INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

ORIGINAL ARTICLE

OPEN ACCESS

Received: 24/09/2025

Accepted: 14/11/2025

Published: 07/12/2025

Citation: Brigith Gladys L, Merline Vinotha J (2025) Multi-objective Fixed Charge Blending and Truck Slot Constrained Fuzzy Rough Profit Maximization Transportation Problem with Mobile Carbon Capture and Utilization Technology. Indian Journal of Science and Technology 18(45): 3560-3567. https://doi.org/10.17485/IJST/v18i45.1628

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Funding: None

Competing Interests: None

Published By Indian Society for Education and Environment (iSee)

ISSN
Print: 0974-6846
Electronic: 0974-5645

Multi-objective Fixed Charge Blending and Truck Slot Constrained Fuzzy Rough Profit Maximization Transportation Problem with Mobile Carbon Capture and Utilization Technology

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Abstract

Objectives: To instigate and rationalize utilization of carbon from mobile capture technology in a fuzzy rough multi-objective fixed charge profit maximization transportation problem with truck slot and product blending constraints. **Methods:** Two trapezoidal fuzzy rough multi-objective profit maximization mathematical models based on carbon taxation policy and mobile carbon capture and utilization technology are formulated for multi-objective fixed-charge transportation problem with product blending and truck slot constraints. The fuzzy rough models are metamorphosed into deterministic problems using their expected values and further untangled using Global Criterion Method in LINGO (19.0). Numerical examples and their outcomes are ventilated to inspect the proposed models and their advantages. **Findings:** The solutions obtained by solving the two trapezoidal fuzzy rough multi-objective profit maximization sustainability models ensure mobile carbon capture and utilization technology as the most promising sustainability technique than carbon taxation policy. Utilization of onboard captured carbon elevate the profit by 82.64 dollars in spite of its additional expense on mobile capture and is found to be a progressive game changer in global climate emergency management than the usual taxing scheme. **Novelty:** Mathematical model for fuzzy rough blending and truck slot constrained multi-objective profit maximization fixed-charge transportation problem with mobile carbon capture and utilization technology is not yet investigated in literature.

Mathematics Subject Classification (2020): 90B06, 90C08

Keywords: Fuzzy rough; Multi-objective; Fixed-charge; Product blending constraint; Truck slot constraint; Profit maximization; Mobile carbon capture and utilization

1 Introduction

1.1 Literature Review

Transportation problem is a peculiar variety of decision-making problem which picks out the way in which items are to be transported from source points to demand areas such that the goals contemplated are optimized. Classical transportation problem is a linear programming problem that had only single objective with supply and demand constraints [1]. Requirement of additional constraints and objectives provoked multi-objective transportation problem with other constraints remarkably on conveyance capacity, safety, fixed-charges, budget and so on. Multi-stage and multi-item transportation are also more prevalent among the supply chain as vehicles penetrate intermediate stages and carry more than one product.

Crisp transportation problems regarded only precise values which is impossible in real life cases. This put up the need for uncertainty in transportation problem with respect to all the transport parameters. In early times, ÓhÉigeartaigh, M proposed a procedure for solving transportation problem with fuzzy constraints and inspected its answer with the crisp problem [2]. Later, the theory has provoked more interest among researchers as they acknowledged uncertainty in decisions. Peng, Zhihao, et al. devised a transportation problem with interval-valued trapezoidal fuzzy numbers which is illustrated by way of an example [3]. Mardanya, Dharmadas, et al. studied a rough multi-modal transportation problem using a proposed algorithm [4]. Various fuzzy programming approaches are also launched to spell out uncertainty in multi-objective problems. Ali, W., & Javaid, S. gave a mathematical formulation using fermatean fuzzy parameters and fathomed them using Fermatean Fuzzy Programming Approach [5]. Amidst all these imprecise measures, there exists futuristic emerging risk factor which does not deplete uncertainty. Shivani, Rani, D. and Ebrahimnejad, A. investigated an unbalanced multi-objective fully rough fixed-charge transportation problem using a case study with a new approach [6]. Kacher, Y. and Singh, P. developed an algorithm with the help of fuzzy harmonic mean technique to decode the solution of a fully fuzzy multi-objective transportation problem [7]. Researchers are still exploring other optimization methods which may be efficient than the existing.

