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Enhancing decision-making in multi-objective fractional transportation problems : A neutrosophic goal programming framework

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Abstract

This study presents an innovative solution for the optimization of Multi-Objective Fractional Transportation Problems (MOFTP) which is a key challenge in modern logistics and supply chain management. This study proposes a pioneering solution by integrating Neutrosophic Goal Programming (NGP) into the MOFTP framework, offering a substantial methodology that accommodates the complexity and uncertainty implicit in transportation systems. The integration of NGP and specified weights enables the consideration of multiple objectives simultaneously while addressing the partial nature of transport parameters. Through simulations and case studies, the effectiveness of the proposed approach is demonstrated, showcasing its ability to provide well-balanced solutions that align with decision-makers strategic objectives.

Subject Classification: *90C32, 90C29.*

Keywords: *FTP, NGP, Inexactitude parameters, Lingo, Exquisite solutions.*

1. Introduction

In the realm of MOFTP, decision-makers are faced with the complex task of optimizing the transportation of goods while considering diverse and often conflicting objectives. The objectives can range from minimizing transportation costs and time to maximizing resource utilization and adhering to sustainability goals. This complex problem has a significant impact on industries such as

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manufacturing, distribution, and services, where efficient logistics plays a vital role in organizational success. Joshi et.al [4, 5] solving a multi-objective linear fractional transportation problem under neutrosophic environment. As decision-makers attempt to navigate the complex landscape of MOFTP, advanced mathematical programming techniques, heuristic algorithms, and simulation methods aim to provide practical and effective solutions that address diverse and often complex challenges and balance competing goals. Smarandache [1] introduced neutrosophic logic in unifying field. Veeramani et. al [3] solves multi- objective fraction transportation problems using the NGP approach. This framework enables decision-makers to express goals with degrees of truth, indeterminacy, and falsifiability, providing a more realistic representation of the complexities inherent in real-world problems. By accommodating conflicting objectives and allowing the assignment of priority levels, NGP provides a versatile tool for optimizing systems with multiple, often competing, goals. Revathi [6] proposes an efficient neutrosophic technique for handling uncertain MOTP. NGP has found application in a variety of fields, including finance, engineering, and operations research, where decision-makers grapple with incomplete or uncertain information. By Jalil et. al [2] proposes a model for addressing the uncertain MOTP with fractional objectives. This innovative approach contributes to more realistic and adaptive decision-making processes, which better deal with the complexities of dynamic and uncertain environments. Applied in a variety of areas such as project management and resource allocation, NGP contributes to more adaptive decision support systems, where solutions not only align with explicit objectives but are also tailored to the dynamic and uncertain nature of the decision environment.

2. Mathematical Model

Our proposed model puts decision-makers at the forefront of the optimization process, providing a tailored and adaptable approach to solving the MOFTP. By incorporating NGP with specified weights (W_k), decision-makers are empowered to incorporate their strategic preferences and priorities into the optimization framework. This utilization of confidence intervals (φ) serves to further enhance the robustness of our model by accounting for various levels of certainty in the decision-making process.

MOFTP Model	**Proposed Model**
Minimize= $\sum_{l=1}^{L} Z_l(x')=\frac{C_l(x')}{D_l(x')} = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}^{L} x_{ij}^{L}}{\sum_{i=1}^{m}\sum_{j=1}^{n} d_{ij}^{L} x_{ij}^{L}}$ **Subject to:** $\sum_{j=1}^{n}\sum_{i=1}^{m} x_{ij} \le a_i,$ $\sum_{i=1}^{m}\sum_{j=1}^{n} x_{ij} \ge b_j,$ $x_{ijp} \ge 0,$ $\forall\, i = 1, 2 \dots m, j = 1, 2 \dots n$	**Minimize =** $\sum_{k=1}^{K} w_k \left(\lambda(1-\mu)(1-\nu)\right)$ **Subject to:** $\sum_{l=1}^{L} Z_l + \left(\Cup_l^T - \Cap_l^T\right)(1-\nu) \le \Cup_l^T$ $\sum_{l=1}^{L} Z_l + \left(\Cup_l^I - \Cap_l^I\right)(1-\mu) \le \Cup_l^I$ $\sum_{l=1}^{L} Z_l + \left(\Cup_l^F - \Cap_l^F\right)\lambda \le \Cup_l^F$ $\sum_{l=1}^{L} Z_l \le Z_l^* + \sum_{k=1}^{K}(1-w_k)$ $\sum_{j=1}^{n} x_{ij} \le a_i \; (i = 1, 2, \dots, m),$

	$\sum_{i=1}^{m} x_{ij} \geq b_j$ $(j = 1, 2, \ldots, n)$, $0 \leq \lambda + \mu + \nu \leq 3, \mu, \nu \geq 0, \lambda \leq 1$ $x_{ij} \geq 0$, $\sum_{k=1}^{K} W_k = 1, 0 \leq W_k \leq 1 \;\forall\; k = 1, 2 \ldots K$.

