Opportunities and Challenges in Sustainability
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Policy Evaluation for Overcoming Barriers to E-Document Implementation in the Logistics Sector

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Received: 12-15-2024 **Revised:** 02-20-2025 **Accepted:** 02-28-2025

Citation: Tadić, S., Krstić, M., Veljović, M., & Milovanović, A. (2025). Policy evaluation for overcoming barriers to e-document implementation in the logistics sector. *Oppor Chall. Sustain.*, *4*(1), 1-16. https://doi.org/10.56578/ocs040101.

Abstract: The adoption of electronic documents (e-documents) in logistics has emerged as a critical component for enhancing efficiency, reducing operational costs, and contributing to environmental sustainability. However, despite its numerous advantages, the transition from traditional paper-based systems to e-documents has been sluggish, hindered by a range of barriers including legal and regulatory constraints, lack of standardization, and insufficient system interoperability. This study aims to identify and analyze these barriers, propose relevant policy measures to mitigate them, and evaluate the most effective policy for promoting widespread adoption. Four primary policy strategies were proposed to address the challenges of e-documents in logistics. These policies were assessed using multi-criteria analysis, incorporating fuzzy Step-Wise Weight Assessment Ratio Analysis (SWARA) and Axial-Distance-Based Aggregated Measurement (ADAM) methods, to rank their effectiveness in overcoming adoption barriers. The results indicate that the policy ensuring full compliance with regulatory and documentation requirements, through a harmonized approach, offers the most significant potential for driving the adoption of e-documents. This policy emphasizes standardization and mandates compliance, fostering a more robust and efficient transition to digital systems. The findings provide a comprehensive understanding of the policy measures that can most effectively support the expansion of e-documents in logistics, thereby contributing to the long-term sustainability and operational excellence of the sector.

Keywords: Logistics; E-documents; Implementation barriers; Policy measures; Fuzzy Step-Wise Weight Assessment Ratio Analysis (SWARA); Axial-Distance-Based Aggregated Measurement (ADAM)

1. Introduction

In a dynamic environment, logistics companies must adapt quickly to market changes and innovative solutions. The level of competitiveness among companies has significantly increased in recent years due to factors such as the growing role of e-commerce (heavily influenced by COVID-19), the expansion of multinational companies, and the proliferation of digital networks.

In industrialized nations, innovative and modern solutions account for a significant portion of economic growth, thereby holding considerable macroeconomic importance. A company's ability to adapt to modern solutions is not only a success factor but also a necessity for remaining competitive in the market (Ignat, 2017). Globalization has led to greater complexity in supply chain management, with rising, diversified, and more stringent customer demands. Moreover, shortened innovation cycles and digitalization have transformed how companies develop new products. Digitalization enables organizations to optimize their processes, enhancing both effectiveness and efficiency (Nezamova & Olentsova, 2022).

Digital transformation permeates all aspects of modern business, with e-document implementation emerging as one of its key components in logistics. E-documents have become essential for improving efficiency and accuracy in logistics and supply chain management. Solutions based on e-documents allow faster data processing, reduced administrative costs, less paper consumption, and better communication among supply chain stakeholders. E-documents, such as e-invoices, e-delivery notes, and e-receipts, enable companies to automate and optimize processes, minimizing manual data entry. This reduces human error and accelerates business operations.

The advantages of e-documents extend beyond operational improvements. Their implementation brings significant environmental benefits, as transitioning from paper to e-documentation reduces paper consumption, contributing to forest conservation and lower CO_2 emissions associated with paper production. This aspect is increasingly important as companies and nations commit to sustainable development goals and reducing their ecological footprints. E-documents also integrate seamlessly with modern technologies like blockchain and artificial intelligence, further enhancing data security, integrity, and the optimization of logistics chains (Piers et al., 2018).

However, despite these advantages, the adoption of e-documents in logistics has yet to reach its full potential. Paper-based documentation continues to dominate many sectors, and the shift to e-documents is slow and inconsistent. Several barriers hinder this transition, including legal and regulatory obstacles, the lack of international standardization, and limited interoperability among information systems (Piers et al., 2018).

To address these challenges and accelerate the adoption of e-documents in logistics, various policies and strategies have been developed, aiming to improve legal frameworks, establish international standards, and promote the interoperability of information systems. These policies represent critical steps toward creating an enabling environment for broader adoption of digital solutions in logistics processes. Since not all policies are equally effective in overcoming the barriers to e-document adoption, they must be evaluated against various relevant criteria to select the optimal one. Multi-criteria decision-making (MCDM) methods are particularly suitable for this task. To select the optimal policy, the weights for each defined criterion must first be determined, followed by the final ranking of policies. This study addresses the first task using the fuzzy SWARA method and the second task using the ADAM method.

The goal of this study is to evaluate and rank policies for overcoming barriers and challenges in implementing e-documents in logistics, using the SWARA and ADAM MCDM methods. The contribution of this study lies in developing an integrated approach that provides an innovative framework for evaluating and selecting optimal policies for the digitalization of logistics processes. By identifying key criteria and analyzing relevant policies, the study offers insights into the factors critical to the successful implementation of e-documents. Furthermore, the research results have practical implications, providing concrete recommendations for improving regulatory and operational frameworks in logistics.

Apart from the introduction, this study consists of a literature review in Section 2 and four additional sections that present a comprehensive approach to evaluating policies for overcoming barriers to e-document adoption in logistics. Section 3 identifies and defines the key challenges faced by logistics companies in implementing e-documents. This section explores issues such as legal and regulatory obstacles, the lack of international standardization, and the limited interoperability of information systems. As a response to these challenges, specific policies offering potential solutions were introduced, forming the basis for further analysis.

Section 4 describes the approach used to select the preferred policy for addressing the identified challenges. This section defines the relevant criteria for MCDM analysis. The fuzzy SWARA method was applied to determine the weights of these criteria, while the ADAM method was used for the final ranking of policies. This section provides detailed insights into the mathematical and methodological foundations of the research, ensuring transparency and reproducibility of the results.

Section 5 presents the analysis and interpretation of the obtained results. This section showcases solutions generated through the application of the fuzzy SWARA and ADAM methods, focusing on identifying the policy most effective in overcoming barriers to e-document adoption. The discussion of results offers insights into the implications of the proposed solutions for logistics practices and recommendations for their implementation. Section 6 provides the conclusion of this study.

2. Literature Review

To gain a comprehensive understanding of current research and define relevant challenges in implementing e-documents in logistics, it is necessary to review existing literature on digital transformation, barriers and issues related to the application of e-documents, policies for overcoming these barriers and issues, and methods for selecting the optimal policy. This section examines key studies and reports addressing these aspects.

The trend of digitalization undoubtedly impacts various fields, such as the economy (Bezrukov et al., 2022), agriculture (Rasputina, 2022), tourism (Filipiak et al., 2023), and others. As Ignat (2017) and Nezamova & Olentsova (2022) pointed out, digitalization is also crucial for improving logistics and enhancing efficiency. Winkler & Zinsmeister (2019) highlighted the particular importance of digitalization in intralogistics. It enables the integration of physical and virtual processes, thus improving production management and reducing costs. For companies to become sustainable and competitive, they must invest in the development of new digital capacities and innovations.

An essential factor for success in logistics is e-documents, which can be used in all parts of the supply chain.

