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Ranking Logistics System Configurations Based on Flexibility and Elasticity: A Case Study Using IMF SWARA-MABAC Approach

Zhouyu Zeng[1], Jinbo Song[1,2,*], Mengchun Zhou[3], Jianjun Wang[4]

1 School of Transportation Management, Jiangxi Vocational and Technical College of Transportation, Nanchang 330013, China
2 Key Laboratory of Maintenance and Intelligence of Transportation Infrastructure of Jiangxi Education Institutes, Nanchang 330013, China
3 Shangpu Expressway Project Construction Management Co., Ltd. in Shangrao City, Shangrao 334499, China
4 Jiangxi Provincial Highway and Bridge Engineering Co., Ltd, Nanchang 330013, China

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ABSTRACT

Flexibility equips organisations with the capability to respond effectively to fluctuating market dynamics. This encompasses managing delivery delays, modifying delivery schedules and frequencies, and accommodating alterations in order requirements. Multiple forms of flexibility exist, each possessing unique attributes, which are explored further within the study. Conversely, elasticity within logistics typically denotes the supply chain's ability to reorganise and preserve core functions amidst internal or external disruptions. It represents the system's potential to either restore its original condition or adapt to altered circumstances while maintaining an acceptable performance threshold. Given these considerations, the relevance of flexibility and elasticity to a logistics enterprise and its operational mechanisms is apparent. In response to this, the central objective of the study was to construct a detailed framework for ranking logistics systems according to these two attributes. To achieve this, the Improved Fuzzy Stepwise Weight Assessment Ratio Analysis (IMF SWARA) technique was applied to ascertain the weighting of evaluation criteria, whereas the Multi-Attributive Border Approximation Area Comparison (MABAC) method facilitated the ranking procedure. The framework was tested by assessing five separate logistics systems across six pertinent criteria. Results demonstrated that, in terms of both flexibility and elasticity, Alternative A5—Automated Smart Logistics incorporating Internet of Things (IoT) sensors—emerged as the most effective system.

1. Introduction

To remain viable and competitive within unpredictable and rapidly evolving markets, companies must possess the capacity to respond effectively to the shifting demands and expectations of their customer base. Contemporary consumers increasingly require tailored conditions concerning the design, production, and delivery of goods and services. Within this context, flexibility has become a critical concept, denoting a system's ability and readiness to swiftly adjust to changing conditions and customer preferences [9; 12; 13; 15; 17; 21; 24]. Enhancing flexibility not only improves customer

* *Corresponding author.*
E-mail address: 320220944270@lzu.edu.cn

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satisfaction but also fosters loyalty, which is vital for sustained business success across sectors. A satisfied clientele enhances an organisation's reputation and strengthens its competitive standing, thereby opening avenues for growth and the attraction of new consumers.

In logistics systems, flexibility is recognised as a key enabler of improved operational efficiency. The ability to respond promptly to fluctuating market scenarios and unexpected disruptions is a fundamental goal for contemporary logistics operations. Service providers in this domain are frequently expected to raise service quality levels to ensure timely and appropriate responses. Flexibility, in terms of performance, functions as a structural mechanism that promotes consistent and reliable operations even amidst environmental variability. Given the prevalent disturbances and uncertainties in logistics networks, investing in flexibility represents a strategic approach to enhancing responsiveness in the face of emergent challenges. Alongside flexibility, elasticity is also an essential attribute within logistics systems and broader supply chains [8, 9]. Elasticity refers to the system's capacity to recover from disruptions, adjust to unforeseen events, and resume operations under either standard or revised conditions. This attribute is typically assessed by measuring the time required for the system to revert to its functional state and maintain core activities. A shorter recovery time indicates a higher level of elasticity.

Considering the growing intricacy of global logistics frameworks, this study seeks to develop a comprehensive decision-making model for evaluating flexibility and elasticity within logistics systems. Through the application of Multi-Criteria Decision-Making (MCDM) methodologies, the research introduces a systematic approach for assessing and ranking different logistics configurations. This enables decision-makers to identify the most effective strategies for cultivating adaptive and resilient logistics infrastructures. Accordingly, the IMF SWARA technique was employed to determine the weighting of evaluation criteria, while the MABAC method facilitated the ranking of logistics alternatives. The structure of this paper is outlined as follows: Section 2 discusses the theoretical background on flexibility and elasticity and provides a review of the relevant literature. Section 3 introduces the proposed framework, incorporating the IMF SWARA and MABAC approaches. Section 4 details the case study and presents the corresponding application outcomes. Finally, Section 5 contains the concluding observations.

