 10 critical success factors or criteria such as cybersecurity, data protection and transparency, data governance, data management, product liability and standardization, governing bodies, cybernetics law, semantic web, sustainable legal- tech and technological development. Further, sustainable LI, smart legal contracts, ICT law, E- Governance and security and privacy are the various alternatives, which are directly or indirectly affects the legal informatics systems.

Sustainable LI refers to a technology driven framework which support legal processes and procedures and promote economic, environmental and social sustainability. This system integrates principles of sustainability into legal informatics system, decision-making, and operations, aiming to minimize adverse impacts on the environment, improve social equity, and ensure long-term economic feasibility within the legal domain. Moreover, smart legal contracts, also known as self- executing contracts or blockchain-based contracts, are digital agreements that incorporate self- executing code to automate and enforce the terms and conditions of a contract. These contracts leverage blockchain technology to enable parties to interact and transact without the need for intermediaries, such as lawyers or traditional legal institutions, thereby streamlining the contracting process and reducing costs.

Table 1. Critical success factors or criteria of Industry 4.0 in legal informatics systems

Criteria	Description	References

Cybersecurity	Cybersecurity measures are vulnerable to a spectrum of threats, including phishing attacks, integrity breaches, adversarial assaults, zero-day exploits, and malware infiltrations.	Agrawal et al. (2022); Sahu et al. (2021)
Data protection and transparency	Transparency entails providing citizens or data subjects with information that is concise, readily accessible, and comprehensible. This involves using plain and transparent language and, when applicable, incorporating visualization aids.	Chourasia et al. (2023); Ladleif and Weske (2019)
Data governance	Data governance is the practice of exercising authority and control over the management of data.	Sahu et al. (2021); Lloyd (2020)
Data management	Data management encompasses the development, implementation, and monitoring of plans, strategies, programs, and practices aimed at controlling, managing, delivering, and enhancing the value of data and information resources.	Boella et al. (2016); Salami (2017)
Product liability and standardization	Product liability is the branch of law that regulates the responsibility of manufacturers to manufacture and distribute defective goods and to compensate consumers for the resulting harm.	Niebla Zatarain et al. (2018)
Governing bodies	As governing bodies devise and implement specific LI laws and policies, they become more sensitive. Promoting sound governance that leverages the emerging technologies of Industry 4.0 assumes increased significance. This research presents a technologically-driven methodology for gathering and evaluating public engagement and consensus regarding policies and processes. Unfair, biassed, and unjustified practices.	Lyulyov et al. (2024); Agrawal et al. (2022)
Cybernetics law	It refers to the legal principles governing the use of information technology systems, networks, and their interactions within society.	Lloyd (2020); Rühl (2021)
Semantic web	The semantic web is an extension of the internet designed to enable machines to understand and process information more effectively, allowing for better data integration and automation.	Salami (2017)

Sustainable legal- tech	Sustainable legal-tech involves using technology in the legal sector to promote environmental, social, and economic sustainability.	Percival et al. (2021); Liu et al. (2021)
Technological development	Implementation of emerging technology in legal informatics systems helps in real-time case status, develop data base for easiness of decision-making.	Agrawal et al. (2022)

In addition, study identified five major alternatives of Industry 4.0 in legal informatics systems, including ICT law, e-governance, security and privacy, smart legal contracts and sustainable LI. These alternatives are shown in Table 2.

Table 2. Major alternatives of Industry 4.0 in legal informatics systems

Alternatives	**Description**	**References**
Sustainable LI	Sustainable legal informatics focuses on developing and applying technology to improve the efficiency, accessibility, and sustainability of legal systems. It involves creating digital tools and platforms that streamline legal processes, reduce resource consumption, and enhance the accessibility of legal information.	Percival et al. (2021); Liu et al. (2021)
Smart legal contracts	Smart legal contracts are self-executing agreements with terms encoded in computer programs, typically using blockchain technology. They automate the execution and enforcement of contract terms, reducing the need for intermediaries and minimizing human error. These contracts offer transparency, security, and efficiency by ensuring all	Ladleif and Weske (2019); Rühl (2021)

