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Atypical Restricted Transportation Modeling of Wholesale Vegetable Procurement

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ABSTRACT

Introduction: This paper is the second in a series of papers on modeling mathematically and optimizing the whole sale vegetable business. It addresses problems faced by vendors critically in transportation of vegetables. A typical wholesale market orders vegetables from various places at varying prices which get transported by various means of transport from those places to that wholesale vegetable market.

Aim: It aims to minimize the cost of vegetables considering their availability at the sources, the demand for each vegetable at the wholesale market. This problem conforms to a atypical transportation problem wherein there are restrictions on the supply of each vegetable at each available place. This paper frames the model in spread sheet and solves for optimum solution using open solver as the problem involves hundreds of variables and constraints.

Methodology: The case study methodology has been done at Arakkonam Wholesale market.

Result: As a result, distances more than 100 km, up to 2.5 tons one-fourth is charged, from 2.5 tons to 5.0 tons half charge applies and from 5.0 tons to 10.00 tons full charges will apply. Different formulae can be applied depending on the practice of sharing. This mathematical modeling and optimization of transporting vegetables from many sources to the wholesale market can help to purchase vegetables at minimal cost by entering the cost and requirements on any particular day.

Conclusion: The researcher concludes that this model can be extended effortlessly to any number of vegetables and any number of source cities and as such will prove to be an effective way to optimize vegetable business.

Key Words: Vegetables, Market, Transportation, Spreadsheet modeling, Open solver

INTRODUCTION

Background: Vegetables are of great importance in everyday domestic usage. They are the important sources of energy sold and consumed on regular basis. Arakkonam wholesale market gets vegetables from various places which are transported by various means of transport to this wholesale vegetable market. Prizes and availability of vegetables vary from place to place on day-to-day basis. Not all vegetables are available at all places. Durable vegetables are purchased from long distant places at reasonable rate. A truck can transport 10 tons of vegetables in a single trip. Sharing basis helps to reduce the cost of transportation.

Nature of Problem: This calls for minimizing the cost of vegetables considering their availability at the sources, the demand for each vegetable at the wholesale market. This problem conforms to an atypical transportation problem wherein there are restrictions on the supply of each vegetable at each available place. The case study has been done with Arakkonam wholesale vegetable Market. 46 types of vegetables are procured from 13 places directly. These 13 places receive the vegetables from primary sources which we do not consider now. There are restrictions on the maximum quantum of vegetables that can be procured from these sources.

Methodology-Mathematical Model: The first table (in four parts) gives the collected data for a typical day with unit in kilograms. The second table (in four parts) gives the collected data for a typical day the unit cost of vegetables. Now the problem has 13x46 = 598 variables and 13x46+46 = 644

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constraints. This optimization problem is modeled in spreadsheet and solved with open solver as the number of variables is large. Here vegetables are transported from many places to a single market and availability & cost of vegetables differ from place to place. Hence this is a atypical transportation problem, with hundreds of variables and solved by mathematical modeling. The case study methodology has been done at Arakkonam Wholesale market. As a result, distances more than 100 km, up to 2.5 tons one-fourth is charged, from 2.5 tons to 5.0 tons half charge applies and from 5.0 tons to 10.00 tons full charges will apply

Discussion- Vegetables and Max Supply from Sources:

The spreadsheet model is split into four parts for convenience of display. The abbreviations of names of vegetables and cities are given at the end of the tables:

Table 1: Sources of Vegetables to Arakkonam

MAX	VLR	KVM	CHN	CHR	BLR	MUM	ERD
POT	155	0	100	25	50	28	22
TOM	150	0	160	160	0	0	0
SON	25	0	60	0	100	0	0
BON	120	0	0	0	500	500	0
GBL	25	0	30	0	10	0	20
DRM	25	0	45	0	0	25	20
CAB	20	0	20	0	40	0	10
SNG	35	0	25	0	0	0	0
BNS	60	0	55	0	85	0	0
CFR	20	0	20	0	50	0	15
YAM	35	0	0	0	0	0	0
BJL	75	0	60	0	75	0	0
SPO	8	0	5	0	5	0	0
RGG	20	0	25	0	25	0	0
CRT	90	0	70	0	80	0	5
BTG	25	0	18	5	0	0	8
BOG	20	0	20	0	0	0	0
BTT	25	0	20	0	40	0	0
TRP	43	0	20	0	20	0	0
LFR	55	0	45	0	0	0	0
ASG	12	0	0	0	0	0	0
IVG	26	0	0	0	0	0	0
GIN	10	0	5	8	0	0	0

contd..