2. Background with Literature Review

2.1 Flexibility

Logistics flexibility is recognised as a multifaceted and intricate concept. It encompasses a variety of forms within logistics operations, including flexibility in procurement, delivery, and the ability to adjust supply and demand parameters. Through effective flexibility, companies are better equipped to navigate fluctuating market conditions, such as delivery delays, alterations in delivery schedules or frequencies, and changes to order specifications. A comprehensive understanding of logistics flexibility requires differentiation among its attributes, capabilities, and constituent components [22]. Attributes of flexibility pertain to the expansion and adaptability of the range of goods and services provided. Achieving flexibility should not entail excessive time consumption, elevated costs, or a reduction in the quality of products or services. Flexibility capability refers to a firm's internal operational structure—specifically, the way its processes and functions are carried out. These are internally driven activities that contribute to customer value creation, albeit not directly visible to the customer. The components of flexibility typically include supply chain adaptability, physical distribution responsiveness, procurement flexibility, and demand management practices. Attaining a high degree of flexibility requires strategic planning and oversight of logistics processes spanning the entire product or service lifecycle, from production through to consumption. Facilitating information

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flow and maintaining transparency across all levels of the supply chain are essential to enhancing system flexibility.

The challenges imposed by globalisation, rapid technological advancement, and innovation have introduced increasingly complex, unpredictable, and dynamic environments for modern enterprises. As customer requirements continue to evolve, firms strive to bolster their flexibility to manage rising uncertainty and volatility. To effectively deliver customer value, organisations must consider flexibility from a holistic perspective, encompassing the full supply chain or value chain. Flexibility at each stage of the supply chain is instrumental in improving customer experience, which, in turn, enhances satisfaction levels. Various forms of flexibility can affect customer satisfaction differently. Since business success is significantly dependent on meeting consumer needs, organisations that retain high levels of customer satisfaction and loyalty tend to achieve greater profitability and long-term growth prospects.

Flexibility may also be evaluated through three primary lenses: economic, organisational, and production or operational perspectives. From an economic viewpoint, system flexibility is assessed based on total operational costs. A flexible system maintains relatively stable average costs, avoiding major fluctuations. Profitability increases when the system can adapt swiftly to changing market positions, underscoring its efficiency in responding to demand shifts. The organisational perspective focuses on the system’s capacity to accommodate change with minimal disruption, relying on the availability of suitable internal and external resources. This reflects the resilience of the organisation's structure and its ability to preserve operational continuity during change. From the production perspective, flexibility is defined as the capacity to modify production tasks, timelines, or even entire processes to meet evolving requirements, enabling adaptation in how manufacturing activities are executed. Flexibility can further be categorised into three hierarchical levels: operational, tactical, and strategic. Operational flexibility pertains to short-term horizons where available resources such as machinery, personnel, and capital remain unchanged. At this level, the system responds within its fixed asset constraints. Tactical flexibility encompasses pre-operational decisions, including the determination of product ranges or design of production systems. Strategic flexibility, on the other hand, refers to long-term adaptability, guiding future market orientation and informing high-level business strategies that influence firm sustainability and competitiveness.

Finally, flexibility can be quantified using two principal dimensions: range and response [1]. The range reflects the number of viable options available for the system to adjust and maintain operation, indicating system efficiency. This may be measured by the count of alternatives or through a standardised index. The response dimension assesses the system’s capacity to implement changes, typically gauged by the time or cost incurred in adapting to disruptions. Together, these dimensions offer a practical basis for evaluating a system’s resilience and adaptability within dynamic and uncertain operational environments.

2.2 Agility

In the business context, agility refers to the capability of an organisation to respond effectively and promptly to continuous change, often driven by the evolving demands of customers. It involves an awareness of uncertainty and the ability to adapt to emergent conditions. Agile operations are characterised by the swift assimilation of diverse knowledge, iterative development processes over short cycles, and continuous feedback collection from end users throughout product or service development. Recognised as a contemporary approach to sustaining competitive advantage [16], agility reflects a firm's readiness to confront unforeseen challenges, mitigate unexpected threats, and harness change as a strategic opportunity. Both agility and flexibility are inherently linked to an organisation's responsiveness to market demands and customer expectations, rendering them critical for maintaining competitiveness. Flexibility, in this context, may be interpreted as the capacity for an efficient response to evolving circumstances.