In recent years, there has been increased involvement of sustainability parameters in transportation problem with the desire for green environment. Rani D and Gupta G detailed a sustainable four-dimensional transportation problem with time windows and driver's rest period so as to improve safety together with operational efficiency [8]. Revathi, A. N., and S. Mohanaselvi. addressed a 4D transportation problem with constraints on budget, vehicle speed, carbon emission by utilizing a neutrosophic fuzzy set [9]. Rani, D., & Rizk-Allah, R. M created an intelligent transport system green rough 4D transportation model which is vindicated by a case study on apple transportation [10]. Ghosh and Roy SK modelled a fuzzy rough multi-objective fixed-charge blending and truck load constrained transportation problem with minimization of transport and carbon emission expenses [11]. Mardanya D and SK Roy discussed a profit maximization just-in-time solid transportation problem provoked from incurred expenses including carbon emission cost from the overall revenue alongside budget and carbon emission constraints [12]. Samanta S, Chakraborty D and Jana DK offered the formulation of an uncertain multi-objective 4D transportation problem with multiple breakable and non-breakable items with maximum profit and minimum carbon emission as crucial targets [13]. Jana B elaborated a single objective profit maximization transportation problem with carbon cost expenses [14].

The concept of carbon capture is suggested as a climate emergency solution in supply chain management in the late 90's in spite of its high investment cost. Wu, Yiwei, et al. formulated a mixed integer programming model for carbon capture, utilization and storage to find the amount of carbon dioxide emitted, transported and stored at power plants [15]. Kou, Gang et al merged AI and decision making to identify the financial problems and regulations that disturb carbon capture technology investments [16]. Though proficient, these techniques are employed only in stationary sources that leave emissions from transportation undisturbed. Stationary carbon capture has land constraints for setting up capturing units and are applicable only to major carbon emitters with high infrastructure. This induced mobile carbon capture technology which permits the on-board storage or reuse of captured carbon. Kim, Taenam, et al. abridged the onward movement of adsorbents tested for mobile carbon capture and detailed the challenges of them [17]. Saafi, M. A., & Hamad, E. performed an economic analysis of abatement cost of mobile carbon capture and concluded that the technique should be reconnoitered as a climate severity choice [18]. C. Reynolds has done abatement cost comparison between mobile carbon capture and other carbon neutralizing options [19]. Voice and Hamad advised mobile carbon capture technology as an achievable antidote for transport emission reduction through installation of mobile capturing system on a semi-truck [20]. Saafi and Hamad carried out a techno-economic analysis of mobile carbon capture system in heavy duty vehicles across the world to stress its ability [21]. Storing or reusing of captured carbon for multiple purposes is a blooming technique currently addressed by many climatologists and model designers as an everlasting green technique which enhances profit, sustainability, manpower for infrastructure etc.

1.2 Research Gap

Existing mathematical models concerning sustainability in transportation problem did not figure out any curative measure for carbon emission rather than minimizing emission or imposing tax that fluctuate corresponding to different countries. The chances of earning income from harmful carbon emissions focused only on cap-and-trade policies or taxing but not on other possible technologies. No profit maximization problem has been proposed for transportation problems with alternative check outs for carbon emission. The prevailing works did not mitigate carbon emissions physically that leads to cost redistribution without confirming actual emission reduction. Joint maximization of profit aftermath carbon tax and minimization of time with carbon tax policy or the growing mobile carbon capture technology is not considered in any transportation problem with blending and truck load constraints. Carbon utilization-based transport models are rarely explored and not compared to conventional carbon control procedures like carbon taxation ever in literature.

1.3 Our Contributions

The extended models are designed as a profit maximization problem with carbon taxation and an additional sustainability promoter, namely carbon capture and reuse technology. Captured carbon is used for many purposes by many industries with green goals. Several companies even manufacture products from this captured carbon which is an ongoing application around the globe. So, this paper formulates models to analyze the advantage of utilizing the captured carbon in a fuzzy rough blending and truck slot constrained multi-objective profit maximization fixed-charge transportation problem over the carbon taxation policy to benefit sustainability. Integration of carbon capture and reuse technology to transport optimization problems confirm that additional profit is gained even after spending cost for capturing as the captured carbon is reused for other purposes. Income incurred from selling captured carbon to enhanced oil recovery is taken for examined as case study. This ensures emission reduction directly with capture and reuse thereby assuring operational efficiency with environmental benefits by performing better than that of carbon taxing policy.

