**Table 5:** Optimal solution of the SC model under various approaches

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Model/ Approaches | (MT) | (%) | (Year) | (Year) | (Year) | (MT) | ($) |  |  |
| Crisp | 602.22 | 4.872 | 0.369 | 0.554 | 0.923 | 221.399 | 70219.289 | 0 | +50.90 |
| General Fuzzy | 558.301 | 4.453 | 0.392 | 0.588 | 0.980 | 214.620 | 61326.797 | -12.66 | +31.79 |
| Al-Tarawneh **(2021)**  Bi-objective strategic fuzzy game | 558.828 | 4.458 | 0.411 | 0.616 | 1.027 | 225.022 | 176462.000 | +151.30 | +279.21 |
| Bhattacharya and De **(2021)**  Standard normal strategic fuzzy game | 558.828 | 4.458 | 0.411 | 0.617 | 1.028 | 225.022 | 112808.938 | +60.65 | +142.42 |
| Random strategic fuzzy  game (rsfg) | 558.079 | 4.451 | 0.384 | 0.576 | 0.960 | 210.240 | 46533.887 | -33.73 | 0 |

**Table 7:** Sensitivity Analysis on fuzzy deviation parameters of the proposed model

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fuzzy parameters | % Change | (Year) | (Year) | (Year) | (%) | (MT) | ($) | (MT) |  |  |
| 0.2 | +50 | 0.384 | 0.576 | 0.960 | 4.450 | 210.239 | 45032.006 | 558.079 | -35.869 | -8.620 |
| +30 | 0.384 | 0.576 | 0.960 | 4.450 | 210.239 | 45632.796 | 558.079 | -35.012 | -8.620 |
| -30 | 0.384 | 0.576 | 0.960 | 4.450 | 210.239 | 47434.976 | 558.079 | -32.447 | -8.620 |
| -50 | 0.384 | 0.576 | 0.960 | 4.450 | 210.239 | 48035.707 | 558.079 | -31.591 | -8.620 |
| 0.1 | +50 | 0.384 | 0.576 | 0.960 | 4.450 | 210.239 | 47284.736 | 558.079 | -32.661 | -8.620 |
| +30 | 0.384 | 0.576 | 0.960 | 4.450 | 210.239 | 46984.429 | 558.079 | -33.088 | -8.620 |
| -30 | 0.384 | 0.576 | 0.960 | 4.450 | 210.239 | 46083.339 | 558.079 | -34.372 | -8.620 |
| -50 | 0.384 | 0.576 | 0.960 | 4.450 | 210.239 | 45782.976 | 558.079 | -34.800 | -8.620 |
| 0.2 | +50 | 0.384 | 0.576 | 0.960 | 4.306 | 204.480 | 46355.714 | 542.789 | -33.984 | -11.618 |
| +30 | 0.384 | 0.576 | 0.960 | 4.364 | 206.783 | 46426.984 | 548.905 | -33.883 | -10.427 |
| -30 | 0.384 | 0.576 | 0.960 | 4.538 | 213.696 | 46640.792 | 567.253 | -33.578 | -6.856 |
| -50 | 0.384 | 0.576 | 0.960 | 4.596 | 216.000 | 46712.062 | 573.369 | -33.477 | -5.665 |
| 0.15 | +50 | 0.384 | 0.576 | 0.960 | 4.341 | 205.919 | 45389.890 | 546.611 | -35.360 | -10.899 |
| +30 | 0.384 | 0.576 | 0.960 | 4.385 | 207.647 | 45847.488 | 551.198 | -34.708 | -9.996 |
| -30 | 0.384 | 0.576 | 0.960 | 4.516 | 212.832 | 47220.281 | 564.959 | -32.753 | -7.307 |
| -50 | 0.384 | 0.576 | 0.960 | 4.633 | 217.440 | 48440.546 | 217.440 | -31.015 | -4.906 |

