1. Hypothetical Input Data

Table 1: Input data for models

Notation	Values	Notation	Values
Ω^1	0.002	P^1	0.5083
Ω^2	0.0022	P^2	0.3846
t^1	0.00139	L	1.3730
t^2	0.00111	$t^{"}$	0.25
α^1	0.01373	D_s	2.7476
α^2	0.01511	ϑ_1	30
S^1	0.9616	ϑ_2	90
S^2	0.8929		

Table 2: Demand matrix (kg)

Retailers	2	3	4	5	6	7	8	9	10
Product 1	250	300	150	245	275	160	280	190	220
Product 2	100	170	299	200	150	280	160	190	275

Table 3: Distance matrix along different routes (km)

i/j	1	2	3	4	5
1	∞	(240.0, 216.0, 200.0)	(132.4, 136.0, 132.4)	(132.8, 131.6, 135.6)	(134.4, 130.0, 138.4)
2	(240.0, 216.0, 200.0)	∞	(158.0, 152.0, 160.4)	(162.4, 159.6, 152.0)	(404.0, 428.0, 460.0)
3	(132.4, 136.0, 132.4)	(158.0, 152.0, 160.4)	∞	(16.0, 28.0, 12.0)	(190.4, 172.8, 192.8)
4	(132.8, 131.6, 135.6)	(162.4, 159.6, 152.0)	(16.0, 28.0, 12.0)	∞	(139.2, 132.6, 130.2)
5	(134.4, 130.0, 138.4)	(404.0, 428.0, 460.0)	(190.4, 172.8, 192.8)	(139.2, 132.6, 130.2)	∞
6	(146.0, 148.4, 143.6)	(293.0, 306.0, 289.0)	(46.6, 47.8, 49.0)	(164.5, 168.7, 159.6)	(53.2, 50.2, 54.2)
7	(148.8, 148.0, 147.2)	(150.8, 155.6, 144.0)	(60.6, 58.2, 59.8)	(152.0,147.5, 155.5)	(54.8, 50.8, 44.8)
8	(126.4, 124.2, 122.8)	(172.4, 168.0, 169.2)	(65.4, 66.2, 62.8)	(65.6, 62.0, 58.6)	(64.8, 69.6, 62.4)
9	(148.6, 212.4, 220.0)	(147.4, 148.2, 144.0)	(162.8, 167.2, 168.4)	(163.2, 156.0, 164.8)	(43.6, 41.2, 40.0)
10	(220.4, 215.2, 217.2)	(157.2, 160.0, 154.2)	(216.8, 220.4, 212.0)	(217.2, 210.4, 220.4)	(54.6, 56.4, 60.2)
i/j	6	7	8	9	10
1	(146.0, 148.4, 143.6)	(148.8, 148.0, 147.2)	(126.4, 124.2, 122.8)	(148.6, 212.4, 220.0)	(220.4, 215.2, 217.2)
2	(293.0, 306.0, 289.0)	(150.8, 155.6, 144.0)	(172.4, 168.0, 169.2)	(147.4, 148.2, 144.0)	(157.2, 160.0, 154.2)
3	(46.6, 47.8, 49.0)	(60.6, 58.2, 59.8)	(65.4, 66.2, 62.8)	(162.8, 167.2, 168.4)	(216.8, 220.4, 212.0)
4	(164.5, 168.7, 159.6)	(152.0, 147.5, 155.5)	(65.6, 62.0, 58.6)	(163.2, 156.0, 164.8)	(217.2, 210.4, 220.4)
5	(53.2, 50.2, 54.2)	(54.8, 50.8, 44.8)	(64.8, 69.6, 62.4)	(43.6, 41.2, 40.0)	(54.6, 56.4, 60.2)
6	∞	(36.4, 40.8, 34.4)	(64.4, 68.8, 63.6)	(36.4, 34.0, 39.2)	(46.4, 44.8, 42.2)
7	(36.4, 40.8, 34.4)	∞	(27.2, 30.4, 32.8)	(31.6, 26.0, 23.6)	(56.8, 64.4, 60.4)
8	(64.4, 68.8, 63.6)	(27.2, 30.4, 32.8)	∞	(44.8, 38.0, 42.0)	(49.2, 55.2, 46.4)
9	(36.4, 34.0, 39.2)	(31.6, 26.0, 23.6)	(44.8, 38.0, 42.0)	∞	(67.2, 60.4, 72.8)
10	(46.4, 44.8, 42.2)	(56.8, 64.4, 60.4)	(49.2, 55.2, 46.4)	(67.2, 60.4, 72.8)	∞