3. Notation

• $\nu, \mu, \lambda =$ parameters indicating truth, indeterminacy, or falsity, respectively • $⋓_l^{T,I,F}$=least value for the states of truth, indeterminacy, or falsehood	• $⋒_l^{T,I,F}$= peak value for the states of truth, indeterminacy, or falsehood • Z_l^*= exquisite solutions

4. Illustrative Scenario

Let's update an illustration: In this scenario we consider three factories (S_1, S_2, S_3), and four warehouse (D_1 , D_2, D_3). The costs and time denoted as $Z_1 and\ Z_2$ are expressed in fractional form. C_{ij} and D_{ij} are constituent elements of numerator and denominator for l^{th} objective shown in Table 1.

Table 1
Expenses Associated with Transportation Z_1 and Time Metrics for Transportation Z_2

		D_1		D_2		D_3		D_4		**Supply**
		Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	Z_1	Z_2	
S_1	C_{ij}	(20,0.1)	(5,1)	(18,0.1)	(6,1.5)	(22,0.1)	(4,1)	(24,0.1)	(3,0.5)	(55,4)
	D_{ij}	(3,0.1)	(4,1)	(3.5,0.1	(4,1)	(2.5,0.1	(3,1)	(5,0.1)	(5,2)	
S_2	C_{ij}	(10,0)	(6,1)	(12,0.2)	(5,1.5)	(15,0)	(5,0.5)	(13,0)	(4,1)	(60,5)
	D_{ij}	(3,0)	(3,1)	(6,0.2)	(6,1)	(4,0)	(4,1)	(4,0)	(4,1)	
S_3	C_{ij}	(22,0)	(9,1)	(20,0.1)	(8,1.5)	(24,1)	(8,2)	(23,0.15)	(10,2)	(70,4)
	D_{ij}	(4,0)	(4,1.5)	(3,0.1)	(3,1)	(4,1)	(4,1)	(5,0.15)	(5,1.5)	
Demand		(40,3)		(36,4)		(35,5)		(40,3)		

5. Result and Discussion

Utilizing Lingo 18 software, our proposed model was implemented, resulting in values of 0.55 and 0.90. These values reflect the key results obtained from the application of our formulated model. And a total of 9 weights are assigned to the respective components shown in Table 2.

Table 2
Comparative Results of Our Proposed Model

Weight	$\varphi = 0.55$		$\varphi = 0.90$	
	Z_1	Z_2	Z_1	Z_2
0.1,0.9	4.629726	0.685096	4.535665	0.585706
0.2,0.8	4.465805	0.785097	4.39955	0.685705
0.3,0.7	4.332301	0.865674	4.212424	0.785703
0.4,0.6	4.332301	0.865674	4.208109	0.788514
0.5,0.5	4.332301	0.865674	4.208109	0.788514
0.6,0.4	4.332301	0.865674	4.178566	0.80786
0.7,0.3	4.247764	1.005698	4.078565	0.874739
0.8,0.2	4.147767	1.053512	3.978565	0.94385
0.9,0.1	4.047356	1.200685	3.878569	1.125292
Ideal	3.947808	0.585189	3.778611	0.485785
Anti-Ideal	4.791577	1.200728	4.710073	1.142373

Graphically in Figure 1 compare the performance of our models with optimal values at different weights, illustrate trade-offs, and inform decision-makers' strategic choices.

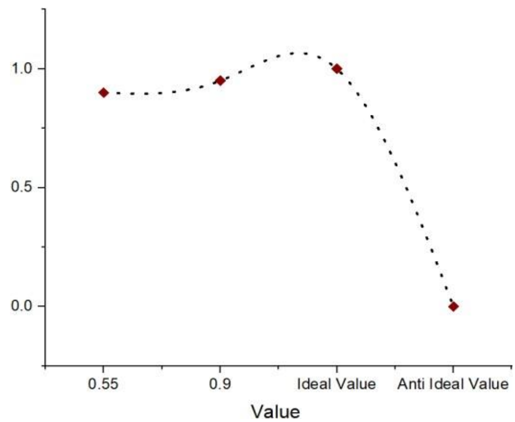

Figure 1
The Graph Comparing Our Model and Previous Existing Models

6. Conclusion

In conclusion, our innovative approach, integrating MOFTP with NGP and specified weights, represents a significant advance in addressing the complexities of real-world logistics and transportation optimization. Furthermore, the derivation of categorical values and exploration of multiple confidence intervals increases the transparency and adaptability of the model. Our model stands as a comprehensive and adaptable solution, placing decision-makers at the center of the optimization process and providing a practical tool for aligning transportation strategies with organizational goals while effectively managing uncertainties. Our model provides decision-makers with a multidimensional approach, providing a spectrum of possible solutions and accommodating different decision scenarios. The proposed model is used in logistics and supply chain management to assist decision-makers in optimizing transportation strategies through adaptive and informed decision-making.

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