Lyovin & Efimova (2017) and the European Commission (EC) (Piers et al., 2018) have recognized the significance of the broad application of e-documents in business logistics, particularly in the transportation subsystem. However, as Piers et al. (2018) points out, the use of e-documents in logistics is still at a low level. The reasons for this include legal barriers, operational uncertainty, and a lack of interoperable systems. To overcome these barriers, Piers et al. (2018) has defined various policy measures and subsequent policies to overcome obstacles and increase the use of e-documents. Lyovin & Efimova (2017) emphasized the main benefits of e-documents: increased efficiency, reduced errors, improved transparency, and cost savings. In addition to the transportation subsystem, Chang et al. (2023) analyzed the need to introduce e-documents in the warehouse and customs processes, specifically in a customs warehouse at the Port of Busan. This study analyzed current delivery problems and the existing operational systems used to manage import cargo. The research showed that both service providers and users consider it necessary to introduce standard e-documents, and they also emphasized that this would contribute to reducing errors and preventing unauthorized deliveries. However, the authors mainly focused on the problems encountered by logistics companies already using e-documents and developing solutions to overcome them. Thus, a review of the literature reveals a research gap that should be filled by defining an approach for selecting the optimal solution to overcome barriers and problems in the application of e-documents in logistics.

To address the identified challenges and improve the implementation of e-documents in logistics, it is essential to explore multi-criteria analysis methodologies and select one suitable for solving this type of problem. Multi-criteria analysis plays a significant role in modern decision-making processes, allowing decision-makers to systematically evaluate different options based on multiple criteria, enabling the selection of optimal solutions in complex situations (Dodgson et al., 2009; Mardani et al., 2017; Siksnelyte et al., 2018).

This research utilizes a hybrid multi-criteria decision-making model that integrates the fuzzy SWARA and ADAM methods to identify the most suitable policy for addressing challenges and obstacles associated with the implementation of e-documents in logistics. The existing literature presents numerous cases where these methods have been applied separately or in combination with other multi-criteria decision-making approaches. Examples include fuzzy SWARA paired with the Combined Compromise Solution (CoCoSo) (Ulutaş et al., 2020), fuzzy SWARA with the fuzzy Compromise Ranking of Alternatives from Distance to Ideal Solution (CRADIS) (Puška et al., 2023), and fuzzy SWARA with the fuzzy Measurement of Alternatives and Ranking according to Compromise Solution (MARCOS) (Tuş & Adalı, 2022). Other notable combinations involve fuzzy SWARA with fuzzy Complex Proportional Assessment (CORPAS) (Zarbakhshnia et al., 2018), as well as its integration with CORPAS in separate studies (Mishra et al., 2020; Xiang et al., 2022). Additionally, fuzzy SWARA has been applied alongside fuzzy Efficiency Analysis Technique with Output Satisficing (EATWOS) (Görçün et al., 2022) and fuzzy Multi-Attributive Border Approximation Area Comparison (MABAC) (Zolfani et al., 2021). Furthermore, other multi-criteria approaches such as SWOT, Analytical Network Process (ANP), and ADAM (Agnusdei et al., 2023), as well as Full Consistency Method (FUCOM) with ADAM (Andrejić et al., 2023), fuzzy Analytical Hierarchy Process (AHP) with ADAM (Kalem et al., 2024), and fuzzy FARE with ADAM (Krstić & Tadić, 2023) have been explored in the literature. Beyond this study, the integration of fuzzy SWARA and ADAM has previously been applied in evaluating transshipment technologies at intermodal terminals (Krstić et al., 2024). Nevertheless, despite the extensive application of these and other MCDM methods, no prior research has utilized the combination of fuzzy SWARA and ADAM to determine the optimal policy for overcoming barriers in e-document adoption within the logistics sector.

3. Problem Description and Solutions

Although companies often do not require paper copies of documents accompanying goods during transport, there is still legal and operational uncertainty among companies and governmental authorities regarding the acceptance of e-documents. Additionally, there are no unified standards at the European Union (EU) level regulating the electronic transport contract in terms of its legal validity and evidentiary value. Since the recognition of digital formats differs across legal systems, this creates significant obstacles to the adoption of electronic transport contracts in business transactions (Piers et al., 2018).

Ongoing legal uncertainties hinder the development of interoperable Information Technology (IT) infrastructure and efficient data exchange between businesses and governmental institutions. As long as these uncertainties persist, the demand for such infrastructure is expected to remain limited. The absence of a clearly defined legal framework may lead to significant challenges in ensuring interoperability between business and administrative IT systems. Based on these considerations, Figure 1 presents a fault tree diagram outlining the primary and specific issues associated with the implementation of e-documents in logistics, along with their underlying causes.

3.1 Rejection of E-Documents by Authorities

Authorities require transport documents to conduct inspections necessary for ensuring compliance with various regulatory requirements. During these inspections, transport documents serve as key tools for verifying the accuracy of information regarding cargo, transport conditions, and adherence to relevant regulations. Currently, many competent institutions are either unable or unwilling to accept e-documents and instead exclusively recognize paper versions of such documents. This particularly applies to a range of essential transport documents described in the previous section.

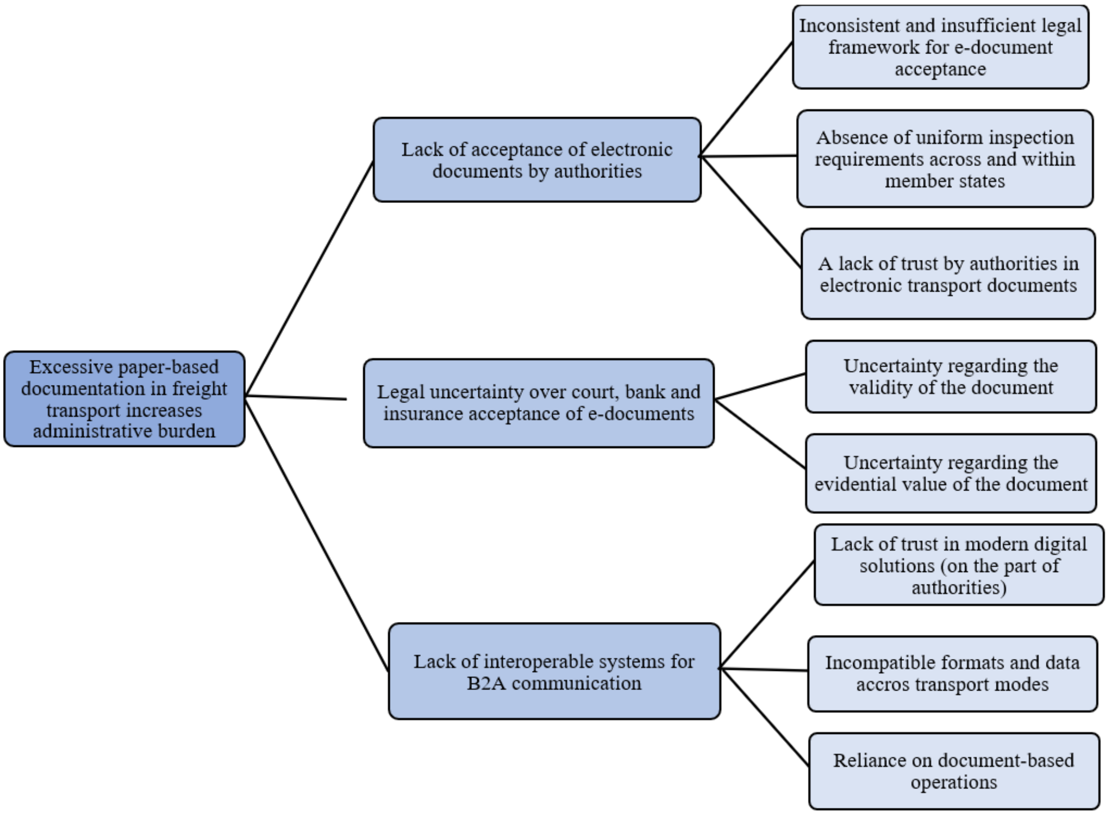

Figure 1. Problems in the e-document implementation (Piers et al., 2018)