**Table 6:** Solution of the fuzzy game model under various strategy vector

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Strategy | Game strategies  , | (Year) | (Year) | (Year) | (%) | (MT) | ($) | (MT) |  |  |
| 1 | (0.667, 0.185, 0.148)  (0.696, 0.158, 0.146) | 0.141 | 0.212 | 0.353 | 4.387 | 77.198 | 141605.063 | 551.369 | 101.661 | -9.955 |
| 2 | (0.371, 0.481, 0.148)  (0.146, 0.486, 0.368) | 0.929 | 1.394 | 2.323 | 4.597 | 508.628 | 107498.906 | 573.325 | 53.090 | -5.644 |
| 3 | (0.409, 0.386, 0.205)  (0.233, 0.370, 0.397) | 0.390 | 0.585 | 0.975 | 4.452 | 213.525 | 73862.641 | 558.246 | 5.188 | -8.621 |
| 4 | (0.211, 0.400, 0.389)  (0.592, 0.243, 0.165) | 0.839 | 1.259 | 2.098 | 4.572 | 459.353 | 87932.242 | 570.789 | 25.225 | -6.158 |
| 5 | (0.153, 0.671, 0.176)  (0.216, 0.633, 0.151) | 0.839 | 1.259 | 2.098 | 4.572 | 459.353 | 138133.047 | 570.789 | 96.717 | -6.158 |
| 6 | (0.124, 0.534, 0.342)  (0.141, 0.255, 0.604) | 0.173 | 0.259 | 0.433 | 4.395 | 94.717 | 113522.969 | 552.249 | 61.669 | -9.791 |
| 7 | (0.211, 0.389, 0.400)  (0.592, 0.243, 0.165) | 0.299 | 0.449 | 0.748 | 4.428 | 163.702 | 71792.953 | 555.726 | 2.241 | -9.113 |
| 8 | (0.102, 0.148, 0.750)  (0.140, 0.697, 0.163) | 0.384 | 0.576 | 0.960 | 4.450 | 210.239 | 46533.886 | 558.079 | -33.731 | -8.662 |
| 9 | (0.200, 0.313, 0.487)  (0.100, 0.233, 0.667) | 0.588 | 0.882 | 1.470 | 4.505 | 321.929 | 96245.141 | 563.754 | 37.064 | -7.533 |

**Selection of best strategy vector**

We have the strategy vector of customer (demand rate *d*) is ( and that for the producer (*p*) is (). We also assume that these vectors follow the curve near Gaussian normal satisfying the following relations:

Probability

Customer

Producer

**Fig. 3** Strategies for positively skewed of player1 & player2.

Random Variable ( *x* )

*P(x)*

**Strategy 1:** We take and that satisfies Fig 3.

**Fig. 4** Strategies for normal of player1 & positively skewed of player2

Random Variable ( *x* )

*P(x)*

**Strategy 2:** We take and that satisfies Fig 4.

Probability

Customer

Producer

**Fig. 5** Strategies for negatively skewed of player1 & positively skewed of player 2.

*P(x)*

Random Variable ( *x* )

Probability

**Strategy 3:** We take and that satisfies Fig. 5.

Customer

Producer

Probability

**Strategy 4:** We take and that satisfies Fig 6.

**Fig. 6** Strategies for positively skewed of player1 and normal of player2.

*P(x)*

Random Variable ( *x* )

Customer

Producer

**Fig. 7** Strategies for normal of both player1 & player 2.

*P(x)*

Probability

**Strategy 5:** We take and that satisfies Fig 7.

Random Variable ( *x* )

Customer

Producer

**Fig. 8** Strategies for negatively skewed player1 & normal of player2.

**Strategy 6:** We take and that satisfies Fig 8.

*P(x)*

Random Variable ( *x* )

Customer

Producer

Probability

**Fig. 9** Strategies for positively skewed player1 & negatively skewed of player 2.

Random Variable *x*

*P(x)*

Probability

**Strategy 7:** We take and that satisfies Fig 9.

Customer

Producer

**Strategy 8:** We take and that satisfies Fig. 10.

Probability

*P(x)*

**Fig. 10** Strategies for normal of player1 & negatively skewed of player 2.

Random Variable *x*

Customer

Producer

*P*(x)

**Fig. 11** Strategies for negatively skewed player1 & negatively skewed of player2.

Random Variable *x*

**Strategy 9:** We take and that satisfies Fig. 11.

Probability

Customer

Producer