2 Methodology

2.1 Preliminaries

2.1.1. Fuzzy rough variable

A function ω from a rough space to set of fuzzy variables is called a fuzzy rough variable and for Borel set B of the set of all real numbers, $Pos\{\omega(\lambda) \in B\}$ is a measurable function of $\lambda \in \Lambda$. For example, let $\omega = (\rho - 1, \rho, \rho + 1)$ with $\rho = [2,3][4,5]$. Here, (a, b, c) is a triangular fuzzy variable with $a \leq b \leq c$ while ρ is a rough variable.

2.1.2. Trapezoidal fuzzy number

Trapezoidal fuzzy number $\tilde{\alpha} = (\alpha_1, \alpha_2, \alpha_3, \alpha_4)$ where $\alpha_1 \leq \alpha_2 \leq \alpha_3 \leq \alpha_4$ is a quadruple and its membership function is defined as follows:

$$\mu_{\widetilde{\alpha}}(x) = \begin{cases} 0\ if\ x < \alpha_1 \\ \dfrac{x-\alpha_1}{\alpha_2-\alpha_1} if \alpha_1 \leq x \leq \alpha_2 \\ 1\ if\ \alpha_2 \leq x \leq \alpha_3 \\ \dfrac{\alpha_4 - x}{\alpha_4 - \alpha_3} if \alpha_3 \leq x \leq \alpha_4 \\ 0\ if\ x > \alpha_4 \end{cases}$$

2.1.3. Expected value of fuzzy rough variable

Let $\mathrm{R}(\tilde{\alpha}_p) = (\mathrm{R}(\tilde{\alpha}_{p1}), \mathrm{R}(\tilde{\alpha}_{p2}), \mathrm{R}(\tilde{\alpha}_{p3}), \mathrm{R}(\tilde{\alpha}_{p4}))$ be a trapezoidal fuzzy rough variable with $\mathrm{R}(\tilde{\alpha}_{pq}) = [\mathrm{R}(\alpha_{pq1}), \mathrm{R}(\alpha_{pq2})][\mathrm{R}(\alpha_{pq3}), \mathrm{R}(\alpha_{pq4})]$ where $\mathrm{R}(\alpha_{pq3}) \leq \mathrm{R}(\alpha_{pq1}) \leq \mathrm{R}(\alpha_{pq2}) \leq \mathrm{R}(\alpha_{pq4})$ for q=1 to 4. Then, $E[\mathrm{R}(\tilde{\alpha}) = \frac{1}{16} \sum_{q=1}^{4} \sum_{r=1}^{4} \mathrm{R}(\alpha_{pqr}) \forall p, q, r.$