Due to the current situation, logistics companies are forced to continue using paper documents, even in EU member states where the legal acceptance of electronic equivalents has been established. This practice is essential for complying with the requirements of member states that still only recognize paper documents and to prevent potential complications during inspections in those member states that do accept e-documents. Several key factors contribute to the inconsistencies in the acceptance of electronic transport documents by authorities (Piers et al., 2018): a fragmented and insufficient legal framework for the acceptance of e-documents, the lack of harmonized inspection requirements across and within member states, and the lack of trust by authorities in electronic transport documents. One of the primary reasons for the rejection of e-documents is the absence of an international convention mandating their acceptance by law enforcement authorities. The number of ratifications is particularly low for road, maritime, and inland waterway transport, although it remains uncertain whether higher ratification rates would resolve the issue. Currently, there is no specific legal document or EU legislative initiative that directly addresses the acceptance of electronic transport documents across all transport modes. It is important to highlight that existing EU regulations do not provide comprehensive guidelines on how competent authorities in member states should conduct inspections of transport documents. With few exceptions, there is no clear specification regarding the form and content of documents required to be deemed valid and legally effective. A significant challenge to the acceptance of e-documents by authorities is the variation in inspection requirements, both within individual countries and between member states. Authorities in different member states follow distinct requirements during inspections conducted under national legislation.

Additionally, the issue of e-document acceptance extends to situations where transport documents within a single member state may be inspected by different authorities. While some authorities may accept e-documents, others may only accept paper versions, even if the paper document is merely a printed copy of the electronic transport document. Inspections of transport documents, depending on the member state and transport mode, are carried out to enforce various regulations related to safety, fiscal policy, customs, environmental protection, security, working conditions, and more (Piers et al., 2018). Another issue is the lack of trust by authorities in the authenticity of e-documents, often due to concerns about falsification or inaccuracies. Some authorities have expressed doubts about their ability to adequately verify the authenticity of submitted e-documents. However, other authorities have pointed out that paper transport documents can also be filled out incorrectly or falsified (Piers et al., 2018).

3.2 Legal Uncertainty Regarding E-Document Acceptance by Courts, Banks, and Insurers

Transport documents play a crucial role in B2B transactions, serving either as proof of the terms of a transport contract or, in some cases, as the transport contract itself. This is particularly relevant where applicable regulations require a specific form to validate a transport contract.

The acceptance of electronic transport documents in court is crucial, as it directly impacts their legal validity. However, paper-based transport documents are often the only ones accepted, while electronic versions are not. Two key issues contribute to the limited or complete non-acceptance of electronic transport documents in legal proceedings (Piers et al., 2018): uncertainty about the document's validity and uncertainty about its evidential value. As previously noted, the acceptance—or lack thereof—of e-documents in national courts is often influenced by the regulatory framework governing transport contracts in individual member states. In some countries, national laws require that transport contracts be in written form (e.g., recorded with handwritten signatures) for them to be valid. However, in countries such as France, Germany, the Netherlands, Denmark, and Spain, transport contracts do not necessarily need to be in paper form to be recognized as valid by national courts. Additionally, in countries like Germany, Sweden, and Spain, even oral transport contracts are considered valid. The question remains whether e-documents would be accepted as valid in other member states' courts. The acceptance of electronic transport documents by banks and insurance companies is closely tied to the acceptance and validity of electronic transport contracts in the judicial system.

3.3 Lack of Interoperable Systems for (Business-to-Administration) B2A Communication

A significant challenge in the acceptance and implementation of e-documents is the lack of interoperable systems for communication between business entities and government institutions or administrations. This lack of interoperability is caused by several factors, including (Piers et al., 2018): A lack of trust in modern digital solutions by authorities, non-interoperable formats and data across different transport modes, and the continued reliance on document-based operations.

One contributing factor to the limited adoption of e-documents is the lack of trust in existing digital solutions. Many authorities are hesitant to trust current technological systems due to concerns about the manipulation of electronically transmitted information, such as the potential for inaccurate cargo value declarations. Before implementing electronic solutions, some member state authorities require assurances regarding the authenticity, availability, and reliability of signatories.

Related to this trust issue is the reluctance to use external platforms for sharing information. Proposed solutions often involve authorities and companies using third-party-managed platforms to exchange information. However, most private companies are wary of sharing data due to competitive concerns, while authorities generally have fewer reservations about participating in such platforms. A major concern for both authorities and private companies is the reliability and impartiality of the platform operator. Many private companies oppose the idea of third parties benefiting financially from their data, even though authorities are typically less concerned about the operator’s role.

Another critical issue contributing to the lack of interoperable systems is the incompatibility of formats and data used across different transport modes. Various authorities operate independently, each with its own datasets, formats, and transmission preferences. This results in the need for multiple, varied data sets and formats, which discourages private companies from adhering to additional regulatory requirements (Piers et al., 2018).

Finally, adherence to document-based operations is another cause of the lack of interoperable systems. Before computers could easily share information, documents were an efficient way to exchange essential data, which recipients would later input into their systems. Data is generated and entered into small internal systems or large enterprise resource planning (ERP) systems, and various stakeholders create data at different stages of transport. Data exchange remains a complex task, as each stakeholder may use a different format. As previously mentioned, these formats are not interoperable, and ensuring compatibility is costly (Piers et al., 2018).

3.4 Policies for Overcoming Barriers to the Implementation of E-Documents in Logistics

Emphasis has been placed on leveraging digital technologies, which enable faster and more secure information exchange—key for successfully managing complex cross-border transport operations. This approach not only enhances the operational aspects of logistics but also strengthens the global market position of European companies through modernization and digitalization of their business processes. The implementation of e-documents can significantly reduce administrative costs, expedite procedures, improve data transparency and accuracy, and further promote a sustainable and integrated European logistics and transport system (Ignat, 2017;

Lyovin & Efimova, 2017; Piers et al., 2018).

To achieve the overarching goal of transitioning from traditional paper-based documents to e-documents in logistics, certain specific goals below must be met across various domains (Piers et al., 2018):

- SG1 – Ensure acceptance of e-documents by authorities and courts,
- SG2 – Ensure acceptance of e-documents by banks and insurance companies,
- SG3 – Support the development of interoperable standards and IT solutions for document exchange.

Regarding SG1, the adoption of digital solutions in the freight transport sector is hindered by a lack of acceptance of e-documents, primarily by public authorities and courts. Courts are further deterred by uncertainties regarding the validity and evidentiary value of such documents. Addressing this goal requires substantial efforts focused on (Piers et al., 2018): developing and implementing common legal frameworks at the EU level to define standards and conditions for the acceptance of e-documents, standardizing inspection requirements, educating and training authorities and courts on the security and validity of e-documents, promoting digital solutions and enhancing cooperation between legal, logistics, and IT sectors.