Although the terms flexibility and agility are frequently used interchangeably, there exist significant conceptual differences between them. From a resource-based perspective, agility is viewed as a core organisational competence that is supported by a range of internal capabilities, notably the various forms of flexibility. Agility is derived from the integrated use of these flexible capabilities within the organisation. While both concepts are interrelated, their emphasis diverges: flexibility pertains to the ability to adapt and reconfigure operations, whereas agility concerns the speed with which such adaptations can be made. In essence, agility signifies the rapidity of organisational response, while flexibility denotes the structural or process-related ability to enact such a response. Hence, while flexibility may exist in the absence of agility, agility cannot be realised without flexibility as its foundation. Moreover, flexibility tends to be internally oriented, focusing on the operational and structural adaptability within the organisation. Agility, in contrast, is externally oriented, involving the use of market intelligence to identify and exploit emerging opportunities in unstable or rapidly changing environments [18]. As an overarching business capability, agility spans across multiple domains including information systems, organisational design, logistics processes, and strategic frameworks. While agility initially emerged as a concept in manufacturing systems, its foundational element—flexibility—has progressively been integrated throughout the entire supply chain, broadening its applicability and strategic significance.

2.3 Elasticity

Elasticity within logistics is interpreted in various ways; however, a widely accepted definition characterises it as the capacity of a supply chain to reorganise and sustain its core functions amidst internal or external disruptions [22]. Fundamentally, elasticity pertains to the system's ability to either revert to its original operational state or adjust to new conditions while maintaining acceptable levels of performance. The degree of supply chain elasticity is commonly evaluated based on the extent of performance degradation and the speed at which standard operations are restored. At a systemic level, this assessment includes the extent to which the regulatory and business environments encourage or facilitate resilience-oriented practices at the organisational level. Elasticity is increasingly recognised as a dynamic capability that reinforces both responsiveness and robustness. While flexibility supports the reconfiguration of activities in response to changes, elasticity encapsulates the system's capacity to absorb disruptions and recover, thereby ensuring operational stability and continuity under uncertain circumstances. This characteristic is particularly relevant in today's complex and globally interconnected logistics networks.

A holistic approach to evaluating supply chain elasticity comprises four principal elements: partnerships, policy, strategy, and information technology [2]. Each element includes defined attributes that assist in enhancing elasticity and establishing tools for monitoring progress. Achieving optimal elasticity and efficiency requires the integration of disciplined analytics, decision-making models, and collaborative efforts among internal and external stakeholders, including operational, technological, and managerial leadership. Elasticity in partnerships is underpinned by long-term collaborative practices within supply chains. Strengthening such partnerships involves improving security measures and promoting the exchange of knowledge and information. The persistent issue of limited transparency in complex supply chains underscores the need for continuous advancement in this area. Many external partners, particularly small and medium-sized enterprises (SMEs), may lack the necessary resources or risk management capabilities. Consequently, developing a deeper understanding of partners and fostering transparent relations, especially with SMEs and a broader range of local participants in emerging markets—is essential for effective risk mitigation.

In the policy domain, regulatory frameworks may at times restrict operational autonomy, potentially constraining the flexibility necessary to enhance elasticity. Conversely, governments play a crucial role in shaping actions of public interest, whether through trade, investment, or security policies, all of which can directly or indirectly affect supply chain elasticity. Policy interventions should strive to maximise operational flexibility during disruptions while also providing incentives that promote elastic behaviours during stable periods. Although infrastructure redundancy is a core feature of supply chain elasticity, deploying additional capacity quickly remains a challenge. As such, governments have a responsibility to support the development of alternative infrastructures at potential chokepoints. Effective policy responses to security risks should also involve consultation with supply chain experts to determine efficient strategies for minimising initial disruptions. Strategic elasticity enables supply chains that are typically formed during periods of stability to remain functional in more volatile settings. Although numerous strategic approaches may be implemented, adaptability remains the most critical determinant in enhancing elasticity. Two organisational capabilities are particularly vital for strengthening supply chain elasticity and bolstering resilience against future disruptions [2]:

- Supply chain entities must possess the capability to integrate both external and internal data sources effectively and respond swiftly to mitigate the effects of disruptions.
- Supply chain configurations need to exhibit adaptability and agility to address shifts in market dynamics and economic conditions with minimal delay.