	parties have access to the same information and by streamlining processes, ultimately lowering transaction costs and increasing trust in contractual relationships.	
ICT law	ICT law, also known as information and communication technology law, encompasses the legal framework governing the use, development, and regulation of information and communication technologies (ICTs). It covers the intricate legal problems presented by the fast-increasing digital technologies and their connections to a multiplicity of jurisdictions society segments and appears at numerous sides including privacy, cyber safety, e-commerce intellectual property telecommunications data security etc.	Lloyd (2020); Sharma and AL (2021)
E-Governance	E-governance — short for electronic governance – refers to the use of ICTs by governments as both tools (e. g., e-mail, websites) and a mode of operational. (on-line government services), generally offering greater efficiency, effectiveness transparency, accountability among stakeholders in the public and private sectors and citizens transacting business with the government. It concerns the digitization of government administration and processes to deliver information, decisions, services, transactions in a faster, more cost-effective manner and to provide better quality outcomes for the people who use them.	Niebla Zatarain et al. (2018); Lyulyov et al. (2024)
Security and privacy	Given that legal data is highly sensitive and the system needs to guarantee confidentiality, integrity, and availability proper security and privacy mechanisms should be implemented in all levels of a legal informatics systems.	Agrawal et al. (2022); Yang (2024)

3. Research methodology

In this section, the research methodology and detailed steps of Fuzzy TOPSIS and sensitivity analysis concepts are presented.

3.1 Fuzzy TOPSIS

The TOPSIS method was initially developed by Chen and Hwang (1992) who based their work on the results reported in Hwang and Yoon (1981). This technique relies on the assumption that the preferred alternative should be as far as possible from a negative ideal solution but close to positive ideal modification, which maximizes benefit and minimizes cost. Moreover in the present TOPSIS method weights and rankings of criteria are quantitatively well defined which is not enough for a live scenario. For solving these difficulties, the fuzzy set theory was pioneered (Xu and Chen 2007). To reduce the ambiguity and uncertainty associated with human decisions Zadeh (1976) modified this technique by incorporating Fuzzy Set Theory in to TOPSIS. The fuzzy TOPSIS method ranked the alternatives and determined the weights of criteria, sub-criteria, and alternatives using a five-point linguistic scale (Afrane et al., 2021). The subsequent sub-stages comprise the imprecise TOPSIS procedure.

Sub-step 1: Selection of the top best alternatives to identify a decision matrix, via linguistic term according to expert respondent. Methodology: The five point descriptive scale is written in linguistic terms of Little Importance (LI), Important (I), Absolute Important (AI), Moderately Important, and Very Important(VI) as shown in Table 3. Those linguistic terms that mentioned each criterion (C) to be related with one alternative (A).

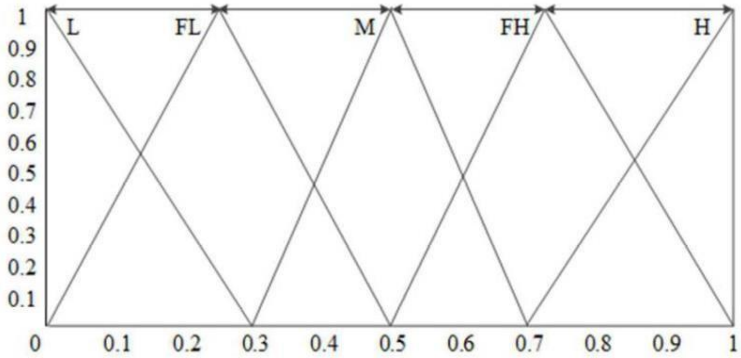

Figure 1. Linguistics scales and triangular fuzzy numbers

TOPSIS approach calculates the following fuzzy decision matrix

$$D = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{13} & \cdots & X_{1n} \\ X_{21} & X_{22} & \cdots & X_{23} & \cdots & X_{2n} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \cdots & & & & & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ [X_{m1} & X_{m2} & \cdots & X_{m3} & \cdots & X_{mn}] \end{bmatrix}$$

Sub-step 2: Evaluate combined fuzzy decision matrix x_{ij} through Eq. (1), Eq. (2), and Eq. (3). $x_{ij} = (a_{ij}, b_{ij}, c_{ij})$
Where,

$$a_{ij} = \min_{k} \{a^{k}\} \quad (1)$$

$$b_{ij} = \frac{1}{k} \sum_{k=1}^{k} \overline{b_{ij}^{k}} \quad (2)$$

$$C_{ij} = \max \{C_{ij}\} \quad (3)$$

And, k is the decision-maker number and x_{ij} is fuzzy opinion.

Sub-step 3: Constructed fuzzy normalized decision matrix $[r_{ij}]_{m\times n}$ through vector normalization technique for the beneficial criteria (see Eq. 4).

$$r_{ij} = \frac{x_{ij}}{\left(\sum_{i=1}^{m} x_{ij}^2\right)^{1/2}} \quad (4)$$

Where i = 1, . . . , m and j = 1, . . . , n.