SG2 focuses on ensuring the effective acceptance of e-documents by banks and insurance companies. Efforts to achieve this goal must include developing and implementing legal provisions obliging the banking and insurance sectors to accept e-documents, defining standardized formats and protocols for e-documents to be used by these sectors, implementing advanced technological tools such as digital signatures and encryption to ensure the authenticity and security of e-documents, training and educating banking and insurance sector employees on the advantages and security of e-documents, enhancing collaboration between the transport, banking, and insurance sectors and introducing incentives for companies adopting electronic solutions, such as tax breaks or subsidies.

SG3 is challenged by the lack of widely interoperable standards and IT solutions that would facilitate interaction between all relevant stakeholders. Efforts to meet this goal must focus on developing common standards, developing and implementing interoperable IT solutions that enable efficient data exchange across different systems and platforms used by transport sector stakeholders, adopting legal frameworks mandating the use of defined standards for data exchange in the transport sector and providing incentives for companies investing in interoperable systems and IT solutions (Piers et al., 2018).

To address the identified challenges, detailed in the previous section, a set of policy measures has been defined, aligned with the specific goals. Based on stakeholder consultations, the EC initially established a set of 28 policy measures. However, to assess their feasibility, additional data were collected from target groups. During this evaluation, the following five criteria were considered (Piers et al., 2018):

a) Legal feasibility,
b) Technical feasibility,
c) Efficiency and effectiveness,
d) Political feasibility,
e) Proportionality.

Following the evaluation based on defined criteria, the number of policy measures was reduced from 28 to 17. These measures primarily focus on harmonizing legislation and administrative processes within the EU, fostering international cooperation to align regulations, and enhancing technical interoperability for the acceptance of electronic documents. Additionally, they include incentives for national authorities and the private sector to develop and implement digital solutions, while strengthening institutional support through strategic initiatives and legal acts. The overall approach aims to improve efficiency, legal certainty, and the broader adoption of electronic transport documents in international business operations. Based on the final list of measures and their initial evaluation, several base policies have been established in agreement with the EC. In addition to the basic option, four additional policies have been formulated below, which gradually build upon each other, ranging from minimal legislative efforts to options with complete obligations for the acceptance of e-documents.

a) BP1: Member states are fully required to adhere to the existing legal framework for e-document acceptance, while implementation remains voluntarily harmonized. Under this policy, the EU enacts a legal measure mandating member states to comply with all relevant international conventions, ensuring a consistent application of provisions related to e-document validity. Furthermore, the Commission encourages various non-binding initiatives to support uniform implementation of the current EU legal framework, including aligning e-document format requirements. BP1 represents a policy with minimal legal intervention.

b) BP2: Authorities are fully required to accept e-documents, with only minimal harmonization of implementation. The EU enacts a legal measure imposing a general obligation on authorities to recognize e-transport documents. This applies to international transport contracts regulated by specific international conventions for different transport modes, as well as any other transport agreements concluded or documented electronically. Additionally, the EC will advocate for the incorporation of mutual e-document acceptance provisions in relevant bilateral agreements between the EU and third countries.

c) BP3: Authorities are fully required to accept regulatory information and/or e-transport documents, with partially harmonized implementation. The EU will enact a legal measure obligating authorities to recognize B2A regulatory data and electronic transport documents as valid. Similar to BP2, the European Commission will support the inclusion of provisions ensuring mutual recognition of e-transport contracts in relevant bilateral agreements between the EU and third countries.

Additionally, the legal act will require the development and adoption of binding technical specifications that define standardized implementation requirements. These specifications will be finalized and enforced through a supplementary act at a later stage. To address sector-specific requirements and varying levels of digitalization in information exchange, technical specifications may be adapted separately for different transport modes, provided that key interoperability principles, such as minimum semantic interoperability, are maintained.

Aligned with the European Interoperability Framework Implementation Strategy, authorities will need to assess their information and data needs to ensure compliance with regulatory requirements. This assessment will define a maximum data set, encompassing all essential information necessary for universal application. This dataset will form the foundation for a unified European "Multimodal Transport Dictionary," which will standardize terminology and definitions for all relevant transport data, enhancing interoperability and facilitating seamless information exchange across transport modes and EU Member States.

d) BP4: Authorities are fully required to accept regulatory information or freight documentation in electronic format, with a fully harmonized implementation. Under this policy, member states must recognize all regulatory data and freight documents in digital form. This means that any information or documentation necessary for regulatory compliance must be accepted electronically by authorities.

The key distinction from BP3, where technical specifications may differ across transport modes, is that BP4 enforces a unified set of technical specifications applicable to all transport modes. This guarantees complete interoperability, ensuring that various authorities' systems can seamlessly function together and exchange information without compatibility issues, regardless of transport mode or legal framework.

The objective of this harmonization is to establish full compatibility between the systems of different member states and the electronic information and documentation submitted by companies to demonstrate regulatory compliance. This approach aims to streamline processes, simplify and standardize communication between companies and authorities, reduce administrative burdens, and enhance operational efficiency.

4. Methodology

The first part of this section defines the relevant criteria to be applied in the multi-criteria analysis. In the second part, two methods were used to determine the preferred policy: the fuzzy SWARA, for determining the weights of the criteria, and ADAM, for establishing the final ranking of the policies.

4.1 Criteria for Evaluating Base Policies

To determine which of the four proposed policies can have the most significant impact on implementing e-documents in logistics, it is necessary to define the criteria for multi-criteria analysis and ranking. For the purposes of the analysis conducted in this study, the following four fundamental criteria were defined (Piers et al., 2018):

- Policy penetration level (policy outreach level). This criterion measures the extent to which a specific policy can be implemented and accepted in practice, assessing how effectively it can increase the adoption of e-documents in logistics. It involves evaluating the applicability of the policy across various sectors and users.
- Economic impact. In the era of rapid digitalization, technological advancements are reshaping all sectors of the economy and public life. The economic impact of transitioning from traditional paper documents to e-documents in logistics can be reflected in the reduction of the following costs (Pankova et al., 2022; Piers et al., 2018): administrative costs for companies, printing and archiving costs, compliance costs for companies, enforcement costs for authorities and compliance costs for authorities.
- Environmental impact. Digitalization has significantly optimized processes and decision-making, contributing to sustainability goals. The adoption of e-documents in logistics supports ecological preservation by reducing greenhouse gas emissions and conserving natural resources. For instance, digital documentation reduces printing requirements, saving substantial resources. It is estimated that over 70% of EU member states expect a reduction of more than 10% in annual paper consumption. A single company adopting digital workflows can save 8–9 trees annually. With the potential for 1.5 billion shipments to go paperless and assuming 1–5 fewer copies of documents per shipment, savings could range between 1.6 and 8.0 billion sheets of paper. This projection only considers the main transport document, not supplementary ones. By digitalizing all accompanying documents—enabled by policies BP3 and BP4 – these savings could be even greater (Peng et al., 2023; Piers et al., 2018).
- Social impact. Digitalization, defined as the introduction of digital technologies into various public domains, significantly affects society, particularly in applying e-documents in logistics. This influence spans four public domains: economic, political, social, and spiritual. These domains represent fundamental societal needs, such as employment, participation in public and state life, social engagement, and spiritual development. Digitalization impacts key social aspects, including (Piers et al., 2018; Travkina, 2022): working conditions, safety and security, protection of personal and commercial data and employment levels.

4.2 Evaluation and Ranking of Policies

Decision-making is a structured process that typically involves four stages: identifying the issue, determining preferences, evaluating alternatives, and selecting the most suitable option. This process also incorporates three types of analysis, as outlined by Thakkar (2021). Descriptive analysis requires the decision-maker to actively interpret and draw conclusions from data presented in graphical or tabular formats. Prescriptive analysis focuses on methods that improve the decision-maker's ability to analyze and assess alternatives effectively. Normative analysis deals with complex problems that demand the decision-maker's deep involvement in evaluating various arguments, balancing both positive and negative perspectives, and requiring consensus-building to reach a decision.