Table 4: Fixed carrying cost(C^0_{ijr}) matrix ($)

i/j	1	2	3	4	5
1	∞	(9.0671, 8.2428, 7.8994)	(20.6759, 17.9969, 15.5241)	(21.2254, 18.8899, 20.6759)	(21.7749, 22.3244, 21.9810)
2	(9.0671, 8.2428, 7.8994)	∞	(22.0497, 21.6375, 22.6679)	(23.4235, 22.6679, 24.0417)	(11.6087, 10.5783, 11.8835)
3	(20.6759, 17.9969, 15.5241)	(22.0497, 21.6375, 22.6679)	∞	(7.5559, 6.1821, 9.6167)	(34.7575, 33.6584, 35.8565)
4	(21.2254, 18.8899, 20.6759)	(23.4235, 22.6679, 24.0417)	(7.5559, 6.1821, 9.6167)	∞	(28.2318, 27.5449, 28.9188)
5	(21.7749, 22.3244, 21.9810)	(11.6087, 10.5783, 11.8835)	(34.7575, 33.6584, 35.8565)	(28.2318, 27.5449, 28.9188)	∞
6	(26.0337, 24.0417, 26.4459)	(29.3309, 30.5673, 28.8501)	(35.4444, 34.0706, 34.9635)	(29.2622, 21.7749, 21.0880)	(33.3150, 32.4220, 26.9267)
7	(27.2015, 26.5146, 26.8580)	(18.6151, 19.1647, 19.4394)	(18.2717, 24.0417, 23.3548)	(18.4091, 17.2413, 23.9043)	(20.8132, 21.6375, 22.0497)
8	(28.1632, 34.2766, 28.9874)	(27.3389, 28.7127, 26.1024)	(21.2941, 15.1119, 27.4763)	(22.0497, 15.8675, 21.8436)	(24.4539, 25.0721, 23.1487)
9	(31.1856, 30.6360, 36.4060)	(22.5992, 14.7685, 20.8819)	(27.4076, 18.5465, 33.2463)	(27.3389, 33.0402, 35.0322)	(32.9028, 32.2846, 33.5210)
10	(36.4747, 32.9715, 31.0482)	(29.4683, 21.5688, 29.9491)	(33.5210, 32.3533, 31.5977)	(33.9332, 33.1776, 34.2766)	(27.4763, 21.6375, 28.0945)
i/j	6	7	8	9	10
1	(26.0337, 24.0417, 26.4459)	(27.2015, 26.5146, 26.8580)	(28.1632, 34.2766, 28.9874)	(31.1856, 30.6360, 36.4060)	(36.4747, 32.9715, 31.0482)
2	(29.3309, 30.5673, 28.8501)	(18.6151, 19.1647, 19.4394)	(27.3389, 28.7127, 26.1024)	(22.5992, 14.7685, 20.8819)	(29.4683, 21.5688, 29.9491)
3	(35.4444, 34.0706, 34.9635)	(18.2717, 24.0417, 23.3548)	(21.2941, 15.1119, 27.4763)	(27.4076, 18.5465, 33.2463)	(33.5210, 32.3533, 31.5977)
4	(29.2622, 21.7749, 21.0880)	(18.4091, 17.2413, 23.9043)	(22.0497, 15.8675, 21.8436)	(27.3389, 33.0402, 35.0322)	(33.9332, 33.1776, 34.2766)
5	(33.3150, 32.4220, 26.9267)	(20.8132, 21.6375, 22.0497)	(24.4539, 25.0721, 23.1487)	(32.9028, 32.2846, 33.5210)	(27.4763, 21.6375, 28.0945)
6	∞	(13.7381, 12.9825, 14.9058)	(24.3165, 23.6983, 23.0800)	(12.3643, 14.4250, 13.5320)	(35.0322, 34.2766, 35.6505)
7	(13.7381, 12.9825, 14.9058)	∞	(10.2349, 10.6470, 9.6167)	(11.8835, 12.5017, 11.3339)	(22.0497, 21.2254, 21.9123)
8	(24.3165, 23.6983, 23.0800)	(10.2349, 10.6470, 9.6167)	∞	(16.8979, 17.2413, 16.8292)	(18.6151, 18.2030, 17.2413)
9	(12.3643, 14.4250, 13.5320)	(11.8835, 12.5017, 11.3339)	(16.8979, 17.2413, 16.8292)	∞	(25.3468, 25.5529, 24.3852)
10	(35.0322, 34.2766, 35.6505)	(22.0497, 21.2254, 21.9123)	(18.6151, 18.2030, 17.2413)	(25.3468, 25.5529, 24.3852)	∞