2.2 Mathematical Model

2.2.1. Notations

I': total number of starting points,
J': total number of transfer stations,
K': total number of ending points,
$D_{i'j'}$: distance between i' and j',
$D_{j'k'}$: distance between j' and k',
W: weight capacity of truck in barrels,
e: carbon emission rate per unit per km,
p_i: product purity level at i',
$p_{j'}^{\min}$: least product purity needed at j',
$p_{k'}^{\min}$: least product purity demanded at k',
R($\tilde{s}$): fuzzy rough selling price per unit,
R($\tilde{c}_{i'j'}$): fuzzy rough transportation cost per unit from i' to j',
R($\tilde{c}_{j'k'}$): fuzzy rough transportation cost per unit from j' to k',
R($\widetilde{F}_{i'j'}$): fuzzy rough fixed charge for a single slot from i' to j',
R($\widetilde{F}_{j'k'}$): fuzzy rough fixed charge for a single slot from j' to k',
R($\tilde{f}_{j'}$): fuzzy rough fixed charge per unit at j',
R($\tilde{\beta}_{j'}$): fuzzy rough transfer cost per unit at j',
R($\tilde{c}_t$): fuzzy rough carbon tax per tonne,
R($\tilde{c}_c$): fuzzy rough carbon capture cost per tonne,
R($\tilde{c}_r$): fuzzy rough carbon reuse cost per tonne,
R($\tilde{t}_{i'j'}$): fuzzy rough transportation time from i' to j',
R($\tilde{t}_{j'k'}$): fuzzy rough transportation time from j' to k',
R($\tilde{a}_{i'}$): fuzzy rough supply at i',
R($\tilde{b}_{k'}$): fuzzy rough demand at j',
$\delta_{i'j'}$: integer variable that decides the entirety of truck slots from i' to j',
$\delta_{j'k'}$: integer variable that determines the totality of truck slots from j' to k',
$\eta_{i'j'}$: binary variable depending on $x_{i'j'}$,
$\eta_{j'k'}$: binary variable depending on $y_{i'j'}$,
$\phi(\sum_{i'=1}^{I'} x_{i'j'})$: binary variable depending on $\sum_{i'=1}^{I'} x_{i'j'}$,
$x_{i'j'}$: quantity transported from i' to j',
$y_{j'k'}$: quantity transported from j' to k'.

2.2.2. Assumptions

- Only vehicles with mobile carbon capturing units are utilized for transportation in Model-B.
- Carbon emitted during transportation is completely captured and reused in Model-B.
- Capturing of carbon takes place only by sustainable means in Model-B.
- Carbon capture takes place during transit, and it doesn't exceed the usual time taken for transporting the products in Model-B.
- The capacity of the capture units doesn't exceed the overall emission discharged during transit.

2.2.3. Limitations

- Only changes in the profit and expense from carbon taxation policy and reuse of mobile carbon capture are discussed in the models.
- Only operational cost but not capital cost of mobile carbon capture infrastructure is considered.
- Offloading time of captured carbon, time lapse between storage and reuse of captured carbon are not considered in Model-B.

2.2.4. Mathematical Formulation for Multi-objective Fixed Charge Blending and Truck Slot Constrained Fuzzy Rough Profit Maximization Transportation Problem

Model-A: ***With Carbon taxation Policy***

$$\mathbf{Max Z^1} = \mathrm{R}(\tilde{\mathbf{s}}) \left[\sum_{i'=1}^{I'}\sum_{j'=1}^{J'} \mathbf{x}_{i'j'} + \sum_{j'=1}^{J'}\sum_{k'=1}^{K'} \mathbf{y}_{j'k'}\right] - \left[\sum_{i'=1}^{I'}\sum_{j'=1}^{J'} \mathrm{R}(\tilde{\mathbf{c}}_{i'j'})\mathbf{x}_{i'j'} + \sum_{j'=1}^{J'}\sum_{k'=1}^{K'} \mathrm{R}(\tilde{\mathbf{c}}_{j'k'})\mathbf{y}_{j'k'}\right]$$

$$- \left[\sum_{i'=1}^{I'}\sum_{j'=1}^{J'} \mathrm{R}(\tilde{\mathbf{F}}_{i'j'})\delta_{i'j'} + \sum_{j'=1}^{J'}\sum_{k'=1}^{K'} \mathrm{R}(\tilde{\mathbf{F}}_{j'k'})\delta_{j'k'}\right] - \left[\sum_{j'=1}^{J'} \mathrm{R}(\tilde{\mathbf{f}}_{j'}).\phi(\sum_{i'=1}^{I'} \mathbf{x}_{i'j'})\right]$$

$$- \left[\sum_{j'=1}^{J'} \mathrm{R}(\tilde{\beta}_{j'}).\left(\sum_{i'=1}^{I'} \mathbf{x}_{i'j'}\right)\right] - \left[\mathrm{R}(\tilde{\mathbf{c}}_{t}).\mathbf{e}\left(\sum_{i'=1}^{I'}\sum_{j'=1}^{J'} \mathbf{D}_{i'j'}\mathbf{x}_{i'j'} + \sum_{j'=1}^{J'}\sum_{k'=1}^{K'} \mathbf{D}_{j'k'}\mathbf{y}_{j'k'}\right)\right] \tag{1a}$$