Within an increasingly interconnected global economy, the development and implementation of such capabilities also enhance the ability to respond to challenges in the public sector. As a result, governmental bodies may benefit from adopting strategies traditionally utilised in the private sector to embed elasticity into their own supply chain frameworks. Although integrating these approaches may necessitate profound organisational and cultural changes, it is imperative that both corporate governance structures and public institutions incorporate these capabilities into their supply networks to promote resilience and maintain sustainable operational continuity. While the concept of resilience frequently appears in academic discourse, it falls outside the scope of this study.

Research over the past two decades has increasingly focused on logistics flexibility, highlighting its conceptual development and various methodological approaches. Most empirical studies examine flexibility at the supply chain level, primarily within the manufacturing industry [4]. One study addressed a flexible delivery routing problem where customer packages can be delivered either directly or through an intermediate station with a separate last-mile service. This research proposed a mathematical programming model supported by a memetic algorithm and performed numerical and parametric analyses to evaluate performance and offer strategic insights for logistics service providers [10]. Another investigation developed optimal capacity planning policies for logistics providers facing uncertain demand due to market disruptions. The findings demonstrated the benefits of adjustable capacity in mitigating ripple effects, which remain relevant even for risk-averse providers [3].

A Physical Internet-based urban logistics distribution model was introduced to manage increasing urban logistics demand while minimising transportation costs. This model focused on process integration and optimisation, enhancing operational flexibility and achieving significant cost advantages compared to traditional logistics systems, especially in expanding distribution infrastructure and handling emergency disruptions [11]. Research into the critical importance of logistics flexibility identified key measurement criteria using the interval-valued Fermatean fuzzy SWARA method, revealing that logistics information integration is paramount, whereas asset efficiency is relatively less important. These insights provide guidance for improving adaptive capabilities in logistics operations [7]. Studies on production capacity management during ongoing uncertainties, such as the COVID-19 pandemic, identified four operational levels of elastic responses and emphasised the significance of resource imitability and substitutability for maintaining competitive advantage. Successful manufacturers blend unique production capabilities with flexible resource management strategies [14]. Research on capacity choices and utilisation under revenue-sharing contracts examined the interaction between capacity, utilisation, and pricing, considering factors like market volatility and product type. The study demonstrated the advantages of vertical integration through coordinated production strategies [8].

Analyses of temporary supply chain disruptions within general equilibrium models revealed that production interruptions lead to declines in shipments and prolonged increases in unfilled order ratios, indicating that even short-term disruptions can have lasting effects on supply chain performance [5]. Further research highlighted the importance of developing resilient supply chain systems to mitigate risks from disruptions such as the COVID-19 pandemic. A novel resilient supply chain system model, incorporating product design changes and a general conceptual framework, quantitatively demonstrated effective loss alleviation by restructuring supply chains to handle raw material shortages [23]. Investigations into healthcare supply chains identified key factors promoting resilience, including supply chain elasticity, operational characteristics, and reporting capabilities. Strategic recommendations were made to enhance resilience in public hospital supply chains using systematic literature reviews and analytic methods [19]. Additionally, the need for a paradigm shift in supply chain and logistics operations was emphasised in response to disruptions highlighted by the COVID-19 pandemic. Key strategies such as supplier diversification, digital technology investments, and flexible manufacturing models were identified as crucial for improving operational resilience in increasingly digitised supply chains [6].

3. Framework for Evaluation

The model developed for evaluating the logistics system employs the IMF SWARA method to calculate criteria weights and the MABAC method for assessing and ranking the logistics system, as illustrated in Figure 1.

Fig.1: Framework Steps

3.1 IMF SWARA Method

The fuzzy SWARA method is effective for determining criteria weights, particularly because it can handle the uncertainty inherent in decision-makers' ideas and the expression of their preferences. The procedure involves the following steps [20]:

Step 1 – Identify and sort the decision-making criteria {c1, c2, …, cn} in descending order of importance.

Step 2 – Compare each criterion Cj to the one ranked just above it (Cj−1). This comparison yields an average comparative significance value ($\overline{s_j}$).