Table 5: Maximum and minimum speed matrix for different routes (km/h)

i/j	1	2	3	4	5
1	((0, 0),(0, 0),(0, 0))	((45, 70),(20, 76),(40, 90))	((20, 100),(30, 80),(20, 90))	((35, 80),(45, 90),(35, 75))	((20, 90),(25, 80),(30, 70))
2	((20, 60),(50, 100),(45, 70))	((0, 0),(0, 0),(0, 0))	((30, 110),(25, 93),(26, 103))	((22, 110),(29, 90),(31, 95))	((24,105),(25,95),(20,95))
3	((35, 100),(40, 75),(35, 85))	((30, 55),(45, 65),(60, 100))	((0, 0),(0, 0),(0, 0))	((35,79),(32,95),(23,110))	((30,120),(25,95),(24,115))
4	((45, 95),(40, 85),(25, 55))	((30, 50),(65, 80),(45, 90))	((35, 85),(45, 70),(55, 80))	((0, 0),(0, 0),(0, 0))	((30,80),(45,90),(30,80))
5	((50, 100),(50, 95),(65, 85))	((40, 75),(35, 85),(50, 80))	((40, 80),(60, 120),(25, 55))	((45, 85),(25, 70),(35, 85))	((0, 0),(0, 0),(0, 0))
6	((45, 85),(35, 90),(40, 75))	((50, 120),(45, 100),(35, 75))	((45, 95),(55, 85),(30, 70))	((45, 85),(50, 100),(35, 65))	((40, 110),(45, 80),(40, 95))
7	((35, 80),(40, 90),(50, 100))	((45, 90),(35, 85),(45, 75))	((40, 120),(35, 70),(50, 100))	((45, 85),(30, 70),(45, 90))	((35, 80),(50, 120),(45, 75))
8	((35, 80),(45, 85),(40, 95))	((40, 85),(50, 100),(30, 90))	((40, 85),(25, 60),(45, 80))	((35, 95),(50, 90),(45, 110))	((40, 85),(30, 70),(40, 85))
9	((30, 70),(45, 100),(50, 95))	((30, 70),(45, 100),(40, 95))	((55, 110),(35, 90),(50, 85))	((45, 110),(40, 85),(35, 85))	((55, 120),(40, 85),(30, 65))
10	((35, 75),(40, 110),(50, 95))	((45, 85),(30, 70),(55, 120))	((45, 95),(35, 90),(40, 95))	((50, 100),(40, 95),(35, 85))	((45, 95),(50, 85),(35, 75))
i/j	6	7	8	9	10
1	((23, 99),(45, 95),(30, 80))	((45, 110),(35, 95),(30, 90))	((35, 75),(20, 85),(40, 110))	((30, 95),(20, 110),(41, 80))	((20, 95),(30, 90),(25, 90))
2	((25,65),(30,75),(20,84))	((25,75),(45,95),(50,90))	((45,90),(30,85),(26,95))	((25,60),(45,112),(20,95))	((30,90),(24,95),(40,90))
3	((25,65),(40,85),(35,95))	((20,90),(30,85),(35,95))	((20,95),(45,115),(40,98))	((50,85),(65,100),(25,70))	((25,80),(40,85),(35,95))
4	((30,95),(25,70),(25,100))	((21,95),(40,110),(45,94))	((25,85),(40,85),(45,95))	((20,120),(30,80),(45,90))	((20,90),(35,75),(35,85))
5	((20,94),(25,100),(27,95))	((25,95),(21,100),(20,90))	((35,85),(35,75),(30,90))	((40,70),(45,95),(35,75))	((20,90),(45,85),(40,80))
6	((0, 0),(0, 0),(0, 0))	((35,90),(35,95),(50,110))	((35,95),(30,85),(20,90))	((30,87),(33,100),(25,65))	((40,80),(30,80),(50,120))
7	((35,105),(25,110),(23,95))	((0, 0),(0, 0),(0, 0))	((30,90),(45,85),(30,120))	((35,75),(27,95),(20,85))	((45,110),(30,80),(45,95))
8	((45,90),(24,90),(40,85))	((35,85),(40,90),(31,95))	((0, 0),(0, 0),(0, 0))	((35,80),(21,85),(25,120))	((22,90),(35,85),(45,85))
9	((35,75),(24,90),(35,85))	((40,110),(20,120),(45,85))	((30,80),(35,85),(35,95))	((0, 0),(0, 0),(0, 0))	((20,75),(50,110),(55,110))
10	((45,85),(40,110),(22,95))	((40,110),(25,100),(35,95))	((30,85),(35,75),(21,95))	((45,90),(27,85),(35,85))	((0, 0),(0, 0),(0, 0))

