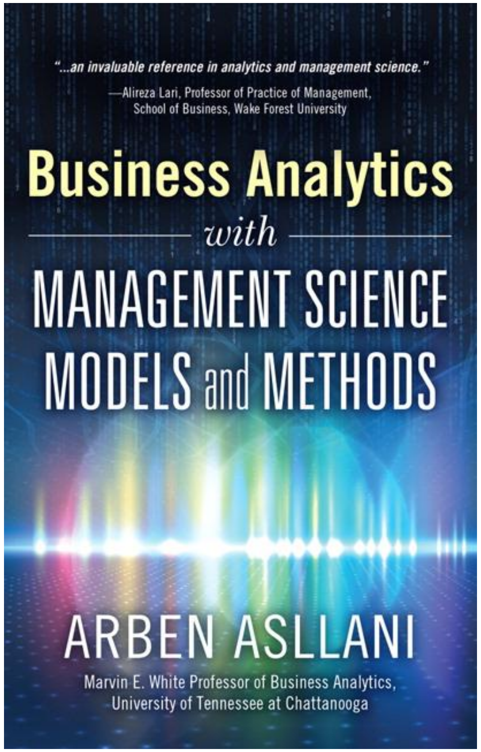
Business Analytics
Prescriptive Models



Based on

Business Analytics
With
Management Science
Models and Methods
by
Arben Asllani

Chapter 9

Marketing Analytics with Multiple Goals

Business Analytics with Management Science Models and Methods

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Chapter Outline

- Chapter Objectives
- Prescriptive Marketing Analytics in Action
- Introduction
- LP Models with Two RFM Dimensions
  - The Recency and Frequency Case
  - The Recency and Monetary Value Case
  - The Frequency and Monetary Case
- LP Models with Three Dimensions
  - Model Formulation
  - Solving the RFM Model with Three Dimensions
- Goal Programming Model for RFM
- Exploring Bid Data with RFM Analytics

Chapter Objectives

- Discuss the importance of seeking multiple goals in marketing campaign
- Demonstrate the process of formulating linear models with a combination of two and three dimensions of RFM approach
- Demonstrate the process of formulating goal programming models with assigned priorities to each dimensions of RFM approach
- Demonstrate the use of Solver for solving goal programming models as a series of several linear programming models
- Discuss the implications of combining mathematical programming models with RFM approach

Prescriptive Marketing Analytics in Action

- First Tennessee Bank: a full-service provider of financial products and services for businesses and consumers
- The availability of large amount of data
  - opportunity to better tailor its marketing strategies
  - Goal: "*shift from the 'marketing-as-an expense' mindset to the idea that marketing is a true profit driver*"
- Using predictive analytics is only the beginning
  - *"What sets the First Tennessee approach apart is how it applies a rigorous, systematic approach to prioritizing which opportunities make it to the campaign stage."*
- Advanced marketing models focus on product revenue and cost information generated from its data warehouse systems

Introduction
(ch9_RFM_LP_two_dimensions.xlsx)

- RFM based optimization models with multiple objectives.
- Specifically, the chapter expands on the single goal RFM based models discussed in Chapter 8 and introduces the following new set of models.
- The same example from the Online Coffee Retailer (OCR) is used here as well to demonstrate the proposed models:
  - Three two-dimensional RFM LP models which combine any two dimensions, such as RF, RM, and FM
  - A three-dimensional RFM LP model which combines all three dimensions in one LP model
  - An RFM based goal programming (RFM GP) model which incorporates all three dimensions of the RFM analysis but assigns different weights to each of them.

LP Model for the Recency and Frequency Case

This case is relevant to companies where recency and frequency are the only significant values in their direct marketing campaign. In this situation, customers are first organized into $R \times F$ groups, with each iso-value group G_{ij} containing customers who belong to recency value i $(1, 2..., R)$ and frequency value j $(1, 2..., F)$. Companies are interested in determining which customer groups should be targeted and which groups should not be reached. The objective, again, is to maximize the expected revenues from potential customer purchases while not exceeding the budget constraints.