$$\mathbf{Min Z^2} = \sum_{i'=1}^{I'}\sum_{j'=1}^{J'} \mathrm{R}(\tilde{\mathbf{t}}_{i'j'})\eta_{i'j'} + \sum_{j'=1}^{J'}\sum_{k'=1}^{K'} \mathrm{R}(\tilde{\mathbf{t}}_{j'k'})\eta_{j'k'} \tag{2}$$

$$\text{Subject to } \sum_{j'=1}^{J'} x_{i'j'} \leq \mathrm{R}(\tilde{a}_{i'}), i' = 1,2,...,I', \tag{3}$$

$$\sum_{j'=1}^{J'} y_{j'k'} \geq \mathrm{R}(\tilde{b}_{k'}), k' = 1,2,...,K', \tag{4}$$

$$\sum_{i'=1}^{I'} (p_{i'} - p_{j'}^{\min}) x_{i'j'} \geq 0, j' = 1,2,\ldots,J' \tag{5}$$

$$\sum_{j'=1}^{J'} (p_{j'}^{\min} - p_{k'}^{\min}) y_{j'k'} \geq 0, k' = 1,2,\ldots,K' \tag{6}$$

$$\sum_{i'=1}^{I'} x_{i'j'} = \sum_{k'=1}^{K'} y_{j'k'}, j' = 1,2,..,J', \tag{7}$$

$$x_{i'j'} \geq 0, y_{j'k'} \geq 0, \forall i', j', k'. \tag{8}$$

$$\delta_{i'j'} = \begin{cases} 0 if x_{i'j'} = 0 \\ \left\lfloor \frac{x_{i'j'}}{W} \right\rfloor + 1 if x_{i'j'} > 0 \; and \; remainder \; of \; \left(\frac{x_{i'j'}}{W}\right) > 0 \\ \left\lfloor \frac{x_{i'j'}}{W} \right\rfloor if x_{i'j'} > 0 \; and \; remainder \; of \; \left(\frac{x_{i'j'}}{W}\right) = 0 \end{cases} \tag{9}$$

$$\delta_{j'k'} = \begin{cases} 0 if y_{j'k'} = 0 \\ \left\lfloor \frac{y_{j'k'}}{W} \right\rfloor + 1 if y_{j'k'} > 0 \; and \; remainder \; of \; \left(\frac{y_{j'k'}}{W}\right) > 0 \\ \left\lfloor \frac{y_{j'k'}}{W} \right\rfloor if y_{j'k'} > 0 \; and \; remainder \; of \; \left(\frac{y_{j'k'}}{W}\right) = 0 \end{cases} \tag{10}$$

$$\phi(\textstyle\sum_{i'=1}^{I'} x_{i'j'}) = \begin{cases} 1if \displaystyle\sum_{i'=1}^{I'} x_{i'j'} > 0 \\ 0else \end{cases} \tag{11}$$

$$\eta_{i'j'} = \begin{cases} 1if x_{i'j'} > 0 \\ 0else \end{cases} \quad and\ \eta_{j'k'} = \begin{cases} 1if y_{j'k'} > 0 \\ 0else \end{cases} \tag{12}$$

Model-B: ***With Mobile Carbon Capture and Utilization Technology***

$$MaxZ^1 = \mathrm{R}(\tilde{s})\left[\sum_{i'=1}^{I'}\sum_{j'=1}^{J'} x_{i'j'} + \sum_{j'=1}^{J'}\sum_{k'=1}^{K'} y_{j'k'}\right] - \left[\sum_{i'=1}^{I'}\sum_{j'=1}^{J'} \mathrm{R}(\tilde{c}_{i'j'})x_{i'j'} + \sum_{j'=1}^{J'}\sum_{k'=1}^{K'} \mathrm{R}(\tilde{c}_{j'k'})y_{j'k'}\right]$$

$$-\left[\sum_{i'=1}^{I'}\sum_{j'=1}^{J'} \mathrm{R}(\widetilde{F}_{i'j'})\delta_{i'j'} + \sum_{j'=1}^{J'}\sum_{k'=1}^{K'} \mathrm{R}(\widetilde{F}_{j'k'})\delta_{j'k'}\right] - \left[\sum_{j'=1}^{J'} \mathrm{R}(\tilde{f}_{j'}).\phi(\sum_{i'=1}^{I'} x_{i'j'})\right]$$