Sub-step 4: Evaluate weighted fuzzy normalized decision matrix $[v_{ij}]_{m\times n}$ through Eq. (5).

$$\tilde{V}ij = \tilde{r}j \times \tilde{w}j,\ i \in [1, m] \text{ and } j \in [1, n] \quad (5)$$

Where, w_j $(j\in n)$ is the weight of j^{th} as evaluated in the first section, i.e. through ANP approach.

$$\frac{CC_i}{} \quad Di^{-} \quad (11)$$
$$Di^{-} + Di^{+}$$

Sub-step 8: Ranking the alternatives based on the highest value of CCi.

Sub-step 5: Evaluation of the fuzzy positive ideal solution (FPIS, A^*) and fuzzy negative ideal solution (FNIS, A^-).

$A^* = \{\tilde{V}1^*, \tilde{V}2^*, \ldots\ldots \tilde{V}n^*\}$, where $\tilde{V}j^* = \max_i \{V_{ij3}\}$ (6)

$A^- = \{\tilde{V}1^-, \tilde{V}2^-, \ldots\ldots V_n^-\}$, where $\tilde{V}j^- = \min_i \{V_{ij1}\}$ (7)

Sub-step 6: Evaluation of the sum of distance (Di^+ and Di^-) from a positive and negative ideal solution for each alternative using the vertex method (See Eq. (8) and Eq. (9)).

$$Di^{+} = \sum_{j=1}^{n} (Vij, Vij^*),\ i \in [1, m] \quad (8)$$

$$Di^{-} = \sum_{j=1}^{n} (Vij, Vij^-),\ i \in [1, m] \quad (9)$$

The distance between two triangular fuzzy numbers can be evaluated through vector algebra $d(\tilde{a}, \tilde{b})$ defined by Eq. (10). Where a = (a1, a2, a3) and b = (b1, b2, b3).

$$d(\tilde{a}, \tilde{b}) = \sqrt{\frac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2]} \quad (10)$$

Sub-step 7: Evaluate the value of closeness coefficient (CC_i) of each alternative to the ideal solution. The CC_i value is evaluated using Eq. (11) to determine the rank of each alternative. Further, the CC_i value with respect to A+ is defined as:

3.2 Sensitivity Analysis

Sensitivity analysis addresses the hypothetical scenarios involved in decision-making by exploring the potential outcomes of adjusting certain criteria. It aims to reveal the extent to which specific criteria impact the decision-making process, allowing decision-makers to understand how changes in these criteria affect the final decision compared to the original decision prior to adjustments. To assess the influence of uncertainties in experts' judgments, a sensitivity analysis was conducted. Table 18 illustrates the criterion weights for four distinct cases, while Figure 1 demonstrates how changes in criterion weights affect the ranking order of different Waste-to-Energy (WtE) alternatives.

- Case 1: initially obtained weights (Business-as-usual)
- Case 2: all criterion weights were considered equal and set to "little Importance (0.0, 0.1, 0.3)"
- Case 3: "Absolute Important (0.3, 0.5, 0.7)"
- Case 4: "Very Important (0.7, 0.9, 1.0)"

- Scenario 1: weights all technical criteria is the most weight for and set on "very high- (0.7, 0.9, 0.9)" at once considerate all economic criteria unimportant lowering them ant low of importance("very low- (0.1, 0.1, 0.3)")

- Scenario 2: weights of all economic criteria were considered most influential and set to "very high- (0.7, 0.9, 0.9)" while simultaneously considering all technical criteria as least influential and setting them as "very low- (0.1, 0.1, 0.3)"
- Scenario 3- the beneficial criteria were all weighted as "very high" (0.7, 0.9, 0.9) and all non- beneficial criteria are least important in decision making and set as "very low- (0.1, 0.1,.03).
- Scenario 4- weights of all non-beneficial criteria were considered most influential and set to "very high- (0.7, 0.9, 0.9)" while simultaneously considering all beneficial criteria as least influential and setting them as "very low- (0.1, 0.1, 0.3)".

