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Weak Domestic Production and Its Impact on Freight Transport Demand: A Fuzzy MCDM Analysis

Ibrahim Badi[1,*], Mouhamed Bayane Bouraima[2]

[1] Department Mechanical Engineering, Libyan Academy-Misrata, 2949 Misrata, Libya; i.badi@lam.edu.ly.
[2] Department of Civil Engineering, Sichuan College of Architectural Technology, Deyang, China; mouba121286@yahoo.fr.

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Abstract

Freight transport systems rely heavily on the volume, frequency, and spatial distribution of goods generated by domestic production activities. In Libya, however, weak industrial output and underdeveloped manufacturing capacity have significantly limited freight demand, resulting in fragmented transport flows and underutilized logistics infrastructure. This study investigates the root causes of weak domestic production and their broader implications for freight transport development. Using the Fuzzy Simple Weight Calculation (F-SEWIC) method, seven critical factors were evaluated: lack of industrial infrastructure, political instability, weak investment climate, poor transportation and logistics, low labor productivity, dependence on imports, and unstable regulatory and legal frameworks. Expert assessments were collected from four specialists in economics and industrial development, using a fuzzy linguistic scale to reflect the uncertainty inherent in such judgments. The results show that weak investment climate, political instability, and institutional barriers are the most significant constraints on production—factors that indirectly suppress freight volumes, limit the formation of industrial supply chains, and hinder the development of efficient transport corridors. By identifying and prioritizing these constraints, this study highlights the foundational role of domestic production in shaping national freight transport strategies and offers actionable insights for aligning industrial policy with infrastructure planning in Libya.

Keywords: Investment climate, Fuzzy simple weight calculation, Domestic production.

1 | Introduction

Freight transport plays a central role in enabling economic growth, trade facilitation, and regional integration. It serves as the backbone of supply chains by ensuring the efficient movement of raw materials, intermediate goods, and finished products across production zones, distribution centers, and consumer markets. An effective freight transport system reduces logistics costs, enhances market accessibility, and supports competitiveness by improving the reliability and speed of deliveries [1]. Moreover, in developing and

Corresponding Author: i.badi@lam.edu.ly

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transitional economies, freight transport is critical for linking producers with domestic and international markets, stimulating industrial activity, and attracting investment in infrastructure and trade corridors [2].

Beyond its role in connecting markets, freight transport is also a key enabler of domestic production [3]. A reliable and integrated freight system allows manufacturers to source inputs efficiently, distribute goods to customers, and access export gateways in a timely and cost-effective manner [4]. In this way, freight transport not only responds to production demand but actively shapes it—by lowering transaction costs, reducing bottlenecks, and expanding the reach of domestic producers. In fragile or underdeveloped economies like Libya, improving freight transport infrastructure and services can help unlock latent production potential, support the development of industrial supply chains, and create a more conducive environment for economic diversification and self-sufficiency.In emerging and transitional economies, identifying and understanding the root causes of weak domestic production is essential for formulating effective industrial and economic policies [5], [6].

Libya's domestic production sector has long struggled with structural and institutional challenges, many of which have been intensified by years of political instability. Although the country is rich in natural resources—particularly oil and gas—it remains heavily dependent on imports to satisfy both consumer demand and industrial needs. One of the critical and often overlooked dimensions of this underperformance is the state of the freight transport system. Inadequate logistics infrastructure, fragmented transport networks, and inefficiencies in the movement of goods have created significant barriers to local production. Limited access to finance, coupled with a weak investment climate, further compounds the issue by discouraging the development of integrated supply chains. These intertwined problems not only constrain Libya's ability to diversify its economy but also weaken its freight transport demand, reduce efficiency in goods distribution, and reinforce the country's vulnerability to external shocks and inflationary pressures [7].

While previous studies have explored various aspects of Libya's macroeconomic challenges—such as inflation, fiscal policy, and trade imbalances—there has also been growing academic and institutional interest in the role of freight transport and logistics within the country. However, much of this work has treated freight transport as a standalone issue, with limited attention to its interdependence with domestic production. This study seeks to bridge that gap by examining how internal production constraints directly influence the efficiency and viability of freight transport systems in Libya. The need for such an integrated perspective is important, where economic diversification and industrial revitalization are strategic priorities. Although the country possesses industrial assets—such as the Iron and Steel Complex—and a range of small and medium-sized enterprises, these have failed to reach their full potential due to persistent structural and institutional barriers. Understanding how these barriers suppress production and, in turn, weaken freight demand and supply chain connectivity is essential for designing coherent economic and transport development strategies.