MAX	KUM	LUK	PAL	KAN	PUN	SHO	TOT
POT	0	0	0	0	50	0	430
TOM	50	0	0	0	0	0	520
SON	0	0	0	0	50	0	235
BON	0	0	0	0	110	0	1230
GBL	0	0	10	22	0	20	137
DRM	0	0	20	0	0	0	135
CAB	0	0	0	0	0	0	90
SNG	0	0	0	15	0	20	95
BNS	0	0	0	0	0	0	200
CFR	0	0	0	0	0	0	105
YAM	0	0	10	0	0	15	60
BJL	0	0	10	0	0	30	250
SPO	0	0	0	0	0	0	18
RGG	0	0	10	0	0	15	95
CRT	0	0	0	0	0	0	245
BTG	0	0	0	5	0	0	61
BOG	0	0	10	13	0	0	63
BTT	0	0	0	0	0	0	85
TRP	0	0	0	0	0	0	83
LFR	0	0	20	15	0	25	160
ASG	0	0	5	13	0	0	30
IVG	0	0	0	7	0	5	38
GIN	0	0	0	0	0	0	23

contd..

MAX	VLR	KVM	CHN	CHR	BLR	MUM	ERD
RWB	0	60	0	30	0	0	0
RAD	20	0	0	0	0	0	0
CBR	15	0	18	0	0	0	0
CPS	30	0	10	0	0	0	0
CYT	10	0	7	8	0	0	0
BFR	0	35	0	5	0	0	0
GMG	0	0	0	0	0	0	100
GCH	10	0	10	0	0	0	0
BST	0	25	0	5	0	0	0
FBN	25	0	10	15	0	0	0
SWC	3	0	0	4	0	0	0
CRL	15	0	5	20	0	0	0
COL	10	0	12	0	0	0	0
CBN	40	0	0	0	0	0	0
YEL	0	0	0	0	0	0	0
GAR	0	0	25	0	25	0	0
MLE	5	0	5	10	0	0	0

SWP	40	0	30	0	0	0	0
PEA	30	0	3	6	0	0	0
CCT	0	40	0	15	0	0	40
BLV	0	13	0	7	0	0	0
MUS	30	0	8	0	0	0	0
LMN	35	0	5	0	0	0	0

contd..

AX	KUM	LUK	PAL	KAN	PUN	SHO	TOT
RWB	0	0	0	0	0	0	90
RAD	0	0	15	0	0	15	50
CBR	0	0	0	0	0	0	33
CPS	0	0	0	0	0	0	40
CYT	0	0	0	0	0	0	25
BFR	0	0	0	0	0	0	40
GMG	0	70	0	0	0	0	170
GCH	0	0	0	0	0	0	20
BST	0	0	0	0	0	0	30
FBN	0	0	0	25	0	0	75
SWC	0	0	1	0	0	0	8
CRL	0	0	0	0	0	0	40
COL	0	0	0	0	0	0	22
CBN	0	0	0	10	0	15	65
YEL	0	0	6	0	0	4	10
GAR	0	20	0	0	0	0	70
MLE	0	0	0	0	0	0	20
SWP	0	0	15	0	10	9	104
PEA	0	0	0	0	0	0	39
CCT	0	0	0	0	0	0	95
BLV	0	0	0	0	0	0	20
MUS	0	0	0	0	0	0	38
LMN	0	0	6	0	0	5	51

Abbreviations of Names of Vegetables:

POT: Potatao, TOM: Tomato, SON: Small Onion, BON: Big Onion:, GBL: Green Brinjal, DRM: Drumstick, CAB: Cabbage, SNG: Snake Gourd, BNS: Beans, CFR: Cauliflower, YAM: Yam, BJL: Brinjal, SPO: Spring Onion, RGG: Ridge Gourd, CRT: Carrot, BTG: Bitter Gouard, BOG: Bottle Gourd, BTT: Beetroot, TRP: Turnip, LFR: Ladys Finger, ASG: Ash Gourd, IVG: Ivy Gourd, GIN: Ginger, RWB: Raw Banana, RAD: Radish, CBR: Cucumber, CPS: Capsicum, CYT: Chayote, BFR: Banana Flower, GMG: Green Mango, GCH: Green Chilly, BST: Banana Stem, FBN: Flat Beans, SWC: Sweet Corn, CRL: Curry Leaves, COL: Corinder Leaves, CBN: Cluster Beans, YEL: Yam Elephant, GAR: Garlic, MLE: Mint Leaves, SWP: Sweet Potato, PEA: Peas, CCT: Coconut, BLV: Banana Leaves, MUS: Mushroom, LMN: Lemon.