Table 3. Fuzzy linguistic scale

Linguistic term (Criteria)	Fuzzy number	Linguistic term (Alternatives)	Fuzzy number
Little Importance (LI)	(0.0, 0.1, 0.3)	Worst (W)	(1, 1, 3)
Important (I)	(0.1, 0.3, 0.5)	Poor (P)	(1, 3, 5)
Absolute Important (AI)	(0.3, 0.5, 0.7)	Fair (F)	(3, 5, 7)
Moderately Important (MI)	(0.5, 0.7, 0.9)	Good (G)	(5, 7, 9)
Very Important (VI)	(0.7, 0.9, 1.0)	Best (B)	(7, 9, 9)

Table 4. Importance weights of the criteria from the five decision-makers

	CSF1	CSF2	CSF3	CSF4	CSF5
DM1	(0.7, 0.9, 1.0)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)	(0.3, 0.5, 0.7)
DM2	(0.7, 0.9, 1.0)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)
DM3	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)	(0.5, 0.7, 0.9)	(0.3, 0.5, 0.7)	(0.1, 0.3, 0.5)
DM4	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)	(0.3, 0.5, 0.7)	(0.1, 0.3, 0.5)
DM5	(0.3, 0.5, 0.7)	(0.5, 0.7, 0.9)	(0.3, 0.5, 0.7)	(0.1, 0.3, 0.5)	(0.5, 0.7, 0.9)
	CSF6	CSF7	CSF8	CSF9	CSF10

DM1	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)	(0.3, 0.5, 0.7)	(0.1, 0.3, 0.5)	(0.5, 0.7, 0.9)
DM2	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)	(0.1, 0.3, 0.5)	(0.7, 0.9, 1.0)
DM3	(0.7, 0.9, 1.0)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)
DM4	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1.0)	(0.3, 0.5, 0.7)	(0.5, 0.7, 0.9)
DM5	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.5, 0.7, 0.9)	(0.1, 0.3, 0.5)	(0.3, 0.5, 0.7)

Table 5. Combined criterion weights

CSF1	CSF2	CSF3	CSF4	CSF5
(0.3, 0.74, 1.0)	(0.5, 0.74, 1.0)	(0.3, 0.78, 1.0)	(0.1, 0.54, 1.0)	(0.1, 0.46, 0.9)
CSF6	CSF7	CSF8	CSF9	CSF10
(0.3, 0.7, 1.0)	(0.3, 0.7, 1.0)	(0.3, 0.78, 1.0)	(0.1, 0.42, 0.9)	(0.3, 0.7, 1.0)

Table 6. Calculation of LI alternative criteria by DM1

	CSF1	CSF2	CSF3	CSF4	CSF5
Sustainable LI	(7, 9, 9)	(5, 7, 9)	(3, 5, 7)	(5, 7, 9)	(7, 9, 9)
Smart legal contracts	(7, 9, 9)	(5, 7, 9)	(5, 7, 9)	(1, 3, 5)	(1, 1, 3)
ICT law	(7, 9, 9)	(7, 9, 9)	(3, 5, 7)	(3, 5, 7)	(1, 3, 5)
E-Governance	(5, 7, 9)	(5, 7, 9)	(1, 3, 5)	(3, 5, 7)	(5, 7, 9)

Security and privacy	(5, 7, 9)	(7, 9, 9)	(7, 9, 9)	(1, 3, 5)	(3, 5, 7)

	CSF6	CSF7	CSF8	CSF9	CSF10
Sustainable LI	(5, 7, 9)	(3, 5, 7)	(1, 3, 5)	(1, 1, 3)	(7, 9, 9)
Smart legal contracts	(5, 7, 9)	(3, 5, 7)	(5, 7, 9)	(3, 5, 7)	(5, 7, 9)
ICT law	(3, 5, 7)	(5, 7, 9)	(7, 9, 9)	(1, 3, 5)	(3, 5, 7)
E-Governance	(1, 3, 5)	(7, 9, 9)	(5, 7, 9)	(3, 5, 7)	(3, 5, 7)
Security and privacy	(3, 5, 7)	(3, 5, 7)	(7, 9, 9)	(1, 3, 5)	(3, 5, 7)

Table 7. Calculation of LI alternative criteria by DM2

	CSF1	CSF2	CSF3	CSF4	CSF5
Sustainable LI	(5, 7, 9)	(3, 5, 7)	(5, 7, 9)	(5, 7, 9)	(3, 5, 7)
Smart legal contracts	(7, 9, 9)	(5, 7, 9)	(3, 5, 7)	(7, 9, 9)	(1, 3, 5)
ICT law	(7, 9, 9)	(7, 9, 9)	(5, 7, 9)	(5, 7, 9)	(5, 7, 9)
E-Governance	(5, 7, 9)	(3, 5, 7)	(7, 9, 9)	(3, 5, 7)	(1, 3, 5)
Security and privacy	(3, 5, 7)	(7, 9, 9)	(5, 7, 9)	(3, 5, 7)	(7, 9, 9)