Let the decision variable for this case be a 0-1 unknown variable as follows:

x_{ij} = 1 if customers in recency i and frequency j are reached in the marketing campaign; 0 otherwise

(x_{ij} = % of customers to be reached in iso-value group G_{ij})

LP Model for the Recency and Frequency Case

$$Maximize\colon\ Z_{rf} = \sum_{i=1}^{R}\sum_{j=1}^{F} N_{ij}(p_{ij}V_{ij} - C)x_{ij}$$

$subject\ to$:

$$\sum_{i=1}^{R}\sum_{j=1}^{F} N_{ij}Cx_{ij} \leq B$$

$$x_{ij} = \{0, 1\}\ or\ x_{ij} \leq 1 \qquad i = 1, \dots, R \qquad j = 1, \dots, F$$

Solving the LP Model for the Recency and Frequency Case

- The parameters of the LP model are calculated using the same RFM Excel template used for the single dimension LP models.

- The only difference is that probability that a customer in a given recency group and given frequency group will make a purchase is calculated using two AVERAGEIFS fucntion, which allow for two conditions to be satisfied

Calculating Parameters for LP Recency and Frequency Model

	A	B	C	D	E	F	G	H	I
1	Cust ID	Recency	Frequency	Monetary	R-score	F-Score	M-Score	Response Rate	Purchases
2	1	12/12/2013	4	$36.13	4	1	2	0.20	$144.50
3	2	1/13/2013	2	$48.56	4	1	2	0.86	$97.11
4	6	6/20/2014	15	$82.40	5	2	4	0.62	$1,236.05
5	7	2/5/2013	1	$22.77	4	1	1	0.82	$22.77
6	8	3/7/2014	2	$24.38	5	1	1	0.12	$48.76
7	9	2/11/2014	4	$38.14	5	1	2	0.87	$152.57
8	11	11/11/2013	6	$41.03	4	1	2	0.94	$246.18
9									

	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
11			Frequency: Vij					Frequency: pij					Frequency: Nij							
12	Recency Cutoffs		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5			
13	1/1/2013	1	$49.02	<--=IFERROR(AVERAGEIFS($I$2:$I$2350,$E$2:$E$2350,$L3,$F$2:$F$2350,M$2),0)									1,373	-	-	-	-			
14	4/1/2013	2	$130.42	$0.00	$6,794.70	$0.00	$0.00	0.50	-	0.68	-	-	163	-	1	-	-			
15	7/1/2013	3	$157.56	$555.19	$0.00	$0.00	$0.00	0.51	<--=IFERROR(AVERAGEIFS($H$2:$H$2350,$E$2:$E$2350,$L5,$F$2:$F$2350,R$2),0)											
16	11/1/2013	4	$184.54	$731.39	$2,207.58	$0.00	$0.00	0.56	0.60	0.85	-	-	170	5	1	-	-			
17	2/1/2014	5	$220.45	$689.65	$934.77	$1,325.23	$1,937.04	0.51	0.48	0.47	0.46	0.81	376	<--=IFERROR(COUNTIFS($E$2:$E$2350,$L7,$F$2:$F$2350,W$2),0)						

	A	B	C	D	E	F	G	H	I
18									
19									
20	27	1/2/2013	1	$26.90	1	1	2	0.46	$26.90
21	28	7/27/2013	2	$64.30	4	1	3	0.78	$128.60
22	29	1/2/2013	1	$57.37	1	1	3	0.79	$57.37
23	30	2/12/2013	2	$45.62	4	1	2	0.74	$91.23
24	31	1/2/2013	1	$55.77	1	1	3	0.20	$55.77