In this context, Multi-Criteria Decision-Making (MCDM) approaches offer powerful tools to systematically evaluate and rank complex, interrelated factors that influence production outcomes [8], [9]. Among the various MCDM techniques, the Fuzzy Simple Weight Calculation (F-SEWIC) method is particularly suitable for situations involving ambiguity and subjective expert judgment. By incorporating fuzzy logic into the evaluation process, F-SEWIC allows for the effective handling of linguistic assessments, thereby providing more realistic and flexible insights in uncertain environments like Libya.

2 | Methodology

To achieve the objective of identifying and prioritizing the main factors contributing to weak domestic production in Libya, this study employs the F-SEWIC method—an approach within the broader MCDM framework. This method was selected due to its ability to handle uncertainty and subjective expert judgments using fuzzy logic, making it particularly suitable for complex economic environments like Libya. The methodology involves collecting expert evaluations using linguistic scales, converting these inputs into fuzzy numbers, and then calculating normalized weights that reflect the relative importance of each factor. The following section outlines the key steps of the F-SEWIC model and its application in this study [10].

Step 1. Decision-Makers (DMs) evaluate the relative importance of each criterion by assigning appropriate linguistic terms—such as Very Low, Low, Medium, High, and Very High—to reflect their expert judgment. These qualitative assessments capture the perceived significance of each factor in influencing weak domestic production within the Libyan context.

Step 2. The linguistic assessments provided by the decision-makers are converted into fuzzy numerical values using predefined membership functions, typically represented as triangular fuzzy numbers. Each linguistic term is expressed as a triplet that defines the lower, middle, and upper bounds, thereby capturing the inherent uncertainty and subjectivity in expert judgments.

$$\tilde{x}_{ij} = \left(x_{ij}^{l}, x_{ij}^{m}, x_{ij}^{u}\right). \tag{1}$$

Where $x_{ij}^{l}, x_{ij}^{m}, x_{ij}^{u}$ represent the lower, middle, and upper values of the fuzzy number assigned to criterion j by decision-maker i, respectively.

Step 3. An initial fuzzy decision matrix is constructed based on the fuzzy numbers derived from the decision-makers' evaluations. Each element in the matrix reflects the perceived importance of a specific criterion, incorporating the uncertainty captured through linguistic assessments. This matrix serves as the foundation for calculating the criteria weights using the F-SEWIC method.

$$\widetilde{A} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ . & . & \cdots & . \\ . & . & \cdots & . \\ . & . & \cdots & . \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix}. \tag{2}$$

Where $\tilde{x}_{ij}$ represents the ranking assigned by the decision-maker to a specific criterion, expressed as a fuzzy number.

Step 4. In this step, all fuzzy values in the decision matrix are normalized by dividing them by the maximum upper bound $\left(\max x_{ij}^{u}\right)$ observed across all criteria and decision-makers.

$$\tilde{n}_{ij} = \frac{x_{ij}^{l}}{\max x_{ij}^{u}}, \frac{x_{ij}^{m}}{\max x_{ij}^{u}}, \frac{x_{ij}^{u}}{\max x_{ij}^{u}}. \tag{3}$$

Step 5. The standard deviation $\left(\text{std.dev}_j\right)$ is calculated for each criterion based on the fuzzy numbers provided by the decision-makers. This measure reflects the variability or consistency in the evaluations for each criterion, allowing the method to emphasize criteria where expert opinions show greater differentiation—an essential feature of the F-SEWIC approach for capturing the relative significance under uncertainty.

Step 6. The normalized fuzzy ratings are multiplied by the corresponding standard deviation values to reflect the influence of each decision-maker's variability.

$$\tilde{v}_{ij} = \tilde{n}_{ij} \times \text{st.dev}_j. \tag{4}$$

Step 7. The fuzzy-weighted values for each criterion are aggregated by summing the weighted fuzzy evaluations provided by all decision-makers. This aggregation yields a collective representation of each criterion's importance, reflecting both the individual expert judgments and the uncertainty captured in previous steps. The outcome is a consolidated fuzzy weight for each criterion, which serves as the basis for determining their final importance rankings.