	CSF6	CSF7	CSF8	CSF9	CSF10
Sustainable LI	(3, 5, 7)	(1, 3, 5)	(3, 5, 7)	(1, 3, 5)	(5, 7, 9)
Smart legal contracts	(5, 7, 9)	(1, 3, 5)	(3, 5, 7)	(3, 5, 7)	(3, 5, 7)
ICT law	(5, 7, 9)	(7, 9, 9)	(5, 7, 9)	(1, 3, 5)	(5, 7, 9)
E-Governance	(1, 3, 5)	(5, 7, 9)	(7, 9, 9)	(1, 1, 3)	(3, 5, 7)
Security and privacy	(5, 7, 9)	(5, 7, 9)	(7, 9, 9)	(3, 5, 7)	(5, 7, 9)

Table 8. Calculation of LI alternative criteria by DM3

CSF1	CSF2	CSF3	CSF4	CSF5
(5, 7, 9)	(5, 7, 9)	(3, 5, 7)	(1, 3, 5)	(7, 9, 9)
(5, 7, 9)	(7, 9, 9)	(3, 5, 7)	(1, 3, 5)	(3, 5, 7)
(3, 5, 7)	(3, 5, 7)	(7, 9, 9)	(7, 9, 9)	(3, 5, 7)
(7, 9, 9)	(5, 7, 9)	(1, 3, 5)	(3, 5, 7)	(1, 3, 5)
(5, 7, 9)	(5, 7, 9)	(5, 7, 9)	(3, 5, 7)	(1, 1, 3)

CSF6	CSF7	CSF8	CSF9	CSF10
(1, 3, 5)	(5, 7, 9)	(3, 5, 7)	(1, 1, 3)	(7, 9, 9)
(3, 5, 7)	(3, 5, 7)	(5, 7, 9)	(5, 7, 9)	(5, 7, 9)
(5, 7, 9)	(5, 7, 9)	(7, 9, 9)	(3, 5, 7)	(7, 9, 9)
(7, 9, 9)	(5, 7, 9)	(5, 7, 9)	(1, 1, 3)	(1, 1, 3)
(3, 5, 7)	(7, 9, 9)	(5, 7, 9)	(3, 5, 7)	(5, 7, 9)

Table 9. Calculation of LI alternative criteria by DM4

	CSF1	CSF2	CSF3	CSF4	CSF5
Sustainable LI	(3, 5, 7)	(3, 5, 7)	(5, 7, 9)	(5, 7, 9)	(7, 9, 9)
Smart legal contracts	(7, 9, 9)	(7, 9, 9)	(7, 9, 9)	(3, 5, 7)	(3, 5, 7)
ICT law	(7, 9, 9)	(5, 7, 9)	(7, 9, 9)	(3, 5, 7)	(1, 3, 5)
E-Governance	(5, 7, 9)	(3, 5, 7)	(3, 5, 7)	(5, 7, 9)	(3, 5, 7)
Security and privacy	(3, 5, 7)	(7, 9, 9)	(5, 7, 9)	(3, 5, 7)	(1, 3, 5)
	CSF6	CSF7	CSF8	CSF9	CSF10
Sustainable LI	(3, 5, 7)	(1, 3, 5)	(1, 1, 3)	(7, 9, 9)	(5, 7, 9)
Smart legal contracts	(5, 7, 9)	(3, 5, 7)	(3, 5, 7)	(3, 5, 7)	(7, 9, 9)
ICT law	(7, 9, 9)	(7, 9, 9)	(7, 9, 9)	(1, 3, 5)	(3, 5, 7)
E-Governance	(1, 3, 5)	(5, 7, 9)	(5, 7, 9)	(3, 5, 7)	(5, 7, 9)
Security and privacy	(3, 5, 7)	(5, 7, 9)	(7, 9, 9)	(5, 7, 9)	(3, 5, 7)