In daily life, decisions are often made based on multiple criteria, with different weights assigned to each by expert groups. Multi-Criteria Decision-Making (MCDM) helps in structuring and solving problems where multiple criteria need to be considered. Problem-solving can be interpreted in several ways, such as selecting the "best" alternative from a set of options, where "best" refers to the most preferred choice according to the decision-maker. Alternatively, it might involve selecting a small set of good alternatives or grouping them into different preference categories. An extreme interpretation could be identifying all efficient or non-dominated alternatives (Aruldoss et al., 2013).

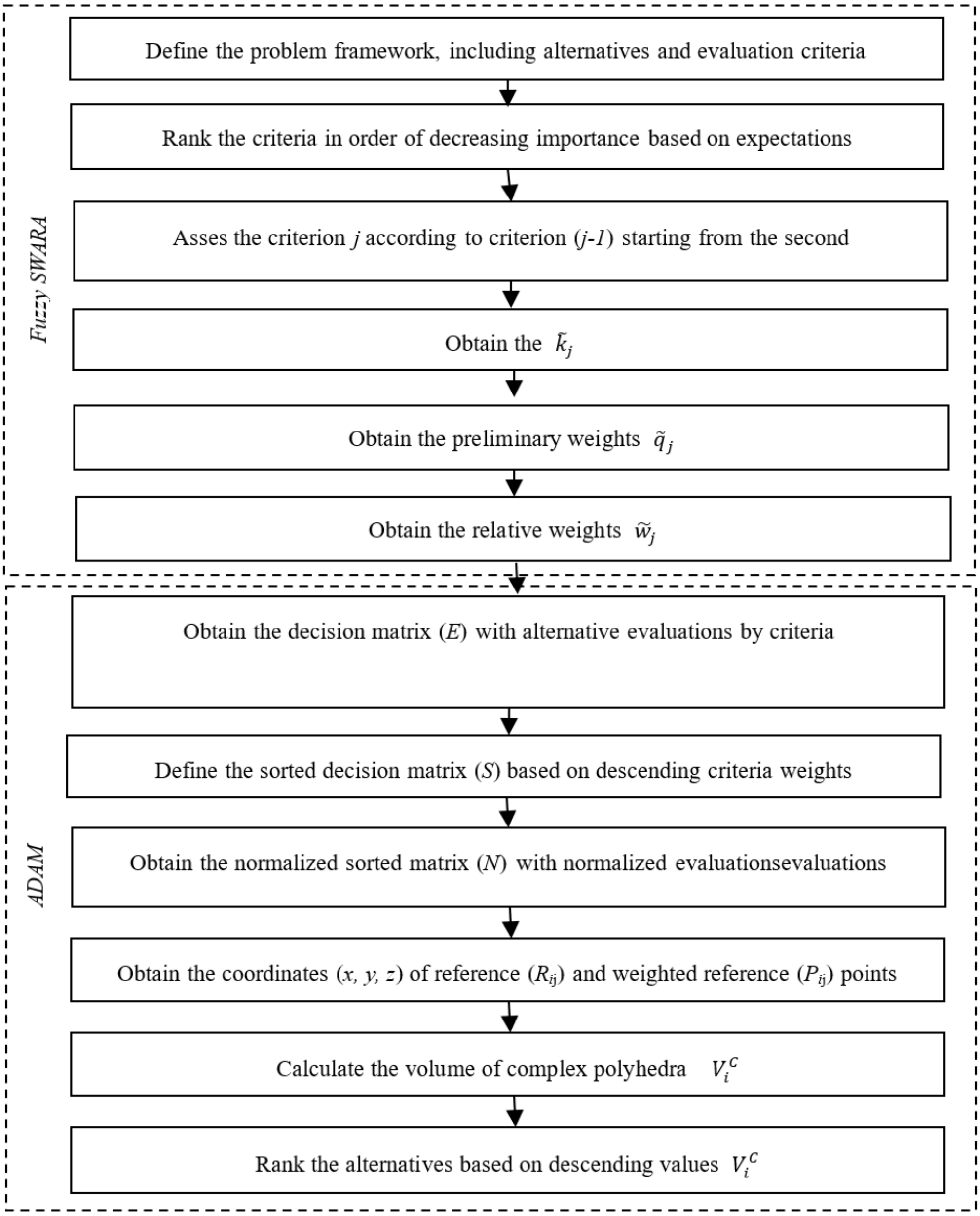

Figure 2. Steps in the applying the fuzzy SWARA and ADAM methods (based on Krstić et al., 2019; Krstić et al., 2023)

When decisions are based on a single criterion, the process is typically straightforward, with the alternative having the highest preference chosen. However, the decision-making process becomes more complex when multiple conflicting criteria are involved, each with varying weights. This complexity requires methods that can accommodate trade-offs between criteria and alternatives, reflecting the decision-maker's real concerns.

To identify the preferred policy in this study, two MCDM methods are applied: fuzzy SWARA for determining the weights of criteria and ADAM for ranking the policies. Fuzzy SWARA is an extension of the SWARA method, adapted to work in a fuzzy environment, and is used to assign weights to criteria in decision-making processes. The steps for applying the fuzzy SWARA and ADAM methods are illustrated in Figure 2, with detailed explanations provided in the following sections.

The SWARA method is particularly valuable when evaluating and ranking interdependent criteria, especially those whose importance can vary based on the specific conditions or preferences of decision-makers. It was developed as an alternative to traditional methods that do not fully account for subjective assessments. Recently, SWARA has been applied across a range of fields, including supplier selection, product design, energy systems sustainability, machine tool selection, and landslide risk assessment (Krstić et al., 2019).

One of the primary advantages of SWARA is its simplicity and ease of use, which makes it effective for both group and individual decision-making. The method's algorithm is straightforward and quick to implement. However, its main disadvantage lies in its subjectivity, as different experts may offer conflicting assessments, influencing the outcomes. The quality of results also depends heavily on the expertise and experience of those assigning weights.

Although SWARA is effective for evaluation and decision-making, it faces challenges such as imprecise or ambiguous judgments due to incomplete or hard-to-process information. To address this, fuzzy set theory can manage the uncertainty and vagueness in decision-making and better represent decision-makers' preferences. Fuzzy SWARA is an extension of SWARA that incorporates fuzzy set theory to handle the ambiguity and imprecision in criteria evaluation, making it particularly useful when decision-makers cannot express preferences with absolute certainty.

First, decision-makers need to define the problem structure, that is, form a set of alternatives and a set of criteria for evaluating the alternatives. It is also necessary to define a fuzzy scale for evaluating the criteria and alternatives. The fuzzy scale consists of seven linguistic ratings. The lowest rating, "None" (N), corresponds to the values (1,1,2), followed by "Very low" (VL) with values (1,2,3) and "Low" (L) with (2,3,4). "Moderately low" (ML) is defined by (3,4,5), while "Medium" (M) corresponds to (4,5,6). Higher ratings include "Moderately high" (MH) with values (5,6,7), "High" (H) with (6,7,8), and the highest rating, "Very high" (VH), corresponding to (7,8,9).

Once the ratings are defined, decision-makers rank the criteria in order of importance, either individually or through consensus. Next, the importance of each criterion is evaluated relative to the previous one, starting from the second criterion.