Abbreviations of Names of Cities:

VLR: Vellore, KVM: Kaveripakkam, CHN: Chennai, CHR: Chithoor, BLR: Bellary, MUM: Mumbai, ERD: Erode, KUM: Kumbakonam, LUK: Lucknow, PAL: Pallipattu, KAN: Kanakammachathram, PUN: Pune, SHO: Sholingar.

Map 1: Location of Arakkonam in Vellore District

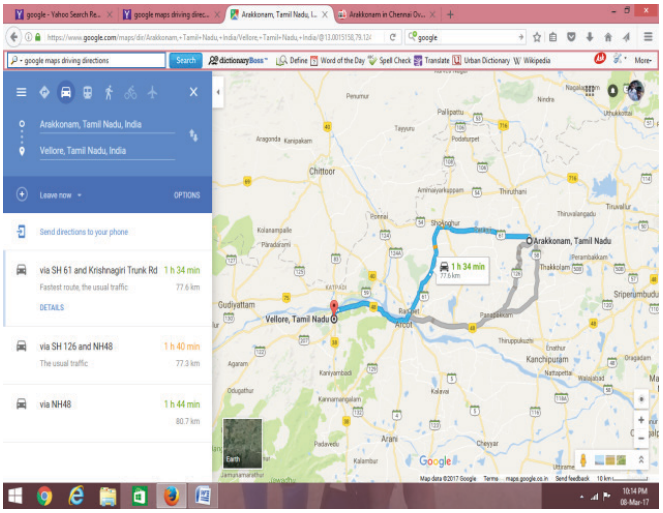

Table 2: Cost of Vegetables on a typical day:

CST	VLR	KVM	CHN	CHR	BLR	MUM	ERD
POT	20	0	12	14	8	6	28
TOM	30	0	35	30	0	0	0
SON	25	0	22	0	15	0	0
BON	25	0	0	0	7	5	0
GBL	25	0	25	0	10	0	28
DRM	30	0	12	0	0	12	20
CAB	9	0	8	0	7	0	16
SNG	35	0	25	0	0	0	0
BNS	60	0	40	0	25	0	0
CFR	20	0	20	0	15	0	50
YAM	15	0	0	0	0	0	0
BJL	40	0	25	0	20	0	0
SPO	45	0	30	0	15	0	0
RGG	20	0	25	0	15	0	0
CRT	48	0	18	0	10	0	21
BTG	25	0	35	30	0	0	36
BOG	20	0	15	0	0	0	0
BTT	25	0	15	0	10	0	0
TRP	23	0	25	0	15	0	0
LFR	35	0	40	0	0	0	0
ASG	25	0	0	0	0	0	0
IVG	30	0	0	0	0	0	0
GIN	70	0	70	8	0	0	0

contd..

CST	KUM	LUK	PAL	KAN	PUN	SHO
POT	0	0	0	0	6	0
TOM	32	0	0	0	0	0
SON	0	0	0	0	12	0
BON	0	0	0	0	5	0
GBL	0	0	22	25	0	28
DRM	0	0	20	0	0	0
CAB	0	0	0	0	0	0
SNG	0	0	0	30	0	34
BNS	0	0	0	0	0	0
CFR	0	0	0	0	0	0
YAM	0	0	10	0	0	15
BJL	0	0	25	0	0	30
SPO	0	0	0	0	0	0
RGG	0	0	18	0	0	22
CRT	0	0	0	0	0	0
BTG	0	0	0	38	0	0
BOG	0	0	15	18	0	0
BTT	0	0	0	0	0	0
TRP	0	0	0	0	0	0
LFR	0	0	45	44	0	48
ASG	0	0	30	35	0	0
IVG	0	0	0	32	0	38
GIN	0	0	0	0	0	0