Table 10. Calculation of LI alternative criteria by DM5

	CSF1	CSF2	CSF3	CSF4	CSF5
Sustainable LI	(1, 3, 5)	(5, 7, 9)	(3, 5, 7)	(3, 5, 7)	(5, 7, 9)
Smart legal contracts	(5, 7, 9)	(5, 7, 9)	(3, 5, 7)	(1, 3, 5)	(1, 1, 3)
ICT law	(7, 9, 9)	(7, 9, 9)	(5, 7, 9)	(3, 5, 7)	(1, 3, 5)
E-Governance	(5, 7, 9)	(3, 5, 7)	(1, 3, 5)	(7, 9, 9)	(5, 7, 9)
Security and privacy	(7, 9, 9)	(7, 9, 9)	(7, 9, 9)	(1, 3, 5)	(1, 1, 3)
	CSF6	CSF7	CSF8	CSF9	CSF10
Sustainable LI	(5, 7, 9)	(3, 5, 7)	(1, 3, 5)	(1, 3, 5)	(7, 9, 9)
Smart legal contracts	(1, 3, 5)	(5, 7, 9)	(7, 9, 9)	(5, 7, 9)	(5, 7, 9)
ICT law	(3, 5, 7)	(5, 7, 9)	(3, 5, 7)	(1, 1, 3)	(3, 5, 7)
E-Governance	(5, 7, 9)	(7, 9, 9)	(7, 9, 9)	(1, 3, 5)	(1, 3, 5)
Security and privacy	(7, 9, 9)	(3, 5, 7)	(5, 7, 9)	(1, 3, 5)	(7, 9, 9)

Table 11. Calculate combined decision matrix

	CSF1	CSF2	CSF3	CSF4	CSF5
Sustainable LI	(1, 6.2, 9)	(3, 6.2, 9)	(3, 5.8, 9)	(1, 5.8, 9)	(3, 7.8, 9)
Smart legal contracts	(5, 8.2, 9)	(5, 7.8, 9)	(3, 5.8, 9)	(1, 4.6, 9)	(1, 3, 7)
ICT law	(3, 8.2, 9)	(3, 7.8, 9)	(3, 7.8, 9)	(3, 6.2, 9)	(1, 4.2, 9)
E-Governance	(5, 7.4, 9)	(3, 5.8, 9)	(1, 4.6, 9)	(3, 6.2, 9)	(1, 5, 9)
Security and privacy	(3, 6.6, 9)	(5, 8.6, 9)	(5, 7.8, 9)	(1, 4.2, 7)	(1, 3.8, 9)
	CSF6	CSF7	CSF8	CSF9	CSF10
Sustainable LI	(1, 5.4, 9)	(1, 4.6, 9)	(1, 3.4, 7)	(1, 3.4, 9)	(5, 8.2, 9)
Smart legal contracts	(1, 5.8, 9)	(1, 5, 9)	(3, 6.6, 9)	(3, 5.8, 9)	(3, 5.8, 9)
ICT law	(3, 6.6, 9)	(5, 7.8, 9)	(3, 7.8, 9)	(1, 3, 7)	(3, 6.2, 9)
E-Governance	(1, 5, 9)	(5, 7.8, 9)	(5, 7.8, 9)	(1, 3, 7)	(1, 4.2, 9)

Security and privacy	(3, 6.2, 9)	(3, 6.6, 9)	(5, 8.2, 9)	(1, 4.6, 9)	(3, 6.6, 9)

Table 12. Calculate normalized fuzzy decision matrix

	CSF1	CSF2	CSF3	CSF4	CSF5
Sustainable LI	(0.111, 0.689, 1)	(0.333, 0.689, 1)	(0.333, 0.644, 1)	(0.111, 0.644, 1)	(0.333, 0.867, 1)
Smart legal contracts	(0.556, 0.911, 1)	(0.556, 0.867, 1)	(0.333, 0.644, 1)	(0.111, 0.511, 1)	(0.111, 0.333, 0.778)
ICT law	(0.333, 0.911, 1)	(0.333, 0.867, 1)	(0.333, 0.867, 1)	(0.333, 0.689, 1)	(0.111, 0.467, 1)
E-Governance	(0.556, 0.822, 1)	(0.333, 0.644, 1)	(0.111, 0.511, 1)	(0.333, 0.689, 1)	(0.111, 0.556, 1)
Security and privacy	(0.333, 0.733, 1)	(0.556, 0.956, 1)	(0.333, 0.867, 1)	(0.111, 0.467, 0.778)	(0.111, 0.422, 1)
	CSF6	CSF7	CSF8	CSF9	CSF10
Sustainable LI	(0.111, 0.6, 1)	(0.111, 0.511, 1)	(0.111, 0.378, 0.778)	(0.111, 0.378, 1)	(0.556, 0.911, 1)
Smart legal contracts	(0.111, 0.644, 1)	(0.111, 0.556, 1)	(0.333, 0.733, 1)	(0.333, 0.644, 1)	(0.333, 0.644, 1)
ICT law	(0.333, 0.733, 1)	(0.333, 0.867, 1)	(0.333, 0.867, 1)	(0.111, 0.333, 0.778)	(0.333, 0.689, 1)
E-Governance	(0.111, 0.556, 1)	(0.333, 0.867, 1)	(0.333, 0.867, 1)	(0.111, 0.333, 0.778)	(0.333, 0.689, 1)
Security and privacy	(0.333, 0.689, 1)	(0.333, 0.733, 1)	(0.556, 0.911, 1)	(0.111, 0.511, 1)	(0.333, 0.733, 1)