Step 3 – Calculate the fuzzy coefficient $\overline{k_j}$ using Equation (1):

$$\overline{k_j} = \begin{cases} \overline{1} & j = 1 \\ \overline{s_j} & j > 1 \end{cases} \tag{1}$$

Step 4 – Compute the fuzzy value $\overline{q_J}$ using Equation (2):

$$\bar{q_J} = \begin{cases} \bar{1} & j = 1 \\ \frac{\overline{q_{J-1}}}{\overline{k_J}} & j > 1 \end{cases} \tag{2}$$

Step 5 – Calculate the fuzzy weight of each criterion using Equation (3):

$$\overline{w_J} = \frac{\overline{q_J}}{\sum_{j=1}^{m} \overline{q_J}} \tag{3}$$

Step 6 – Transform the fuzzy weights into crisp values by applying Equation (4):

$$w_j = \frac{w_j^l + 4w_j^m + w_j^u}{6}, j = 1, 2, \dots, n \tag{4}$$

3.2 MABAC Method

To apply the MABAC method, the following steps must be undertaken [27, 28]:

Step 1 – Construct the initial matrix X, in which m alternatives are assessed according to n criteria.

Step 2 – Normalize the matrix by employing the suitable formula based on the criterion type: for benefit criteria, use Equation (5); for cost criteria, apply Equation (6).

$$n_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \tag{5}$$

$$n_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+} \tag{6}$$

Where, xij is the value of the i-th criterion for the j-th alternative, and x_i^+ and x_i^+ represent the maximum and minimum values for criterion i, calculated using Equations (7) and (8):

$$x_i^+ = \max(x_1, x_2, \dots, x_m) \tag{7}$$

$$x_i^- = \min(x_1, x_2, \dots, x_m) \tag{8}$$

Step 3 – Calculate the weighted decision matrix V by applying Equation (9).

$$v_{ij} = w_i * (n_{ij} + 1) \tag{9}$$

Step 4 – Determine the border approximation area (BAA) matrix (G) by using Equation (10).

$$g_i = \left(\prod_{j=1}^{m} v_{ij}\right)^{1/m} \tag{10}$$

Step 5 – Distance calculation between alternative and the BAA to form matrix Q. This involves subtracting the BAA value gi for each criterion from the corresponding element in the weighted matrix vij. The result is denoted as qij. Each alternative Ai is then classified into one of three areas, Equation (11):

$$Ai \in \begin{cases} G^+ \ if \ q_{ij} > 0 \\ G \ if \ q_{ij} = 0 \\ G^- \ if \ q_{ij} < 0 \end{cases} \tag{11}$$

Step 6 – Rank the alternatives by calculating their overall scores using Equation (12).

$$S_i = \sum_{j=1}^{n} q_{ij}, j = 1, 2, \dots, n \;\; i = 1, 2, \dots, m \tag{12}$$

These scores establish the final ranking of the alternatives by indicating their closeness to the ideal solution.

4. Ranking Logistics Systems – Case Study

Two principal dimensions that are increasingly critical in contemporary logistics operations are flexibility and elasticity. Flexibility denotes a system's capacity to adapt to variations in demand, processes, and structure without substantially impairing performance or incurring excessive costs. This capability is particularly important in dynamic markets, just-in-time production environments, and customised delivery models. Conversely, elasticity refers to a system's ability to withstand disruptions, reorganise under stress, and restore its performance levels. This aspect is especially crucial during supply shocks, geopolitical conflicts, pandemics, and infrastructure breakdowns.

Consequently, the proposed framework was validated through a case study involving the evaluation of five logistics systems, initially in terms of flexibility and subsequent elasticity, using six criteria. To employ the IMF SWARA method, three experts assessed the alternatives based on the criteria using a linguistic scale, necessitating the application of the method within a fuzzy environment.

Table 1
Criteria used for Assessing Flexibility

Criterion	Description
Cost Stability	The ability of the system to operate without large cost fluctuations.
Process Adaptability	Degree to which process steps, timing, or structure can be modified.
Organizational Responsiveness	Capacity to absorb internal/external changes without systemic disruption.
Resource Availability	Readiness of physical, human, or technological resources for reconfiguration.
Decision-Making Agility	Speed and ease with which decisions can be made under changing conditions.
Strategic Options Range	Number of feasible alternatives available to the system at any given moment.

For ranking purposes, the criteria were first established for flexibility assessment (Table 1), followed by those for elasticity evaluation (Table 2).

Table 2
Criteria used for Assessing Elasticity

Criterion	Description
Recovery Speed	Time required to restore normal operations after a disruption.
Shock Absorption	Capacity to withstand sudden internal/external disruptions.
Risk Anticipation	Ability to forecast and prepare for potential disruptions.
Partner Integration	Level of transparency, information sharing, and risk-sharing with partners.
Structural Redundancy	Availability of alternative routes, suppliers, or resources.
Policy and Governance Support	Flexibility of regulations and support mechanisms in disruption scenarios.