Table 6: Input data matrix of Model-D

Retailers	2	3	4	5	6	7	8	9	10
Time intervals	(8 PM, 2 AM)	(8 AM,1 PM)	(6 AM,10 AM)	(2 PM, 6 PM)	(8 AM,2 PM)	(6 PM,12 AM)	(1 PM, 9 PM)	(11 AM,6 PM)	(10 PM,2 AM)
Penalties ($ per hr)	067	0.79	0.68	0.80	0.77	0.82	0.68	0.75	0.78

2. Practical Input Data

Table 7: Demand matrix of fruits (kg)

Retailers	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Apple	110	90	145	120	130	155	120	185	100	100	105	80	110	105	125
Pear	100	105	155	175	255	165	100	195	270	55	70	100	140	120	190

Table 8: Distance matrix for practical implementation (km)

Cities	Shimla	Chandigarh	Ludhiana	Amritsar	Patiala	Jaladhar	Bathinda	Kapurthala
Shimla	–	(112.5, 109.3, 121.2)	(183.7, 199.4, 190.1)	(295.6, 301.5, 299.2)	(173.9, 195.1, 187.4)	(216.2, 220.7, 240.1)	(329.7, 335.1, 330.0)	(234.1, 240.5, 254.4)
Chandigarh	(112.5, 109.3, 121.2)	–	(97.4, 108.3, 100.6)	(226.6, 238.9, 240.3)	(70.8, 79.6, 84.5)	(147.2, 150.4, 156.1)	(228.4, 233.3, 230.2)	(165.1, 174.7, 187.1)
Ludhiana	(183.7, 199.4, 190.1)	(97.4, 108.3, 100.6)	–	(140.7, 150.4, 147.8)	(93.0, 101.8, 120.5)	(61.3, 70.1, 80.6)	(147.3, 157.0, 150.6)	(79.2, 100.4, 87.6)
Amritsar	(295.6, 301.5, 299.2)	(266.4, 218.9, 297.3)	(140.7, 150.4, 147.8)	–	(234.2, 250.1, 246.8)	(82.5, 94.8, 96.1)	(189.4, 200.2, 190.8)	(68.1, 73.2, 90.7)
Patiala	(173.9, 195.1, 187.4)	(70.8, 79.6, 84.5)	(93.0, 101.8, 120.5)	(234.2, 250.1, 246.8)	–	(154.0, 161.7, 178.7)	(155.6, 160.7, 174.1)	(171.9, 204.5, 180.6)
Jaladhar	(216.2, 220.7, 240.1)	(147.2, 150.4, 156.1)	(61.3, 70.1, 80.6)	(82.5, 94.8, 96.1)	(154.0, 161.7, 178.7)	–	(159.9, 190.4, 177.2)	(19.4, 29.2, 25.6)