Table 13. Calculate weighted normalized fuzzy decision matrix

	CSF1	CSF2	CSF3	CSF4	CSF5
Sustainable LI	(0.033, 0.510, 1)	(0.167, 0.510, 1)	(0.1, 0.502, 1)	(0.011, 0.348, 1)	(0.556, 0.911, 1)
Smart legal contracts	(0.167, 0.674, 1)	(0.278, 0.642, 1)	(0.1, 0.502, 1)	(0.011, 0.276, 1)	(0.333, 0.644, 1)
ICT law	(0.1, 0.674, 1)	(0.167, 0.642, 1)	(0.1, 0.676, 1)	(0.033, 0.372, 1)	(0.333, 0.689, 1)
E-Governance	(0.167, 0.608, 1)	(0.167, 0.477, 1)	(0.033, 0.399, 1)	(0.033, 0.372, 1)	(0.333, 0.689, 1)
Security and privacy	(0.1, 0.542, 1)	(0.278, 0.707, 1)	(0.1, 0.676, 1)	(0.011, 0.252, 0.778)	(0.333, 0.733, 1)
	CSF6	CSF7	CSF8	CSF9	CSF10
Sustainable LI	(0.033, 0.42, 1)	(0.033, 0.358, 1)	(0.033, 0.295, 0.778)	(0.011, 0.159, 0.9)	(0.167, 0.638, 1)
Smart legal contracts	(0.033, 0.451, 1)	(0.033, 0.389, 1)	(0.099, 0.571, 1)	(0.033, 0.270, 0.9)	(0.1, 0.451, 1)
ICT law	(0.1, 0.513, 1)	(0.1, 0.607, 1)	(0.1, 0.676, 1)	(0.011, 0.140, 0.700)	(0.1, 0.482, 1)

E-Governance	(0.033, 0.389, 1)	(0.1, 0.607, 1)	(0.1, 0.676, 1)	(0.011, 0.140, 0.700)	(0.1, 0.482, 1)
Security and privacy	(0.1, 0.482, 1)	(0.1, 0.513, 1)	(0.167, 0.711, 1)	(0.011, 0.215, 0.9)	(0.1, 0.513, 1)

Table 14. Calculate fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS)

	CSF1	CSF2	CSF3	CSF4	CSF5
A*	(0.167, 0.674, 1)	(0.278, 0.707, 1)	(0.1, 0.676, 1)	(0.033, 0.372, 1)	(0.033, 0.399, 0.9)
A^-	(0.033, 0.510, 1)	(0.167, 0.477, 1)	(0.033, 0.399, 1)	(0.011, 0.252, 0.778)	(0.011, 0.153, 0.700)
	CSF6	CSF7	CSF8	CSF9	CSF10
A*	(0.1, 0.513, 1)	(0.1, 0.607, 1)	(0.167, 0.711, 1)	(0.033, 0.270, 0.9)	(0.167, 0.638, 1)
A^-	(0.033, 0.389, 1)	(0.033, 0.358, 1)	(0.033, 0.295, 0.778)	(0.033, 0.270, 0.9)	(0.167, 0.638, 1)

Table 15. Calculate the distance from each alternative to the FPIS and FNIS

	CSF1	CSF2	CSF3	CSF4	CSF5	CSF6	CSF7	CSF8	CSF9	CSF10
DA*Sustainable LI	0.122	0.13	0.1	0.019	0	0.066	0.148	0.281	0.065	0
DA*Smart legal contracts	0	0.037	0.1	0.057	0.183	0.052	0.131	0.089	0	0.273
DA*ICT law	0.038	0.129	0	0	0.106	0	0	0.044	0.138	0.098
DA*E-Governance	0.038	0.147	0.164	0	0.083	0.081	0	0.044	0.175	0.098
DA*Security and privacy	0.085	0	0	0.146	0.118	0.018	0.054	0	0.034	0.081
DA-Sustainable LI	0	0.019	0.071	0.139	0.183	0.018	0	0	0.065	0
DA-Smart legal contracts	0.122	0.114	0.071	0.128	0	0.036	0.018	0.207	0	0.114
DA-ICT law	0.102	0.095	0.164	0.146	0.12	0.081	0.148	0.256	0.138	0.098
DA-E-Governance	0.095	0	0	0.146	0.129	0	0.148	0.256	0.138	0.098
DA-Security and privacy	0.043	0.147	0.164	0	0.117	0.066	0.097	0.282	0.034	0.081