Initial Setup with Decision Variables, Cost, and Expected revenue

Budget B= $ 5,000

Cost to Reach: $ 7.50

Recency Score

	Vij	1	2	3	4	5
Frequency	1	$49	$130	$158	$185	$220
	2	$0	$0	$555	$731	$690
	3	$0	$6,795	$0	$2,208	$935
	4	$0	$0	$0	$0	$1,325
	5	$0	$0	$0	$0	$1,937

Decision Variables — Recency Score

	Xij	1	2	3	4	5
Frequency	1	1	1	1	1	1
	2	1	1	1	1	1
	3	1	1	1	1	1
	4	1	1	1	1	1
	5	1	1	1	1	1

Recency Score

	Pij	1	2	3	4	5
Frequency	1	0.50	0.50	0.51	0.56	0.51
	2	0.00	0.00	0.80	0.60	0.48
	3	0.00	0.68	0.00	0.85	0.47
	4	0.00	0.00	0.00	0.00	0.46
	5	0.00	0.00	0.00	0.00	0.81

Recency Score

Cost of Compaign		1	2	3	4	5
Frequency	1	$10,298	$1,223	$1,245	$1,275	$2,820
	2	$0	$0	$23	$38	$518
	3	$0	$8	$0	$8	$105
	4	$0	$0	$0	$0	$30
	5	$0	$0	$0	$0	$0
					Total Budget	$17,587.50