$$\tilde{S}_{ij} = \sum_{j=1}^{n} \tilde{v}_j. \tag{5}$$

Step 8. Each individual fuzzy value $\tilde{s}_{ij}$ is divided by the total sum of all fuzzy values to obtain the normalized fuzzy weight for each criterion. During this process, it is essential to maintain the logical order of the fuzzy numbers—ensuring that the lower bound is less than or equal to the middle value, which in turn must be less than or equal to the upper bound.

$$\widetilde{w}_{ij} = \frac{S_{ij}^{l}}{\sum_{j=1}^{n} S_{ij}^{u}}, \frac{S_{ij}^{m}}{\sum_{j=1}^{n} S_{ij}^{m}}, \frac{S_{ij}^{u}}{\sum_{j=1}^{n} S_{ij}^{l}}. \quad (6)$$

Step 8. The final fuzzy weights obtained for each criterion can be retained in their fuzzy form or de-fuzzified into crisp values, depending on the analytical requirements. In this study, the fuzzy weights are de-fuzzified using an appropriate defuzzification technique to convert each fuzzy number into a single representative value.

$$w_{jdef} = \frac{w_{ij}^{l} + 4 \times w_{ij}^{m} + w_{ij}^{l}}{6}. \quad (7)$$

3 | Case study

Despite Libya's wealth of natural resources and its strategic geographic location, the country continues to face significant challenges in building a strong and sustainable domestic production sector. While some industrial activities do exist—such as the Iron and Steel Complex and a variety of small and medium-sized manufacturing enterprises [11]—their overall contribution to the national economy remains limited [12]. Years of political instability, underinvestment, institutional fragmentation, and inadequate infrastructure have severely constrained production capacity. Strengthening domestic production is not only essential for reducing Libya's dependence on imports, but also for creating jobs, diversifying the economy, and mitigating inflationary pressures [13]. Achieving this goal requires a deeper understanding of the structural and policy-related factors that continue to hinder the development of productive sectors.

To inform evidence-based policy and development planning, this study aims to identify and prioritize the most critical factors contributing to weak domestic production in Libya, with particular attention to their implications for the freight transport sector. Weak domestic production not only undermines economic growth but also reduces freight volumes, disrupts supply chain continuity, and limits the effective utilization of transport infrastructure. Through a review of relevant literature and expert consultation, seven key criteria were identified: (C1) Lack of Industrial Infrastructure, (C2) Political Instability and Conflict, (C3) Weak Investment Climate, (C4) Poor Transportation and Logistics, (C5) Low Labor Productivity, (C6) Dependence on Imports, and (C7) Unstable Regulatory and Legal Framework. These factors represent the core structural and institutional barriers that restrict production capacity and, by extension, freight activity. To assess the relative importance of each criterion, the study engaged four experts with deep expertise in economics, industrial development, and public policy. The experts evaluated each factor using a fuzzy linguistic scale designed to capture the uncertainty and subjectivity inherent in expert judgment. *Table 1* presents the fuzzy linguistic evaluation scale employed in this research.

Table 1. Fuzzy linguistic evaluation scale.

Linguistic terms	Membership function
Absolutely Bad (AB)	(1,1,1)
Very bad (VB)	(1,2,3)
Bad (B)	(2,3,4)
Medium-bad (MB)	(3,4,5)
Equal (E)	(4,56)
Medium-Good (MG)	(5,6,7)
Good (G)	(6,7,8)
Extremely Good (EG)	(7,8,9)
Absolutely Good (AG)	(8,9,10)
Perfect (P)	(9,10,10)

Table 2. Linguistic decision-making matrix.

	C1	C2	C3	C4	C5	C6	C7
E1	G	EG	EG	EG	MG	G	EG
E2	G	G	EG	G	G	EG	EG
E3	MG	G	AG	EG	MG	EG	G
E4	G	EG	EG	EG	MG	G	G

The initial fuzzy decision-making matrix was normalized to ensure consistency and comparability across all criteria and expert evaluations. Following the F-SEWIC methodology, normalization was achieved by dividing each fuzzy number by the highest upper bound observed among all expert-assigned values. This procedure transforms the fuzzy values onto a common scale—typically ranging from 0 to 1—while maintaining the relative differences and significance expressed in the original judgments. By standardizing the data in this way, the normalization process eliminates inconsistencies caused by varying scales or units, thereby providing a reliable foundation for the accurate calculation of criteria weights. The resulting normalized fuzzy decision-making matrix, which serves as the basis for the next stage of the analysis, is presented in *Table 3*.