CST	VLR	KVM	CHN	CHR	BLR	MUM	ERD
RWB	0	80	0	90	0	0	0
RAD	20	0	0	0	0	0	0
CBR	35	0	35	0	0	0	0
CPS	56	0	80	0	0	0	0
CYT	28	0	25	22	0	0	0
BFR	0	35	0	40	0	0	0
GMG	0	0	0	0	0	0	72
GCH	50	0	12	0	0	0	0
BST	0	25	0	30	0	0	0
FBN	48	0	45	48	0	0	0
SWC	60	0	0	65	0	0	0
CRL	75	0	100	90	0	0	0
COL	80	0	120	0	0	0	0
CBN	35	0	0	0	0	0	0
YEL	0	0	0	0	0	0	0
GAR	0	0	180	0	120	0	0
MLE	85	0	110	95	0	0	0
SWP	40	0	25	0	0	0	0
PEA	50	0	35	30	0	0	0
CCT	0	40	0	20	0	0	35
BLV	0	50	0	70	0	0	0
MUS	140	0	140	0	0	0	0
LMN	90	0	75	0	0	0	0

CST	KUM	LUK	PAL	KAN	PUN	SHO
RWB	0	0	0	0	0	0
RAD	0	0	15	0	0	10
CBR	0	0	0	0	0	0
CPS	0	0	0	0	0	0
CYT	0	0	0	0	0	0
BFR	0	0	0	0	0	0
GMG	0	30	0	0	0	0
GCH	0	0	0	0	0	0
BST	0	0	0	0	0	0
FBN	0	0	0	50	0	0
SWC	0	0	70	0	0	0
CRL	0	0	0	0	0	0
COL	0	0	0	0	0	0
CBN	0	0	0	38	0	40
YEL	0	0	40	0	0	44
GAR	0	75	0	0	0	0
MLE	0	0	0	0	0	0
SWP	0	0	30	0	8	16
PEA	0	0	0	0	0	0
CCT	0	0	0	0	0	0
BLV	0	0	0	0	0	0
MUS	0	0	0	0	0	0
LMN	0	0	80	0	0	85

Table 3: Solution given by open solver for Transportation & Cost of Vegetables

SOL	VLR	KVM	CHN	CHR	BLR	MUM	ERD
POT	155	0	100	25	50	28	17
TOM	150	0	155	160	0	0	0
SON	20	0	60	0	100	0	0
BON	115	0	0	0	500	500	0
GBL	25	0	30	0	10	0	20
DRM	20	0	45	0	0	25	20
CAB	20	0	20	0	40	0	5
SNG	30	0	25	0	0	0	0
BNS	55	0	55	0	85	0	0
CFR	20	0	20	0	50	0	10
YAM	35	0	0	0	0	0	0
BJL	70	0	60	0	75	0	0

SPO	3	0	5	0	5	0	0
RGG	20	0	20	0	25	0	0
CRT	85	0	70	0	80	0	5
BTG	25	0	18	5	0	0	8
BOG	15	0	20	0	0	0	0
BTT	20	0	20	0	40	0	0
TRP	43	0	15	0	20	0	0
LFR	55	0	45	0	0	0	0
ASG	12	0	0	0	0	0	0
IVG	26	0	0	0	0	0	0
GIN	10	0	0	8	0	0	0

SOL	KUM	LUK	PAL	KAN	PUN	SHO	DMD
POT	0	0	0	0	50	0	425
TOM	50	0	0	0	0	0	515
SON	0	0	0	0	50	0	230
BON	0	0	0	0	110	0	1225
GBL	0	0	10	22	0	15	132
DRM	0	0	20	0	0	0	130
CAB	0	0	0	0	0	0	85
SNG	0	0	0	15	0	20	90
BNS	0	0	0	0	0	0	195
CFR	0	0	0	0	0	0	100
YAM	0	0	10	0	0	10	55
BJL	0	0	10	0	0	30	245
SPO	0	0	0	0	0	0	13
RGG	0	0	10	0	0	15	90
CRT	0	0	0	0	0	0	240
BTG	0	0	0	0	0	0	56
BOG	0	0	10	13	0	0	58
BTT	0	0	0	0	0	0	80
TRP	0	0	0	0	0	0	78
LFR	0	0	20	15	0	20	155
ASG	0	0	5	8	0	0	25
IVG	0	0	0	7	0	0	33
GIN	0	0	0	0	0	0	18