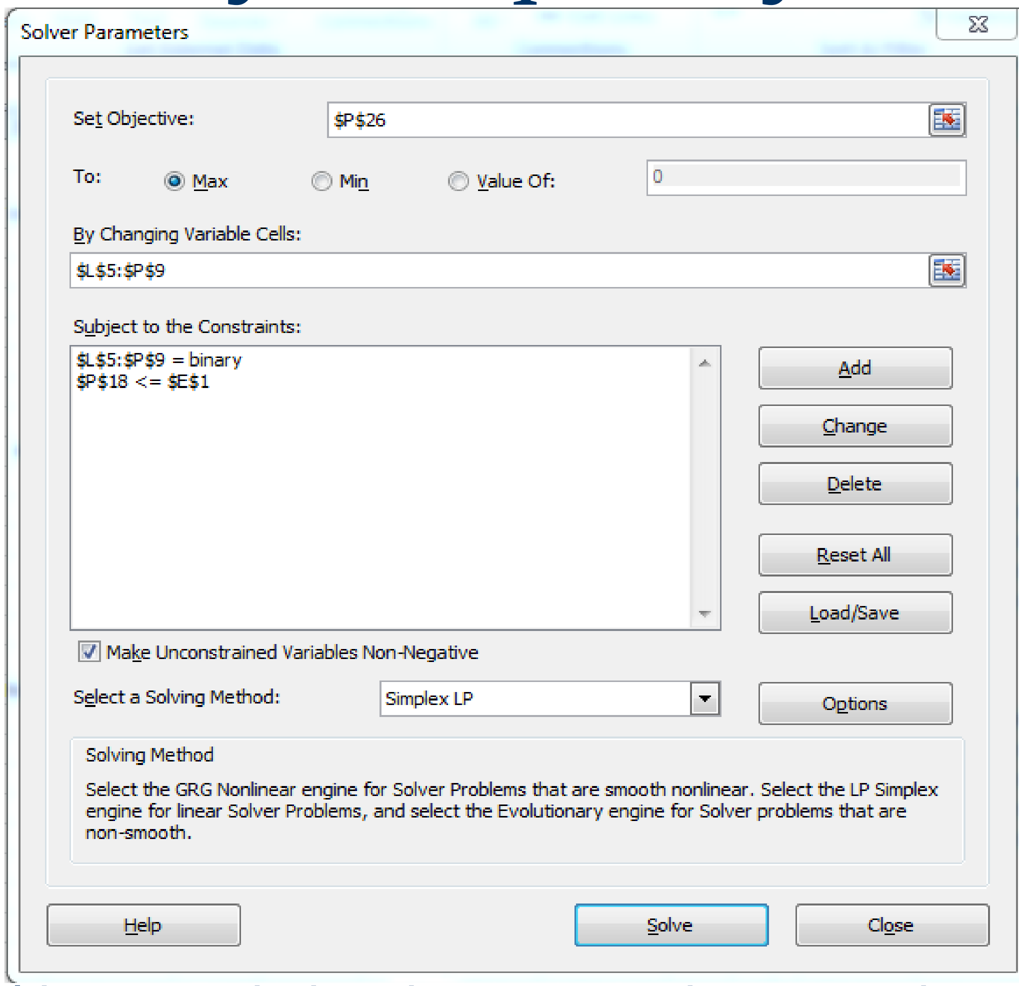
Recency Score

	Nij	1	2	3	4	5
Frequency	1	1373	163	166	170	376
	2	0	0	3	5	69
	3	0	1	0	1	14
	4	0	0	0	0	4
	5	0	0	0	0	4

Recency Score

Total Revenue		1	2	3	4	5
Frequency	1	$23,071	$9,456	$12,221	$16,188	$39,348
	2	$0	$0	$1,310	$2,171	$22,544
	3	$0	$4,613	$0	$1,869	$6,083
	4	$0	$0	$0	$0	$2,382
	5	$0	$0	$0	$0	$0
						$141,258

Solver Setup for the Recency-Frequency Model



The goal is to maximize the expected revenue by changing binary variables L5:P9 under the budget constraints P18<=E1.

Solution for the 0-1 LP Recency-Frequency Model

Decision Variables (Recency Score across, Frequency down)

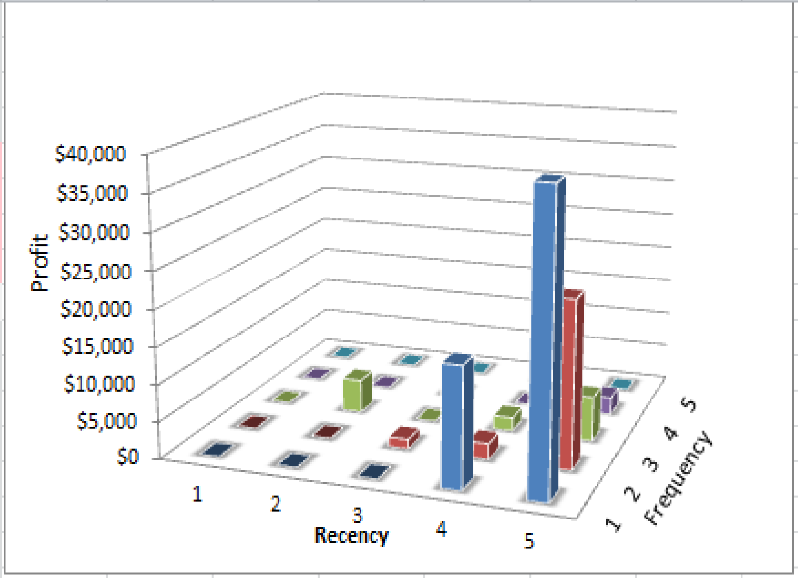
Xij	1	2	3	4	5
1	0	0	0	1	1
2	0	0	1	1	1
3	0	1	0	1	1
4	0	0	0	0	1
5	0	0	0	0	0

Cost of Compaign (Recency Score across, Frequency down)

Frequency	1	2	3	4	5
1	$0	$0	$0	$1,275	$2,820
2	$0	$0	$23	$38	$518
3	$0	$8	$0	$8	$105
4	$0	$0	$0	$0	$30
5	$0	$0	$0	$0	$0
				Total Budget	$4,822.50

Total Revenue (Recency Score across, Frequency down)

Frequency	1	2	3	4	5
1	$0	$0	$0	$16,188	$39,348
2	$0	$0	$1,310	$2,171	$22,544
3	$0	$4,613	$0	$1,869	$6,083
4	$0	$0	$0	$0	$2,382
5	$0	$0	$0	$0	$0
					$96,508