Bathinda	(329.7, 335.1, 330.0)	(228.4, 233.3, 230.2)	(147.3, 157.0, 150.6)	(189.4, 200.2, 190.8)	(155.6, 160.7, 174.1)	(159.9, 190.4, 177.2)	–	(159.8, 167.4, 187.2)
Kapurthala	(234.1, 240.5, 254.4)	(165.1, 174.7, 187.1)	(79.2, 100.4, 87.6)	(68.1, 73.2, 90.7)	(171.9, 204.5, 180.6)	(19.4, 29.2, 25.6)	(159.8, 167.4, 187.2)	–
Moga	(253.6, 260.1, 265.7)	(167.3, 174.8, 180.7)	(68.0, 71.2, 82.6)	(110.1, 132.6, 128.2)	(168.1, 192.1, 189.4)	(79.6, 84.2, 100.4)	(80.9, 90.1, 119.2)	(74.8, 82.6, 95.8)
Khanna	(154.1, 164.2, 170.8)	(67.8, 70.1, 89.4)	(41.7, 58.9, 47.2)	(182.2, 195.9, 193.8)	(51.2, 61.6, 84.7)	(102.9, 157.4, 108.6)	(167.9, 171.7, 199.5)	(121.0, 134.1, 145.6)
Barnala	(250.9, 268.9, 270.2)	(172.1, 181.2, 179.2)	(74.9, 86.1, 81.2)	(176.8, 180.9, 197.2)	(99.3, 108.4, 127.2)	(131.4, 148.9, 137.2)	(64.7, 78.2, 77.1)	(141.6, 158.5, 143.2)
Pathankot	(286.7, 295.9, 293.8)	(257.7, 295.4, 299.8)	(171.8, 195.1, 197.3)	(115.0, 127.2, 133.3)	(264.5, 274.9, 273.8)	(113.3, 125.4, 133.8)	(297.1, 299.2, 303.8)	(125.3, 129.9, 133.8)
Hoshiarpur	(202.4, 211.6, 240.7)	(135.9, 161.6, 140.5)	(77.3, 81.6, 94.7)	(109.0, 115.9, 123.8)	(170.0, 186.6, 194.0)	(46.7, 61.2, 71.8)	(210.7, 221.1, 238.0)	(58.7, 64.3, 78.6)
Firozpur	(308.6, 317.2, 308.9)	(222.3, 257.8, 233.6)	(123.0, 127.4, 138.6)	(120.1, 137.1, 148.6)	(215.1, 227.4, 248.6)	(119.7, 127.4, 138.5)	(100.0, 107.4, 118.4)	(109.9, 127.4, 118.6)
Batala	(302.7, 309.7, 329.5)	(222.1, 241.4, 259.5)	(136.2, 141.7, 139.5)	(41.2, 61.7, 59.1)	(228.9, 251.2, 239.5)	(77.6, 71.2, 79.5)	(223.2, 231.5, 243.5)	(63.6, 81.7, 79.5)
Rajpura	(142.6, 154.1, 175.6)	(41.2, 54.5, 45.6)	(87.8, 94.1, 105.0)	(228.4, 234.1, 255.6)	(27.3, 50.1, 43.2)	(149.0, 153.9, 163.6)	(186.3, 193.1, 199.6)	(167.1, 184.6, 174.2)