$$-\left[\textstyle\sum_{j'=1}^{J'} \mathrm{R}(\tilde{\beta}_{j'}).\left(\sum_{i'=1}^{I'} x_{i'j'}\right)\right] - \left[(\mathrm{R}(\tilde{c}_c)\text{- }\mathrm{R}(\tilde{c}_r)).e\left(\sum_{i'=1}^{I'}\sum_{j'=1}^{J'} D_{i'j'}x_{i'j'} + \sum_{j'=1}^{J'}\sum_{k'=1}^{K'} D_{j'k'}y_{j'k'}\right)\right] \tag{1b}$$

And **(Eq. 2)**-(**Eq. 12**).

Here, **equations (1a) and (1b)** are the profit maximization objective functions without and with mobile carbon capture and utilization technology. The first part of (**Eq. 1a) and (Eq. 1b**) is the revenue from selling the product whereas the remaining are the expenses for transport, fixed-charges and carbon tax in (**Eq. 1a**) meanwhile expense post the reuse of captured carbon in (**Eq. 1b**). (**Eq. 2**) is the transportation time for distributing the products. (**Eq. 3**) and (**Eq. 4)** are the supply and demand constraints while (**Eq. 5**) and (**Eq. 6**) are the product blending constraints. (**Eq. 9**) and (**Eq. 10**) are the truck slot constraints which rely on the number of products transported and the capacity of a truck. (**Eq. 11**) and (**Eq. 12**) are the binary variable constraints.

2.3 Global Criterion Method for Transportation Problem

This optimization approach alters the multi-objective problem into a single objective and diminishes the distance of objective from the aspired solution. Suppose that there is a problem with 'h' objectives. Then, the steps incorporated to determine the compromise solution of this problem using global criterion method are as follows.

Step-1: Solve each objective function individually to get 'h' number of solutions.

Step-2: Substitute the 'h' solutions in every other objective function to get a h X h pay-off matrix.

Step-3: Acquire $U_H = \max(Z_H(x_1), Z_H(x_2), ..., Z_H(x_h))$ and $L_H = \min(Z_H(x_1), Z_H(x_2), ..., Z_H(x_h))$.

Step-4: Evaluate the model provided below using LINGO (19.0) to get the compromise solution.

$MinF(x) = \left[\sum_{H=1}^{h}\left(\frac{Z_H(x)-L_H}{U_H-L_H}\right)^q\right]^{\frac{1}{q}}$,

Subject to (**Eq. 3**)-(**Eq. 12**), where q=1 is Manhattan distance, q=2 is Euclidean distance, and the objective corresponds to minimization.

3 Results and Discussion

3.1 Numerical Example

The trapezoidal fuzzy rough data for the proposed models are extracted from distribution data of crude oil by Ghosh S & Roy SK [11]. Auxiliary parameters with reference to mobile carbon capture and utilization are taken from Reynolds C [19]. Selling price of crude oil is taken from online websites. Carbon taxation is not prevalent in India yet has been accommodated from world bank website for awakening sustainability. The gathered ancillary data are converted into trapezoidal fuzzy rough variables to rectify ambiguity as given below.

$\mathrm{R}(\tilde{s}) = (s-3, s-2, s+2, s+3), s = [72,74][70,77]$ dollars per barrel,
$\mathrm{R}(\tilde{c}_t) = (c_t-2, c_t-1, c_t+1, c_t+2), c_t = [16,20][15,25]$ dollars per tonne,
$\mathrm{R}(\tilde{c}_c) = (c_c-4, c_c-3, c_c+3, c_c+4), c_c = [31,33][30,35]$ dollars per tonne,
$\mathrm{R}(\tilde{c}_r) = (c_r-3, c_r-2, c_r+2, c_r+3), c_r = [25,27][20,30]$ dollars per tonne.