Solution for the Continuous LP Recency-Frequency Model

H I J K L M N O P Q R S T U V W X

Decision Variables (Recency Score across, Frequency down)

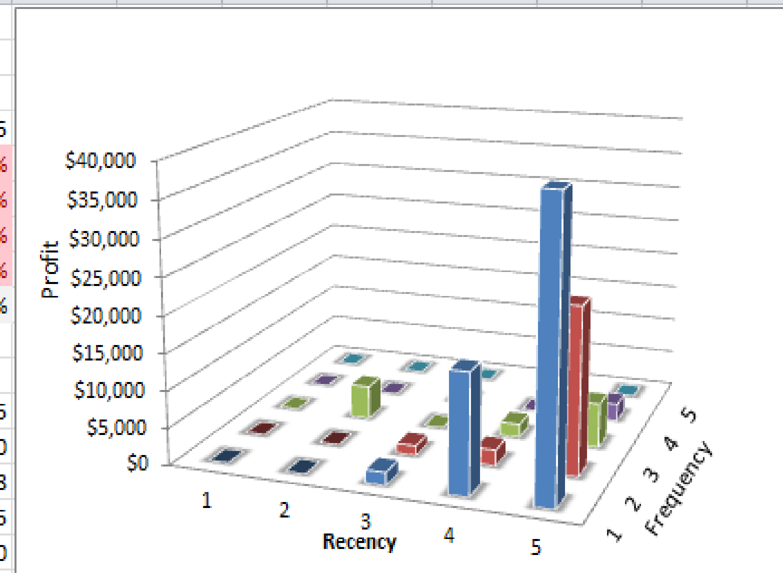
Xij	1	2	3	4	5
1	0%	0%	14%	100%	100%
2	0%	0%	100%	100%	100%
3	0%	100%	0%	100%	100%
4	0%	0%	0%	0%	100%
5	0%	0%	0%	0%	0%

Cost of Compaign (Recency Score across, Frequency down)

	1	2	3	4	5
1	$0	$0	$178	$1,275	$2,820
2	$0	$0	$23	$38	$518
3	$0	$8	$0	$8	$105
4	$0	$0	$0	$0	$30
5	$0	$0	$0	$0	$0
				Total Budget	$5,000.00

Total Revenue (Recency Score across, Frequency down)

	1	2	3	4	5
1	$0	$0	$1,742	$16,188	$39,348
2	$0	$0	$1,310	$2,171	$22,544
3	$0	$4,613	$0	$1,869	$6,083
4	$0	$0	$0	$0	$2,382
5	$0	$0	$0	$0	$0
					$98,251



LP Model for the Recency and Monetary Value Case

Similarly, this case is relevant to companies where recency and monetary value are the only significant values in their direct marketing campaign. In this situation, customers are first organized into $R \times M$ groups, with each iso-value group G_{ik} containing customers who belong to recency value $i\ (1, 2 \ldots, R)$ and monetary value value $k\ (1, 2 \ldots, M)$. Companies are interested in determining which customer groups should be targeted and which groups should not be reached. The objective, again, is to maximize the expected revenues from potential customer purchases while not exceeding the budget constraints.

Let the decision variable for this case be a 0-1 unknown variable as follows:

x_{ik} = 1 if customers in recency i and monetary value k are reached in the marketing campaign; 0 otherwise

LP Model for the Recency and Monetary Value Case

$$Maximize: Z_{rm} = \sum_{i=1}^{R} \sum_{k=1}^{M} N_{ik}(p_{ik}V_{ik} - C)x_{ik}$$

$subject\ to$:

$$\sum_{i=1}^{R} \sum_{k=1}^{M} N_{ik}Cx_{ik} \leq B$$

$$x_{ik} = \{0, 1\}\ or\ x_{ik} \leq 1 \qquad i = 1, \ldots, R \qquad k = 1, \ldots, M$$