Table 16. Evaluations of Di+, Di- and Cci

Alternatives	Di^+	Di^-	CCi	Ranking
Sustainable LI	0.931	0.495	0.347	5
Smart legal contracts	0.922	0.81	0.468	4
ICT law	0.552	1.348	0.709	1

E-Governance	0.830	1.01	0.549	3
Security and privacy	0.536	1.031	0.658	2

Table 17. Sensitivity analysis

Cases	CSF1	CSF2	CSF3	CSF4	CSF5
Case 1	(0.3, 0.74, 1.0)	(0.5, 0.74, 1.0)	(0.3, 0.78, 1.0)	(0.1, 0.54, 1.0)	(0.1, 0.46, 0.9)
Case 2	(0.0, 0.1, 0.3)	(0.0, 0.1, 0.3)	(0.0, 0.1, 0.3)	(0.0, 0.1, 0.3)	(0.0, 0.1, 0.3)
Case 3	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)
Case 4	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)
	CSF6	CSF7	CSF8	CSF9	CSF10
Case 1	(0.3, 0.7, 1.0)	(0.3, 0.7, 1.0)	(0.3, 0.78, 1.0)	(0.1, 0.42, 0.9)	(0.3, 0.7, 1.0)
Case 2	(0.0, 0.1, 0.3)	(0.0, 0.1, 0.3)	(0.0, 0.1, 0.3)	(0.0, 0.1, 0.3)	(0.0, 0.1, 0.3)
Case 3	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)
Case 4	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)	(0.7, 0.9, 1.0)

Table 18. Results of sensitivity

	Case 1		Case 2		Case 3		Case 4	
	CCi	Ranking	CCi	Ranking	CCi	Ranking	CCi	Ranking
Sustainable LI	0.347	5	0.395	4	0.365	5	0.389	5
Smart legal contracts	0.468	4	0.526	3	0.527	3	0.543	3
ICT law	0.709	1	0.663	2	0.671	1	0.643	1
E-Governance	0.549	3	0.27	5	0.506	4	0.494	4
Security and privacy	0.658	2	0.694	1	0.645	2	0.616	2

4. Result and Discussion

In order to prioritize the critical success factors for legal informatics implementation, 10 Industry 4.0 factors are identified for legal informatics implementation. These factors are CSF1: Cybersecurity, CSF2: Data protection and transparency, CSF3: Data governance, CSF4: Data management, CSF5: Product liability and standardization, CSF6: Governing bodies, CSF7: Cybernetics law, CSF8: Semantic web, CSF9: Sustainable legal-tech, CSF10: Technological development. These factors are prioritized on the basis of their financial and non-financial implications in the long term. Five rankings (R1, R2, R3, R4, and R5) based on secondary research across legal domain where legal informatics plays a critical role and their relative importance across literature. These are used to rate the importance of the above mentioned 5-point scale having the linguistic term Little Importance (LI), Important (I), Absolute Important (AI), Moderately Important (MI), and Very Important (VI), as shown in Table 2. A decision matrix is formed based on the responses received from the expert's opinion as shown in the Table 3.

The results of study analyses that "ICT law" found highest ranked alternative followed by "Security and privacy", "E-Governance", "Smart legal contracts" and "Sustainable LI". In addition, based on the sensitivity results analysis "ICT law" again found the highest ranked alternatives followed by "Security and privacy", "Smart legal contracts", "E-Governance", and "Sustainable LI".

5. Conclusion

The study investigated the integration of Industry 4.0 technologies into legal informatics systems, specifically focusing on their ability to expedite and personalize services, in addition to enabling real-time monitoring. Increasing digitalization, e-government, and e-commerce have created a challenging environment in which to manage LI for long-term performance. An advancement in electronic governance that has significant ramifications for the legislative process is the interoperability of applications and document sharing between the court's internal users (judge clerks, attorneys, eyewitnesses, etc.) and all

external users (eyewitnesses, lawyers, etc.). A contemporary attorney must be proficient in the implementation of digital contracts or confront the "know how" of the internet of things. Therefore, it is imperative that it is well-informed regarding the subsequent developments in computer-related issues, the consumer's response to mass acts facilitated by electronic commerce, computer crimes, and the application of Habeas Data. The attorney must be willing to acquire knowledge of the blockchain and transition from their conventional working methods to utilizing programmes that enable them to process information with a single click.

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