Flexibility denotes a system's capacity to adjust to both expected and unexpected changes, facilitating efficient operation under stable conditions as well as during moderate disruptions. This concept underscores the significance of aligning internal processes to maintain uninterrupted functioning. Conversely, elasticity emphasises the system's ability to recover and sustain functionality in the face of shocks or crises. It involves incorporating mechanisms such as redundancy, decentralisation, and strategic buffers to enhance resilience. Furthermore, elasticity fosters the development of adaptive capabilities at a broader, systemic level. Using the criteria previously outlined, the following logistics systems were evaluated and ranked:

4.1 System A – Centralised Distribution Centre of a Large Retail Chain (A1)

This model depends on a large central distribution centre supplying numerous retail outlets. Although it benefits from efficient IT systems, the high degree of centralisation renders it susceptible to transportation disruptions affecting inbound and outbound flows. Its strengths include high operational efficiency and low unit costs, whereas its weaknesses encompass limited elasticity during disruptions and restricted structural flexibility.

4.2 System B – Decentralised Network of Regional Warehouses (A2)

This system employs multiple smaller warehouses spread across various regions, facilitating faster deliveries and enhanced local responsiveness. Its advantages lie in greater elasticity and adaptability, while its drawbacks consist of increased operational costs and heightened coordination complexity.

4.3 System C – Dropshipping Model via External Suppliers (A3)

This approach involves direct shipment of goods from suppliers to end customers, removing the need for the company to hold physical inventory. The system's strengths are high flexibility and reduced inventory costs; however, its limitations include limited control over performance and reliance on third-party providers.

4.4 System D – Make-to-Order Production Model (A4)

Products are manufactured only after customer orders are received, tailored to specific requirements. The system offers a flexible production process and reduced inventory levels but suffers from longer lead times and requires strong integration with both customers and suppliers.

4.5 System E – Automated Smart Logistics with IoT Sensors (A5)

This integrated logistics system incorporates sensors, autonomous vehicles, and predictive analytics to monitor flows in real time and automatically adjust operations accordingly. It exhibits the highest levels of flexibility, elasticity, and rapid responsiveness, yet it is associated with substantial initial investment costs and technical dependency.

4.6 Ranking Logistics Systems from the Perspective of Flexibility

The initial stage of the process involved establishing the importance of the criteria, constituting the first step in applying the IMF SWARA method (Table 3).

Table 3
Criteria Significance – Flexibility

Criteria	Linguistic Assessment
Cost Stability (C11)	-
Organizational Responsiveness (C12)	WLS
Resource Availability (C13)	WLS
Process Adaptability (C14)	MDLS
Strategic Options Range (C15)	LS
Decision-Making Agility (C16)	RLS

Moreover, after conducting the linguistic assessment of criterion importance, the IMF SWARA method was employed using Equations (1)–(4), leading to the calculation of criterion weights (Table 4). Criterion C11 holds the greatest weight, whereas criterion C16 possesses the least.

Table 4
Criteria Weights – Flexibility

s_j			k_j			q_j			w_j			w (crisp)
C11-	-	-	1.000	1.000	1.000	1.000	1.000	1.000	0.267	0.280	0.296	0.280
C120.22	0.25	0.29	1.222	1.250	1.286	0.778	0.800	0.818	0.207	0.224	0.242	0.224
C130.22	0.25	0.29	1.222	1.250	1.286	0.605	0.640	0.669	0.161	0.179	0.198	0.179
C140.250	0.286	0.333	1.250	1.286	1.333	0.454	0.498	0.536	0.121	0.139	0.159	0.139
C150.286	0.333	0.400	1.286	1.333	1.400	0.324	0.373	0.417	0.086	0.104	0.123	0.105
C160.333	0.400	0.500	1.333	1.400	1.500	0.216	0.267	0.312	0.058	0.075	0.093	0.075
Σ						3.377	3.578	3.752				

The subsequent phase involved ranking the logistics systems using the MABAC method. To perform this ranking, it was essential first to assess the alternatives (logistics systems) against the established criteria to generate the input data (Table 5).