Cities	Moga	Khanna	Barnala	Pathankot	Hoshiarpur	Firozpur	Batala	Rajpura
Shimla	(253.6, 260.1, 265.7)	(154.1, 164.2, 170.8)	(250.9, 268.9, 270.2)	(286.7, 295.9, 293.8)	(202.4, 211.6, 240.7)	(308.6, 317.2, 308.9)	(302.7, 309.7, 329.5)	(142.6, 154.1, 175.6)
Chandigarh	(167.3, 174.8, 180.7)	(67.8, 70.1, 89.4)	(172.1, 181.2, 179.2)	(257.7, 295.4, 299.8)	(135.9, 161.6, 140.5)	(222.3, 257.8, 233.6)	(222.1, 241.4, 259.5)	(41.2, 54.5, 45.6)
Ludhiana	(68.0, 71.2, 82.6)	(41.7, 58.9, 47.2)	(74.9, 86.1, 81.2)	(171.8, 195.1, 197.3)	(77.3, 81.6, 94.7)	(123.0, 127.4, 138.6)	(136.2, 141.7, 139.5)	(87.8, 94.1, 105.0)
Amritsar	(110.1, 132.6, 128.2)	(182.2, 195.9, 193.8)	(176.8, 180.9, 197.2)	(115.0, 127.2, 133.3)	(109.6, 111.2, 114.7)	(120.1, 137.1, 148.6)	(41.2, 61.7, 59.1)	(228.4, 234.1, 255.6)
Patiala	(168.1, 192.1, 189.4)	(51.2, 61.6, 84.7)	(99.3, 108.4, 127.2)	(264.5, 274.9, 273.8)	(170.0, 186.6, 194.0)	(215.1, 227.4, 248.6)	(228.9, 251.2, 239.5)	(27.3, 50.1, 43.2)
Jaladhar	(79.6, 84.2, 100.4)	(102.9, 157.4, 108.6)	(131.4, 148.9, 137.2)	(113.3, 125.4, 133.8)	(46.7, 61.2, 71.8)	(119.7, 127.4, 138.5)	(77.6, 71.2, 79.5)	(149.0, 153.9, 163.6)
Bathinda	(80.9, 90.1, 119.2)	(167.9, 171.7, 199.5)	(64.7, 78.2, 77.1)	(297.1, 299.2, 303.8)	(210.7, 221.1, 238.0)	(100.0, 107.4, 118.4)	(223.2, 231.5, 243.5)	(186.3, 193.1, 199.6)
Kapurthala	(74.8, 82.6, 95.8)	(121.0, 134.1, 145.6)	(141.6, 158.5, 143.2)	(125.3, 129.9, 133.8)	(58.7, 64.3, 78.6)	(109.9, 127.4, 118.6)	(63.6, 81.7, 79.5)	(167.1, 184.6, 174.2)
Moga	–	(109.1, 139.4, 114.9)	(70.7, 88.7, 77.9)	(191.5,195.9,193.8)	(125.8, 131.6, 144.7)	(55.1, 87.4, 98.6)	(143.4, 155.7, 173.5)	(155.3, 174.1, 159.8)
Khanna	(109.1, 139.4, 114.9)	–	(88.7, 99.2, 100.8)	(213.6, 225.4, 233.8)	(164.2, 177.6, 180.2)	(177.9, 192.4, 200.3)	(46.2, 57.7, 69.5)	(121.0, 134.1, 145.6)
Barnala	(70.7, 88.7, 77.9)	(88.7, 99.2, 100.8)	–	(241.5, 255.4, 261.3)	(146.9, 163.3, 173.7)	(125.8, 137.4, 140.6)	(210.2, 211.7, 239.5)	(129.3, 134.1, 143.6)
Pathankot	(191.5,195.9,193.8)	(213.6, 225.4, 233.8)	(241.5, 255.4, 261.3)	–	(106.2, 111.3, 134.7)	(226.4, 237.4, 250.8)	(72.8, 81.3, 93.5)	(259.5, 273.1, 279.6)
Hoshiarpur	(125.8, 131.6, 144.7)	(164.2, 177.6, 180.2)	(146.9, 163.3, 173.7)	(106.2, 111.3, 134.7)	–	(181.1, 197.4, 188.6)	(86.6, 99.7, 109.3)	(163.4, 184.1, 195.1)
Firozpur	(55.1, 87.4, 98.6)	(177.9, 192.4, 200.3)	(125.8, 137.4, 140.6)	(226.4, 237.4, 250.8)	(181.1, 197.4, 188.6)	–	(153.1, 171.3, 169.5)	(210.1, 214.1, 222.3)
Batala	(143.4, 155.7, 173.5)	(46.2, 57.7, 69.5)	(210.2, 211.7, 239.5)	(72.8, 81.3, 93.5)	(86.6, 99.7, 109.3)	(153.1, 171.3, 169.5)	–	(223.9, 234.1, 249.6)
Rajpura	(155.3, 174.1, 159.8)	(121.0, 134.1, 145.6)	(129.3, 134.1, 143.6)	(259.5, 273.1, 279.6)	(163.4, 184.1, 195.1)	(210.1, 214.1, 222.3)	(223.9, 234.1, 249.6)	–