Table 3. Normalized fuzzy decision-making matrix.

	C1	C2	C3	C4	C5	C6	C7
E1	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.5,0.6,0.7)	(0.6,0.7,0.8)	(0.7,0.8,0.9)
E2	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.6,0.7,0.8)	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)
E3	(0.5,0.6,0.7)	(0.6,0.7,0.8)	(0.8,0.9,1.0)	(0.7,0.8,0.9)	(0.5,0.6,0.7)	(0.7,0.8,0.9)	(0.6,0.7,0.8)
E4	(0.6,0.7,0.8)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.7,0.8,0.9)	(0.5,0.6,0.7)	(0.6,0.7,0.8)	(0.6,0.7,0.8)

The subsequent step in the F-SEWIC method involves integrating expert judgment variability into the weighting process. This is achieved by multiplying the normalized fuzzy values by the corresponding standard deviation values calculated for each criterion. By doing so, the method accounts for the degree of consensus or divergence among experts, giving greater weight to criteria that exhibit higher variability in evaluations. The resulting fuzzy products are then aggregated by summing the values across all decision-makers for each criterion. This aggregation produces the preliminary fuzzy weights, which capture the collective importance of each criterion under conditions of uncertainty. Throughout this process, care is taken to preserve the structure of triangular fuzzy numbers, ensuring that the lower bound does not exceed the middle value, and the middle value remains below or equal to the upper bound.

Table 4. Obtaining final values of the criteria by using fuzzy SIWEC method.

	C1	C2	C3	C4	C5	C6	C7
$\tilde{s}_{ij}$	(0.26,0.30,0.35)	(0.30,0.34,0.39)	(0.33,0.38,0.42)	(0.31,0.35,0.40)	(0.24,0.28,0.33)	(0.30,0.34,0.39)	(0.29,0.34,0.38)
$\tilde{w}_{ij}$	(0.09,0.13,0.17)	(0.11,0.15,0.19)	(0.13,0.16,0.21)	(0.12,0.15,0.20)	(0.09,0.12,0.16)	(0.11,0.15,0.19)	(0.11,0.15,0.19)

Table 5. Defuzzified value of the weights of criteria.

	C1	C2	C3	C4	C5	C6	C7
w_j	0.1320	0.1473	0.1631	0.1531	0.1224	0.1478	0.1468

The results of the defuzzified weights indicate that Weak Investment Climate (C3) is the most influential factor contributing to weak domestic production in Libya, receiving the highest weight of 0.1631. This underscores the pressing need to address challenges related to attracting both domestic and foreign investment, which are often hindered by political instability, regulatory uncertainty, and limited access to capital. The second most critical factor is Political Instability and Conflict (C2), with a weight of 0.1473, reflecting the substantial impact that prolonged conflict and fragmented governance have on the stability and functionality of production environments. Unstable Regulatory and Legal Framework (C7) and Dependence on Imports (C6) follow closely, with weights of 0.1468 and 0.1478, respectively, highlighting the importance of institutional reform and the urgent need to strengthen local supply chains. Overall, these findings suggest that improving domestic production in Libya requires coordinated efforts to enhance the investment climate, stabilize the political environment, and develop coherent regulatory structures that support local industrial growth.

4 | Conclusion

This study applied the Fuzzy Simple Weight Calculation (F-SEWIC) method to identify and prioritize the key factors contributing to weak domestic production in Libya, with particular attention to their implications for freight transport. The results revealed that a weak investment climate, political instability, and regulatory uncertainty are the most critical barriers to enhancing local production capacity. These factors not only limit industrial growth but also reduce the volume and efficiency of freight transport flows by suppressing cargo generation, disrupting supply chain continuity, and discouraging infrastructure investment. In this context, freight transport development cannot be addressed in isolation; it must be supported by parallel efforts to strengthen domestic production systems. Improving the enabling environment for local industry will stimulate demand for freight services, promote more balanced and sustainable logistics patterns, and support the development of regional transport corridors. This research provides a structured basis for policymakers and planners to coordinate industrial and transport strategies, recognizing the interdependence between what a country produces and how it moves.

Author Contributaion

Conceptualization, I.B. and M.B.; Methodology, I.B.; Validation, M.B; formal analysis, I.B.; writing-creating the initial design, I.B.; writing-reviewing and editing, M.B.; project management, M.B. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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