This relationship is called the comparative significance of the average value and is denoted as $\tilde{s}_j$, where $\tilde{s}_j = (l_j, m_j, u_j)$ for *j* = *1*, ..., *m*, which is a triangular fuzzy number corresponding to the linguistic rating (Table 1). The labels *l*, *m*, and *u* represent the lower, middle, and upper values of the triangular fuzzy number.

Table 1. Results of applying the fuzzy SWARA method to determine criteria weights

		$\tilde{s}_j$	$\tilde{k}_j$	$\tilde{q}_j$	$\tilde{w}_j$	**Criteria Weight**
C1	/	/	(1.00, 1.00, 1.00)	(1.00, 1.00, 1.00)	(0.40, 0.45, 0.49)	0.447
C9	VH	(7, 8, 9)	(1.78, 1.89, 2.00)	(0.50, 0.53, 0.56)	(0.20, 0.23, 0.27)	0.232
C10	H	(6, 7, 8)	(1.67, 1.78, 1.89)	(0.27, 0.30, 0.34)	(0.11, 0.13, 0.16)	0.131
C2	MH	(5, 6, 7)	(1.56, 1.67, 1.78)	(0.15, 0.18, 0.22)	(0.06, 0.08, 0.10)	0.079
C4	MH	(5, 6, 7)	(1.56, 1.67, 1.78)	(0.08, 0.11, 0.14)	(0.03, 0.05, 0.07)	0.048
C5	MH	(5, 6, 7)	(1.56, 1.67, 1.78)	(0.05, 0.06, 0.09)	(0.02, 0.03, 0.04)	0.029
C6	MH	(5, 6, 7)	(1.56, 1.67, 1.78)	(0.03, 0.04, 0.06)	(0.01, 0.02, 0.03)	0.018
C7	L	(2, 3, 4)	(1.22, 1.33, 1.44)	(0.02, 0.03, 0.05)	(0.01, 0.01, 0.02)	0.013
C3	ML	(3, 4, 5)	(1.33, 1.44, 1.56)	(0.01, 0.02, 0.04)	(0.005, 0.01, 0.02)	0.009
C8	M	(4, 5, 6)	(1.44, 1.56, 1.67)	(0.007, 0.01, 0.02)	(0.003, 0.01, 0.01)	0.006
C11	M	(4, 5, 6)	(1.44, 1.56, 1.67)	(0.004, 0.008, 0.02)	(0.002, 0.004, 0.01)	0.004

After evaluating the relative significance of the criteria, it is necessary to determine the coefficient $\tilde{k}_j$, calculate the preliminary weight value $\tilde{q}_j$, and compute the relative weights $\tilde{w}_j$ in Eqs. (1)-(3), respectively.

$$\tilde{k}_j = \begin{cases} (1,1,1), \; j=1 \\ \left(l_j / \max_j u, m_j / \max_j u, u_j / \max_j u \right) \oplus (1,1,1), \; j > 1 \ldots n \end{cases} \tag{1}$$

$$\tilde{q}_j = \begin{cases} (1,1,1), j = 1 \\ \tilde{q}_{j-1} \div \tilde{k}_j, j > 1 \dots n \end{cases} \tag{2}$$

$$\tilde{w}_j = \tilde{q}_j \div \sum_j \tilde{q}_j \tag{3}$$

After determining the criteria weights, the ADAM method ranks the alternatives by using geometric MCDM techniques to calculate the volumes of polyhedra defined by points in three-dimensional space. These points are categorized into origin (*O*), reference (*R*), and weighted reference (*P*) points, with the coordinates of reference points reflecting an alternative's value for a criterion, and weighted points factoring in the criterion's weight. The alternatives are ranked based on the polyhedra volumes.

The first step is to define the decision matrix (*E*), which contains the ratings of alternatives according to the criteria (1-10) or vector intensities representing their values.

$$E = [e_{ij}]_{m \times n} \tag{4}$$

where, *m* is the total number of alternatives, and *n* is the total number of criteria.

Next, two decision matrices are defined: the sorted decision matrix (*S*), where ratings are arranged in descending order based on criterion weights, and the normalized decision matrix, containing the normalized ratings (n_{ij}). The mathematical derivations for these steps follow.

$$S = [s_{ij}]_{m \times n} \tag{5}$$

$$n_{ij} = \begin{cases} \dfrac{S_{ij}}{\max\limits_i S_{ij}}, za j \in B \\ \dfrac{\min\limits_i S_{ij}}{S_{ij}}, za j \in C \end{cases} \tag{6}$$

where, *B* is the set of criteria used, and *C* is the set of cost criteria.

The next step involves finding the coordinates (*x*,*y*,*z*) of the reference points (R_{ij}) and weighted reference points (P_{ij}) that define the complex polyhedron as follows:

$$x_{ij} = n_{ij} \times sin\alpha_j, \forall j = 1, \dots, n; \forall i = 1, \dots, m \tag{7}$$

$$y_{ij} = n_{ij} \times cos\alpha_j, \forall j = 1, \dots, n; \forall i = 1, \dots, m \tag{8}$$

$$z_{ij} = \begin{cases} 0, za R_{ij} \\ \tilde{w}_j, za P_{ij} \end{cases} \tag{9}$$

where, α_j is the angle that determines the direction of the vector defining the value of the alternative, and it is obtained as follows:

$$\alpha_j = (j - 1) \frac{90°}{n - 1}, \forall j = 1, \dots, n \tag{10}$$

Next, calculate the volumes of the complex polyhedra by summing the volumes of the pyramids they comprise, using the following equation:

$$V_i^C = \sum_{k=1}^{n-1} V_k, \forall i = 1, \dots, m \tag{11}$$

where, V_k is the volume of the pyramid, which is calculated using the following equation:

$$V_k = \frac{1}{3} B_k \times h_k, \forall k = 1, \dots, n - 1 \tag{12}$$

where, B_k represents the surface area of the pyramid's base, defined by the reference and weighted reference points of two consecutive criteria, and is calculated as follows:

$$B_k = c_k \times a_k + \frac{a_k \times (b_k - c_k)}{2} \quad (13)$$

where, a_k is the Euclidean distance between the reference points of two consecutive criteria, and is calculated using the following equation:

$$a_k = \sqrt{(x_{j+1} - x_j)^2 + (y_{j+1} - y_j)^2} \quad (14)$$

where, b_k and c_k are the vector intensities corresponding to the weights of two consecutive criteria, and are calculated using the following equations:

$$b_k = z_j \quad (15)$$

$$c_k = z_{j+1} \quad (16)$$

where, h_k is the pyramid's height from the base to the apex at the origin (O), calculated as follows:

$$h_k = \frac{2\sqrt{s_k(s_k - a_k)(s_k - d_k)(s_k - e_k)}}{a_k} \quad (17)$$

where, s_k is the semiperimeter of the triangle defined by the coordinates of two consecutive criteria and the coordinate origin, and is calculated using the following equation:

$$s_k = \frac{a_k + d_k + e_k}{2} \quad (18)$$

where, d_k and e_k are the Euclidean distances from the reference points of two consecutive criteria to the coordinate origin, and they are calculated using the following equations:

$$d_k = \sqrt{x_j^2 + y_j^2} \quad (19)$$

$$e_k = \sqrt{x_{j+1}^2 + y_{j+1}^2} \quad (20)$$

Finally, it is necessary to rank the alternatives according to the descending values of the volumes of complex polyhedra $V_i^C (i = 1, \ldots, m)$. The best alternative is the one with the highest volume value.