Table 5
Input Data – Flexibility

	C11	C12	C13	C14	C15	C16
Weights	0.280	0.224	0.179	0.139	0.105	0.075
A1	3	2	3	2	2	4
A2	3	4	4	3	3	5
A3	4	3	2	4	4	3
A4	3	3	3	4	3	3
A5	4	5	4	5	4	4

Each alternative was evaluated across all criteria employing a scale from 1 to 5, with 5 indicating the highest rating. The initial step in applying the MABAC method involved normalization, which was performed using Equations (5) and (6) (Table 6).

Table 6
Normalized Data – Flexibility

	C11	C12	C13	C14	C15	C16
A1	0	0	0.5	0	0	0.5
A2	0	0.67	1	0.33	0.5	1
A3	1	0.33	0	0.67	1	0
A4	0	0.33	0.5	0.67	0.5	0
A5	1	1	1	1	1	0.5

Following this, the weights derived from the IMF SWARA method were applied to develop the weighted decision matrix (Table 7).

Table 7
Weighted Matrix – Flexibility

	C11	C12	C13	C14	C15	C16
A1	0.280	0.224	0.269	0.139	0.105	0.112
A2	0.280	0.373	0.358	0.186	0.157	0.149
A3	0.560	0.299	0.179	0.232	0.209	0.075
A4	0.280	0.299	0.269	0.232	0.157	0.075
A5	0.560	0.448	0.358	0.279	0.209	0.112

Subsequently, the BAA matrix was calculated using Equations (10) and (11) (Table 8).

Table 8
BAA Matrix – Flexibility

	C11	C12	C13	C14	C15	C16
G_i	0.370	0.320	0.278	0.208	0.162	0.101

Based on the BAA matrix, the Si values were then computed in the final step, providing the foundation for ranking the alternatives (Table 9).

Table 9
Performance Scores and Ranking – Flexibility

	C11	C12	C13	C14	C15	C16	S_i	Ranking
A1	-0.089	-0.096	-0.009	-0.069	-0.058	0.011	-0.310	5
A2	-0.089	0.054	0.080	-0.022	-0.005	0.048	0.065	3
A3	0.191	-0.021	-0.099	0.024	0.047	-0.026	0.116	2
A4	-0.089	-0.021	-0.009	0.024	-0.005	-0.026	-0.127	4
A5	0.191	0.128	0.080	0.071	0.047	0.011	0.528	1

The application of the MABAC method revealed that, regarding flexibility, the highest-ranked alternative was A5 (Automated Smart Logistics with IoT Sensors), followed by A3, A2, and A4. The lowest-ranked alternative was A1 (Centralized Distribution Centre of a Large Retail Chain).

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4.7 Ranking Logistics Systems from the Perspective of Elasticity

As an initial step, the importance of the criteria was evaluated following the same procedure as in the previous case (Table 10).

Table 10
Criteria Significance – Elasticity

Criteria	Linguistic Assessment
Recovery Speed (C21)	-
Shock Absorption (C22)	ES
Risk Anticipation (C23)	WLS
Structural Redundancy (C24)	MDLS
Policy and Governance Support (C25)	RLS
Partner Integration (C26)	MDLS

Moreover, similarly, the IMF SWARA method was applied to determine the criteria weights, followed by defuzzification to convert these into crisp values (Table 11).

Table 11
Criteria Weights – Elasticity

s_j			k_j			q_j			w_j			w (crisp)
C21			1.000	1.000	1.000	1.000	1.000	1.000	0.230	0.237	0.247	0.238
C220	0	0	1.000	1.000	1.000	1.000	1.000	1.000	0.230	0.237	0.247	0.238
C230.222	0.25	0.286	1.222	1.250	1.286	0.778	0.800	0.818	0.179	0.190	0.202	0.190
C240.250	0.286	0.333	1.250	1.286	1.333	0.583	0.622	0.655	0.134	0.148	0.162	0.148
C250.333	0.400	0.500	1.333	1.400	1.500	0.389	0.444	0.491	0.089	0.106	0.121	0.105
C260.250	0.286	0.333	1.250	1.286	1.333	0.292	0.346	0.393	0.067	0.082	0.097	0.082
Σ						4.042	4.212	4.356				

The results indicate that criteria C21 and C22 hold the highest weights, both being equal, whereas criteria C26 has the lowest weight. This contrasts with the flexibility assessment, where the top two criteria differed in weighting.

For this case, the process commenced with the definition of input data (Table 12).