3.2 Solution and Analysis

The two proposed models are solved separately and compared with each other to pinpoint their effectiveness. The results obtained from solving are provided in Table 1 The base model for this profit maximization problem minimized only the transport expenses which furnished an expenditure of 3063. 945 dollars and carbon emission of 4.314 tonne while excluding the sales profit from crude oil. For analyzing the efficiency of the two proposed models with carbon taxation and mobile carbon capture and reuse, selling price along with the expense for carbon tax and mobile carbon capture and utilization is reintroduced into the already acquired solutions of the base model that furnished only the transport expense and the emission discharged.

Table 1. Comparison of carbon taxation (A) and mobile carbon capture and utilization (B)

Objective function	Model A	Model B
Profit	9424.824 dollars	9507.464 dollars
Time	74.5 hours	74.5 hours

The prevailing solution from resolving the base model with only expense objectives using Global Criterion Method are retraced and rethrown below[11].

$$x11 = 39.915, x12 = 2.835, x21 = 9.692, x22 = 10.508, y11 = 21.5, y12 = 10.662, y13 = 17.445, y22 = 10.662, y23 = 2.68.$$

On total, 125.899 barrels of crude oil is being distributed in the expense-based model from which revenue of 9253.5765 dollars is obtained, provided the defuzzified value of selling price of crude oil per unit. Transport expenditure and carbon tax of 81.966 dollars for the emission of 4.314 tonne of carbon altogether add up the expense to 3145.911 dollars. Thus, a sum of 6107.6655 dollars is gained after deducting all these expenses in the base model whereas the proposed profit maximization models with carbon tax earned a profit of 9424.824 dollars while mobile carbon capture and reuse model rendered 9507.464 dollars which clearly makes the developed models more suitable in terms of profit with sustainability concerns. Also, it is observed that mobile carbon capture model generates an outstanding income in spite of its expenses due to its reuse technology than that of the carbon taxation method.

4 Conclusion

Minimization of carbon emission and its effects is the global goal among environmental scientists. Carbon taxation is one among the world-wide policy adopted by countries to enlarge environmental awareness. But this technique is inappropriate for environmental sustainability due to the increasing hikes in tax percentage across different countries. Even though taxation policies don't need any initial investments, they are less profitable which is why a profit maximization problem in fuzzy rough blending and truck slot constrained multi-objective fixed-charge transportation problem under this policy is analyzed. Mobile carbon capture and utilization is one among the budding green technologies that contrasted with existing carbon taxation scheme in this work. This developing technique has gained an excess profit of 82.64 dollars from that of the usual taxation method for carbon emissions thus proving itself to be a systematized profit maximization process for fuzzy rough blending and truck slot constrained multi-objective fixed-charge transportation problem. It is recommended that this mobile capture and reuse system be launched worldwide to encourage sustainability. Here, the captured carbon is utilized for enhanced oil recovery operations while some others use them in construction materials or convert them into sustainable fuels and chemicals. Products like perfumes, sanitizers, luxury jewels are also made from captured carbon that render more profit with selling which is not included here and could be considered as an extension. Assumptions and limitations of the proposed model could be analyzed in future to enhance the result. The work is just an initiative for optimizing transportation problem with reuse of captured carbon and is solved using usual Global Criterion Method. There are also other methods of optimization which are more efficient than the talk through method discussed here. The study can further focus on comparing various strategies employed in capture, regeneration and storage of carbon from mobile transit. Analysis of other carbon policies like cap-and-trade, carbon cap and offset policies with that of mobile carbon capture could be performed. Additional challenges while incorporating capture and reuse system including safety parameters, capturing unit capacity, blending constraints for captured carbon, conveyances and modes to transfer captured carbon could also be elaborated deeply as extensions. Location problems for number of transfer or swapping stations to unload carbon when capturing units reach their full capacity can be an excellent futuristic problem for discussion. The answers to the process and the intermediate stages through which captured carbon is reused, the possibility of capturing the carbon completely and time windows are left unanswered. Also, the capital cost for building such larger infrastructure in trucking industry is time consuming and expensive which may make capturing less compatible than other carbon policies which are investment free and this is left open for future researchers.

5 Acknowledgement

We thank the Department of Science and Technology, Government of India, for providing support through the Fund for Improvement of S&T Infrastructure in Universities and Higher Educational Institutions (FIST) program (Grant No. SR/FIST/College-/2020/943).

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