5. Solving the Problem

In the modern business environment, electronic data exchange is becoming increasingly important, particularly in the logistics sector. The EU has long been striving to standardize and digitalize logistics documents, aiming to improve efficiency, reduce costs, and enhance interoperability among member states. In this context, several policies (BP1, BP2, BP3, and BP4) have been proposed to promote the adoption and implementation of e-documents across the EU.

Each of these policies involves different costs, risks, and potential benefits. Selecting the most suitable policy is a challenge, as it requires consideration of multiple criteria, including economic, technical, and regulatory aspects, as well as the impact on stakeholders and sustainability.

This case study applies the methodology outlined in the previous section to systematically and structurally identify the most advantageous base policy. The methodology allows for the integration of diverse criteria, considering their relative importance, uncertainties in evaluation, and the complexity of interrelationships among them. This approach enables deeper analysis and more objective decision-making, providing a solid foundation for the recommendations presented in the concluding section of the study.

To select the optimal policy, four groups of criteria with corresponding subcriteria were defined: the degree of policy penetration (policy reach – C1), economic impact (savings in administrative costs for companies – C2; savings in printing and archiving costs – C3; compliance costs for companies – C4; implementation costs for authorities – C5; compliance costs for authorities – C6), environmental impact (reduction in paper usage – C7), and social impact (working conditions – C8; safety and security – C9; protection of personal and commercial data

– C10; employment rate – C11).After defining the alternatives, i.e., the base policies (BP1, BP2, BP3, and BP4) and the criteria for their evaluation, the criteria weights were determined using the fuzzy SWARA method (Table 1).

The ranking of criteria is based on their relative significance in the context of selecting the best base policy (BP1, BP2, BP3, and BP4) for the adoption of e-documents. The extent of policy reach (C1) is the most important criterion, as it directly reflects how successfully the policy can be implemented and accepted. This criterion encompasses the scope of impact and the efficiency of policy implementation in practice, which is crucial for ensuring the widespread adoption of e-documents. If the policy fails to achieve a high level of reach, all other factors, such as cost savings and reductions, become irrelevant since the policy's effects cannot be fully realized. Security and safety (C9) is the second most significant criterion because data protection is of paramount importance in the digital era. As e-documents become the standard, it is essential to ensure that this data is secure from unauthorized access and other forms of misuse. However, the security and safety criterion is less important than the extent of policy reach, as high security standards cannot be applied system-wide without widespread implementation. The protection of personal and commercial data (C10) is closely related to C9 but is more focused on specific aspects of data protection, such as confidentiality and data integrity. This criterion is significant because it ensures that digitalization and increased efficiency do not compromise the rights and security of users. However, due to its specificity, it is ranked below general security and safety. Savings in administrative costs for companies (C2) are next in importance. The digitalization of documentation promises significant savings in administrative costs, which is essential for companies operating within and outside the borders of EU member states. While security and data protection are crucial for the system's operational functionality, economic effects, such as cost savings, have a strong influence on the acceptance and sustainability of the policy. Compliance costs for companies (C4) are important but slightly less significant than savings in administrative costs. A successful policy should ensure that the costs companies must bear to comply with new requirements are minimal since high compliance costs can discourage companies from fully embracing the new policy. Implementation costs for authorities (C5) are ranked immediately behind compliance costs for companies, as high implementation costs may pose a barrier to the effective execution of the policy at the national level. If the costs for authorities are high, this could result in slower or limited policy implementation. Compliance costs for authorities (C6) are important but less so than implementation costs, as authorities generally have greater capacity to meet compliance requirements compared to the private sector. Paper usage reduction (C7) comes after the costs, as although the ecological aspect is important, it does not directly affect the operational or economic performance of companies or authorities to the same degree as the previous criteria. Savings in printing and archiving costs (C3) are associated with paper usage reduction but are more specific and operational in nature. These savings are significant but less critical compared to broader administrative cost savings. While working conditions (C8) and employment rates (C11) are important, their direct effects on the efficiency and implementation of the policy are not as pronounced as those of other criteria. Working conditions are crucial for long-term sustainability but are less critical in the context of implementing digital policies. Employment rates have an indirect impact and are therefore the least significant compared to all other criteria. This ranking of criteria allows for a focus on the aspects of the policy that are essential for its successful implementation, while also recognizing and addressing all other important factors that may influence the final selection of the optimal policy.

After carefully defining and ranking the criteria using the fuzzy SWARA method, the next step in the evaluation process is the ranking of alternatives. This process was conducted using the ADAM method, which enables a comprehensive comparison of policies based on multiple criteria. The application of the ADAM method ensures that each alternative is assessed based on relevant factors, allowing for decision-making aligned with the established goals and priorities. Table 2 presents the scores of the alternatives (policies) concerning the criteria, while Table 3 provides the final ranking of each previously described policy.

Table 2. Evaluation of alternatives concerning criteria

Alternatives/Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
BP1	3	2	1	2	2	2	3	2	3	4	4
BP2	5	5	4	6	4	6	5	4	5	5	6
BP3	8	8	7	8	8	8	8	8	8	9	8
BP4	9	8	9	9	8	9	8	8	8	9	8

Table 3. Ranking of base policies using the ADAM method

Alternatives	Volume of the Polyhedron	Rank
BP1	0,00883	4
BP2	0,013075	3
BP3	0,032919	2
BP4	0,034963	1

The final ranking of the policies (BP1, BP2, BP3, and BP4), obtained through the application of the ADAM method, clearly shows which policy best aligns with the set goals and criteria. The highest rank for BP4 indicates its superiority over the other options, while BP3 and BP2 are ranked second and third, respectively, and BP1 occupies the last position. This ranking is not just a result of mathematical analysis, but also a reflection of the broader impact that each policy can have on companies, governments, and society as a whole.

BP4 is rated as the most efficient policy, primarily due to its ability to achieve a high degree of harmonization among EU member states. Complete harmonization allows for a unified and consistent application of regulatory information and documents in logistics, which significantly reduces administrative barriers and facilitates the integration of digital solutions. This leads to the greatest savings in administrative costs, a reduction in compliance costs for companies, and the optimization of operational processes. BP4 not only brings the highest benefits in terms of cost reduction but also enables companies to more efficiently adapt to new regulations, thereby reducing the risk of non-compliance and associated penalties. Another reason BP4 is ranked as the best policy is its positive impact on ecological aspects of business operations. Complete harmonization of digital documents significantly reduces the need for printing and archiving paper documents, directly contributing to the preservation of natural resources and reducing carbon emissions. This is particularly important in the context of European policies that increasingly emphasize sustainability and environmental protection. BP4 enables significant savings not only in costs but also in resources, making it an extremely attractive option for all stakeholders.

BP3, which is second in efficiency, also offers substantial benefits but cannot be fully measured against BP4. The partial harmonization offered by BP3 allows for savings and optimization of operational processes but leaves a certain level of flexibility for member states (due to different technical specifications for different modes of transport). This flexibility, while useful in some cases, may lead to variations in implementation that reduce the overall effectiveness of the policy. Nevertheless, BP3 is a very solid option as it allows for significant savings and improvements in security and operational standards in transport. Companies operating in multiple EU member states can benefit from partial standardization, but may face additional compliance costs due to inconsistencies in application across different jurisdictions.

BP2 provides good results, but its impact is limited due to minimal harmonization of implementation. BP2 allows member states to adopt e-documents but without a clear framework for harmonization, leading to inconsistent application. This policy can bring significant savings, especially in sectors such as road and air transport, but its efficiency is lower compared to BP3 and BP4 due to less consistency and standardization. BP2 is a good option for companies that seek quick implementation with relatively low costs, but in the long term, it may not achieve the same level of optimization and benefits as BP3 or BP4.