Table 12
Input Data – Elasticity

	C21	C22	C23	C24	C25	C26
Weights	0.238	0.238	0.190	0.148	0.105	0.082
A1	2	2	3	2	3	3
A2	3	3	3	4	3	3
A3	2	3	2	2	2	2
A4	3	3	3	3	3	4
A5	4	5	4	4	4	3

Subsequently, following the procedure used for flexibility, the normalized matrix (Table 13) and the weighted normalized matrix (Table 14) were calculated.

Table 13
Normalized Data – Elasticity

	C21	C22	C23	C24	C25	C26
A1	0	0	0.5	0	0.5	0.5
A2	0.5	0.33	0.5	1	0.5	0.5
A3	0	0.33	0	0	0	0
A4	0.5	0.33	0.5	0.5	0.5	1
A5	1	1	1	1	1	0.5

Table 14
Weighted Matrix – Elasticity

	C21	C22	C23	C24	C25	C26
A1	0.238	0.238	0.285	0.148	0.158	0.123
A2	0.357	0.317	0.285	0.296	0.158	0.123
A3	0.238	0.317	0.190	0.148	0.105	0.082
A4	0.357	0.317	0.285	0.222	0.158	0.164
A5	0.476	0.476	0.380	0.296	0.211	0.123

The BAA matrix was then derived using equations (10) and (11) (Table 15).

Table 15
BAA Matrix – Elasticity

	C21	C22	C23	C24	C25	C26
G_i	0.321	0.325	0.279	0.211	0.155	0.120

Finally, the Si values were computed from this matrix, which formed the basis for ranking the alternatives (Table 16). Moreover, Table 16 indicates that A5 (Automated Smart Logistics with IoT Sensors) is also the top-ranked alternative in this case, followed by A2, A4, A1, with A3 (Dropshipping Model via External Suppliers) as the lowest-ranked alternative. Comparing these results with those from the flexibility assessment reveals that A5 consistently holds the highest position, whereas the ranking order of the remaining alternatives varies, including those ranked lowest.

Table 16
Performance Scores and Ranking – Elasticity

	C21	C22	C23	C24	C25	C26	S_i	Ranking
A1	-0.083	-0.087	0.007	-0.064	0.004	0.003	-0.221	4
A2	0.035	-0.008	0.007	0.084	0.004	0.003	0.125	2
A3	-0.083	-0.008	-0.088	-0.064	-0.049	-0.038	-0.330	5
A4	0.035	-0.008	0.007	0.010	0.004	0.044	0.092	3
A5	0.154	0.151	0.102	0.084	0.056	0.003	0.550	1

5. Conclusion

The findings of this study emphasise the crucial role of incorporating both flexibility and elasticity in the assessment of logistics systems. By differentiating these two interrelated yet distinct dimensions, the proposed framework offers a comprehensive perspective on a system's capacity to adapt to variability and endure disruptions. The application of the IMF SWARA method facilitated a detailed evaluation of criteria significance, while the MABAC method provided a transparent and systematic means of comparing alternatives. The outstanding performance of Alternative A5 demonstrates that increasing digitalisation, automation, and real-time data integration significantly enhance logistical responsiveness and resilience. This research makes both theoretical and practical contributions by delivering a robust decision-support tool that logistics managers can utilise to assess and optimise their systems. Considering the constantly evolving global supply chains, the ability to systematically evaluate and prioritise logistics systems based on flexibility and elasticity will remain vital for sustaining competitiveness and ensuring continuous service delivery. Moreover, the proposed framework may serve as a foundation for future investigations into additional factors influencing system adaptability, such as sustainability and cost-efficiency. Subsequent research should apply the model across diverse markets and various case studies to assess its applicability and robustness in different contexts. Comparative analyses would yield valuable insights into how flexibility and elasticity operate in distinct logistical settings. Furthermore, integrating advanced analytical methods, including simulations, could improve the accuracy and dependability of the outcomes. Equally important is the advancement of hybrid models and novel approaches for risk assessment, which could substantially refine the framework and enhance decision-making processes in dynamic and uncertain environments.

Author Contributions

Conceptualization, Z.Y. Zeng and J.B. Song; methodology, Z.Y. Zeng and J.B. Song; software, M.C. Zhou; validation, Z.Y. Zeng; formal analysis, J.B. Song; investigation, J.J. Wang; resources, M.C. Zhou; data curation, J.B. Song; writing-original draft preparation, J.B. Song; writing-review and editing, Z.Y. Zeng and J.B. Song; visualization, J.J. Wang; supervision, Z.Y. Zeng; project administration, J.B. Song; funding acquisition, Z.Y. Zeng. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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