Solving the LP Model for the Recency and Monetary Value Case

		Recency: Vij					Recency: pij					Recency: Nij				
Monetary Cutoffs		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
$0	1	$23.37	$56.64	$60.33	$78.54	$88.22	0.52	0.39	0.56	0.49	0.54	330	19	18	15	25
$25	2	$40.22	$100.23	$127.56	$156.69	$271.15	0.49	0.53	0.51	0.57	0.50	737	100	102	111	298
$50	3	$74.54	$168.65	$230.62	$225.84	$443.89	0.50	0.46	0.53	0.45	0.53	196	25	31	30	102
$75	4	$90.85	$249.33	$338.58	$614.35	$561.70	0.49	0.48	0.47	0.74	0.46	56	11	9	14	26
$100	5	$189.83	$1,110.54	$391.87	$548.13	$857.74	0.46	0.53	0.52	0.61	0.48	54	9	9	6	16

Parameters for LP Recency and Monetary Model

Budget B= $ 5,000

Cost to Reach: $ 7.5

Monetary	Vij	Recency Score 1	2	3	4	5
	1	$23	$57	$60	$79	$88
	2	$40	$100	$128	$157	$271
	3	$75	$169	$231	$226	$444
	4	$91	$249	$339	$614	$562
	5	$190	$1,111	$392	$548	$858

Monetary	Pij	Recency Score 1	2	3	4	5
	1	0.52	0.39	0.56	0.49	0.54
	2	0.49	0.53	0.51	0.57	0.50
	3	0.50	0.46	0.53	0.45	0.53
	4	0.49	0.48	0.47	0.74	0.46
	5	0.46	0.53	0.52	0.61	0.48

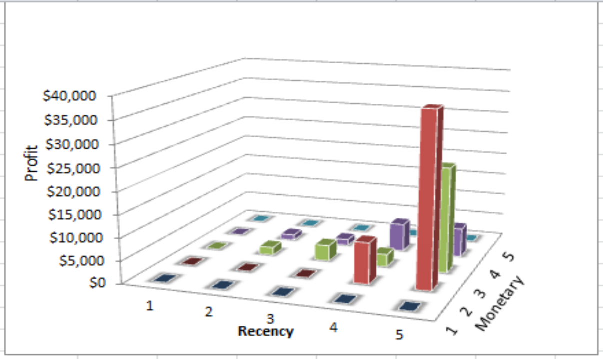
Monetary		Recency Score 1	2	3	4	5
	1	330	19	18	15	25
	2	737	100	102	111	298
	3	196	25	31	30	102
	4	56	11	9	14	26
	5	54	9	9	6	16

Decision Variables

Monetary	Xij	Recency Score 1	2	3	4	5
	1	0	0	0	0	0
	2	0	0	0	1	1
	3	0	1	1	1	1
	4	0	1	1	1	1
	5	0	0	0	0	0

Monetary	Cost of Compaign	Recency Score 1	2	3	4	5
	1	$0	$0	$0	$0	$0
	2	$0	$0	$0	$833	$2,235
	3	$0	$188	$233	$225	$765
	4	$0	$83	$68	$105	$195
	5	$0	$0	$0	$0	$0
					Total Budget	$4,927.50

Monetary	Total Revenue	Recency Score 1	2	3	4	5
	1	$0	$0	$0	$0	$0
	2	$0	$0	$0	$9,141	$38,169
	3	$0	$1,769	$3,540	$2,797	$23,391
	4	$0	$1,244	$1,371	$6,284	$6,467
	5	$0	$0	$0	$0	$0
						$94,173