BP1, which is ranked the lowest, provides the least benefits in terms of cost reduction and increased efficiency. Although BP1 offers some savings, these are significantly lower compared to the other policies due to voluntary harmonization of implementation. This approach allows member states to maintain a high degree of flexibility, which may be useful in certain contexts but simultaneously reduces the possibility of achieving wide reach and a high degree of standardization. As a result, BP1 has a limited impact on reducing compliance and administrative costs, making it the least desirable option in this context.

The final ranking is therefore not surprising given the advantages that BP4 offers over the other policies. This policy enables maximum cost reduction, process optimization, and improvement in security standards, while also providing the greatest benefits in terms of ecological sustainability. BP3 and BP2 are favorable alternatives but with certain limitations, while BP1, although useful in specific situations, does not offer the same advantages as the other options. This ranking allows for decision-making aligned with the set goals and priorities of the policy.

However, to assess the stability of the decision made, a sensitivity analysis must be conducted. The goal is to assess how changes in the importance of the most significant criteria affect the final ranking of the alternatives.

To obtain a more complete insight into the stability of the decisions made, the sensitivity analysis was conducted through three iterations, in which the importance of the three most significant criteria was reduced: C1 (degree of policy reach), C9 (security and safety), and C10 (protection of personal and commercial data).

In the first iteration, the focus was on criterion C1, which was initially rated as the most important criterion. Through this iteration, the importance of C1 was gradually reduced, first by 25%, then by 50%, then by 75%, and finally completely eliminated. After each change, a re-ranking of the alternatives was conducted to determine how the reduction in the importance of C1 affects the final results. Table 4 shows the rankings of the policies after reducing the weight of criterion C1.

Table 4. First iteration-reducing the importance of criterion C1

	Reduction by 25%		**Reduction by 50%**		**Reduction by 75%**		**Elimination of C1**	
Alternatives	V_i^C	**Rank**	V_i^C	**Rank**	V_i^C	**Rank**	V_i^C	**Rank**
BP1	0.0085	4	0.0079	4	0.0074	4	0.0073	4
BP2	0.012	3	0.011	3	0.0087	3	0.0077	3
BP3	0.03	2	0.027	2	0.22	2	0.019	2
BP4	0.032	1	0.029	1	0.23	1	0.019	1

After the first iteration, the original weight of criterion C1 was restored, and the same procedure was applied to criterion C9 during the second iteration. As with C1, the importance of C9 was reduced in four steps, and the ranking results were analyzed to determine whether and to what extent changes in this criterion affect the selection of the optimal policy. Table 5 shows the rankings of the policies after reducing the weight of criterion C9.

In the third and final iteration, the process was repeated for criterion C10. As with the previous two criteria, the weight of C10 was gradually reduced until it was eliminated. Table 6 shows the rankings of the policies after reducing the weight of criterion C10.

The conclusion drawn from the sensitivity analysis confirms the exceptional stability of the solution. Although the importance and weight of the three most important criteria (C1, C9, and C10) were reduced during the iterations, the ranking of the policies remained unchanged. BP4 remained the preferred alternative in each iteration, indicating its significant advantage over the other policies, regardless of variations in priorities.

This result shows that BP4 not only dominates due to its initial ranking based on the given criteria but also because of its comprehensive strength in achieving policy goals across different scenarios. This makes it the safest choice. It not only meets the established criteria but is also resistant to changes in priorities. Such stability ensures the long-term success and sustainability of the policy, even in the case of changes in the regulatory or operational environment.

Table 5. Second iteration-reducing the importance of criterion C9

	Reduction by 25%		**Reduction by 50%**		**Reduction by 75%**		**Elimination of C9**	
Alternatives	V_i^C	**Rank**	V_i^C	**Rank**	V_i^C	**Rank**	V_i^C	**Rank**
BP1	0.0084	4	0.0082	4	0.0078	4	0.0081	4
BP2	0.012	3	0.011	3	0.0096	3	0.0092	3
BP3	0.03	2	0.027	2	0.25	2	0.023	2
BP4	0.032	1	0.029	1	0.26	1	0.025	1

Table 6. Third iteration-reducing the importance of criterion C10

	Reduction by 25%		**Reduction by 50%**		**Reduction by 75%**		**Elimination of C10**	
Alternatives	V_i^C	**Rank**	V_i^C	**Rank**	V_i^C	**Rank**	V_i^C	**Rank**
BP1	0.0086	4	0.0083	4	0.0071	4	0.0082	4
BP2	0.012	3	0.012	3	0.012	3	0.012	3
BP3	0.03	2	0.03	2	0.27	2	0.029	2
BP4	0.033	1	0.032	1	0.29	1	0.031	1

6. Conclusions

The conclusion of this study provides a comprehensive insight into the challenges and opportunities related to the implementation of e-documents in logistics, as well as the roles that different policies can play in overcoming the barriers limiting the wider use of these solutions. The goal of this study was to identify key obstacles slowing down the digitization process in the logistics sector and to propose policies that would enable a more efficient and comprehensive implementation of e-documents. The focus was on analyzing how different policies can be implemented to achieve this goal, with particular emphasis on the impact of these policies on operational costs, legal compliance, and socio-environmental aspects of business.

Through a detailed analysis of different policies (BP1, BP2, BP3, and BP4), as well as the application of multi-criteria analysis using the fuzzy SWARA and ADAM methods, it was concluded that different policies have varying effects on the key aspects of e-document implementation. The analysis showed that policy BP4, which involves complete harmonization of implementation and the obligation to accept regulatory information and e-documents, is the most efficient option for achieving the objectives of this paper.

BP4 stands out as the preferred policy primarily due to its ability to achieve a high degree of harmonization among member states, allowing for consistent and unified implementation of e-documents across the entire logistics chain. This policy not only reduces administrative barriers and costs but also facilitates alignment with international standards, which is a key factor for companies operating in global markets. BP4 also has a significant positive impact on minimizing the risk of non-compliance and related legal sanctions.

Additionally, BP4 contributes to environmental sustainability by reducing the use of paper documents, in line with global trends toward green transition and sustainable development. This policy allows for the maximum reduction of costs related to printing and archiving documents, thereby further improving operational efficiency and reducing the environmental footprint of companies. These economic and environmental benefits, combined with the high level of security and data protection offered by BP4, make this policy the optimal choice for increasing the use of e-documents in logistics.

On the other hand, BP3, which ranks second, also offers significant advantages but is somewhat less efficient compared to BP4 due to partial harmonization of implementation. BP2 and BP1, while useful in specific contexts, have a more limited impact on the implementation of e-documents, primarily due to less obligation and inconsistency in implementation among member states.

These conclusions indicate that in order to achieve a significant increase in the use of e-documents in logistics, it is necessary to adopt a policy that ensures complete harmonization and mandatory implementation, enabling a unified and efficient transition to digitization. BP4 proved to be the most robust option, capable of delivering the most significant impact on improving the efficiency of logistics processes, reducing costs, enhancing data security, and achieving environmental goals.

Based on the above, it can be concluded that for the successful implementation of e-documents in logistics, it is crucial to focus on policies that offer a high degree of standardization and obligation in order to achieve the widest and most efficient application. Only through consistent and comprehensive implementation of such policies can long-term goals of digitization and sustainable development in the logistics sector be achieved.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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