SOL	VLR	KVM	CHN	CHR	BLR	MUM	ERD
RWB	0	60	0	25	0	0	0
RAD	15	0	0	0	0	0	0
CBR	10	0	18	0	0	0	0
CPS	30	0	5	0	0	0	0
CYT	5	0	7	8	0	0	0
BFR	0	35	0	0	0	0	0
GMG	0	0	0	0	0	0	95
GCH	5	0	10	0	0	0	0

BST	0	25	0	0	0	0	0
FBN	25	0	10	15	0	0	0
SWC	3	0	0	0	0	0	0
CRL	15	0	0	20	0	0	0
COL	10	0	7	0	0	0	0
CBN	40	0	0	0	0	0	0
YEL	0	0	0	0	0	0	0
GAR	0	0	20	0	25	0	0
MLE	5	0	0	10	0	0	0
SWP	35	0	30	0	0	0	0
PEA	25	0	3	6	0	0	0
CCT	0	35	0	15	0	0	40
BLV	0	13	0	2	0	0	0
MUS	30	0	3	0	0	0	0
LMN	30	0	5	0	0	0	0

SOL	KUM	LUK	PAL	KAN	PUN	SHO	DMD
RWB	0	0	0	0	0	0	85
RAD	0	0	15	0	0	15	45
CBR	0	0	0	0	0	0	28
CPS	0	0	0	0	0	0	35
CYT	0	0	0	0	0	0	20
BFR	0	0	0	0	0	0	35
GMG	0	70	0	0	0	0	165
GCH	0	0	0	0	0	0	15
BST	0	0	0	0	0	0	25
FBN	0	0	0	20	0	0	70
SWC	0	0	0	0	0	0	3
CRL	0	0	0	0	0	0	35
COL	0	0	0	0	0	0	17
CBN	0	0	0	10	0	10	60
YEL	0	0	5	0	0	0	5
GAR	0	20	0	0	0	0	65
MLE	0	0	0	0	0	0	15
SWP	0	0	15	0	10	9	99
PEA	0	0	0	0	0	0	34
CCT	0	0	0	0	0	0	90
BLV	0	0	0	0	0	0	15
MUS	0	0	0	0	0	0	33
LMN	0	0	6	0	0	5	46

Table 4: Cost of Transportation at Arakkonam

City	Quantum	Distance	Cost Per Truck of ten tons	Cost for Quantum on sharing Basis
VLR	1312	77	4000	4000
KVM	168	37	2250	2250
CHN	901	80	4100	4100
CHR	299	69	3500	3500
BLR	1105	495	23000	5750
MUM	553	1277	57500	14375
ERD	220	366	17500	4375
KUM	50	269	12500	3125
LUK	90	2066	90000	22500
PAL	136	50	2500	2500
KAN	110	26	1750	1750
PUN	220	1134	72000	18000
SHO	149	30	1500	1500
			292100	87725

RESULTS

The sharing cost is computed using a general formula as follows: If the distance is within 100 km then the flat transportation charges apply. For distances more than 100 km, up to 2.5 tons one-fourth is charged, from 2.5 tons to 5.0 tons half charge applies and from 5.0 tons to 10.00 tons full charges will apply. Different formulae can be applied depending on the practice of sharing.

The minimal costs for the problem given above are as follows:

Total Purchase Cost	=Rs.143963
Total Transport Cost	=Rs.87725
Total Cost	=Rs.231688

CONCLUSION

Transportation cost of vegetables from various places to the whole sale market can be minimized taking into consideration the cost of each vegetable from each available city, the restrictions on the supply of each vegetable from each available city and sharing formulae.

Spreadsheet modeling has been proven to be an effective and easy way to design such business models and open solver which is an open source software quickly solves such problems regardless of the number of variables and number of constraints.

This mathematical modeling and optimization of transporting vegetables from many sources to the wholesale market can help to purchase vegetables at minimal cost by entering the cost and requirements on any particular day.

This model can be extended effortlessly to any number of vegetables and any number of source cities and as such will prove to be an effective way to optimize vegetable business.

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