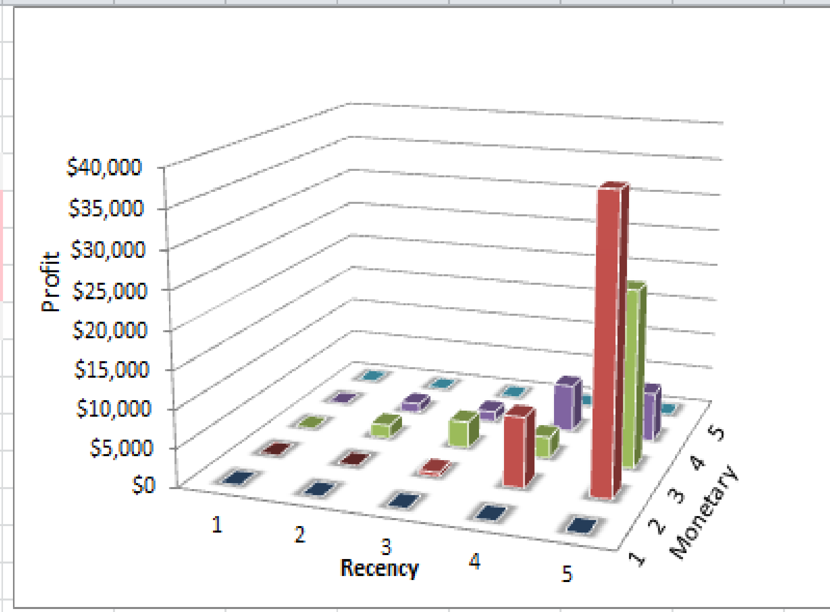
Solution for the binary LP Recency-Monetary Model

Solution for the Continuous LP Monetary-Recency Model

Decision Variables		Recency Score				
Xij		1	2	3	4	5
Monetary	1	0%	0%	0%	0%	0%
	2	0%	0%	9%	100%	100%
	3	0%	100%	100%	100%	100%
	4	0%	100%	100%	100%	100%
	5	0%	0%	0%	0%	0%

Cost of Compaign		Recency Score				
		1	2	3	4	5
Monetary	1	$0	$0	$0	$0	$0
	2	$0	$0	$73	$833	$2,235
	3	$0	$188	$233	$225	$765
	4	$0	$83	$68	$105	$195
	5	$0	$0	$0	$0	$0
					Total Budget	$5,000.00

Sum	Total Revenue	Recency Score				
		1	2	3	4	5
Monetary	1	$0	$0	$0	$0	$0
	2	$0	$0	$562	$9,141	$38,169
	3	$0	$1,769	$3,540	$2,797	$23,391
	4	$0	$1,244	$1,371	$6,284	$6,467
	5	$0	$0	$0	$0	$0
						$94,736



LP Model for the Frequency and Monetary Case

Similarly, this case is relevant to companies where frequency and monetary value are the only significant values in their direct marketing campaign. In this situation, customers are first organized into $F \times M$ groups, with each iso-value group G_{jk} containing customers who belong to frequency value $j\ (1, 2..., F)$ and monetary value value $k\ (1, 2..., M)$. Companies are interested in determining which customer groups should be targeted and which groups should not be reached. The objective, again, is to maximize the expected revenues from potential customer purchases while not exceeding the budget constraints.

Let the decision variable for this case be a 0-1 unknown variable as follows:

x_{jk} = 1 if customers in frequency i and monetary value k are reached in the marketing campaign; 0 otherwise

LP Model for the Frequency and Monetary Case

$$Maximize\colon Z_{fm} = \sum_{j=1}^{F}\sum_{k=1}^{M} N_{jk}(p_{jk}V_{jk} - C)x_{jk}$$

$subject\ to$:

$$\sum_{j=1}^{F}\sum_{k=1}^{M} N_{jk}Cx_{jk} \le B$$

$$x_{jk} = \{0, 1\}\ or\ x_{jk} \le 1 \qquad j = 1, \ldots, F \qquad k = 1, \ldots, M$$

Solving the LP Model for the Frequency-Monetary Case

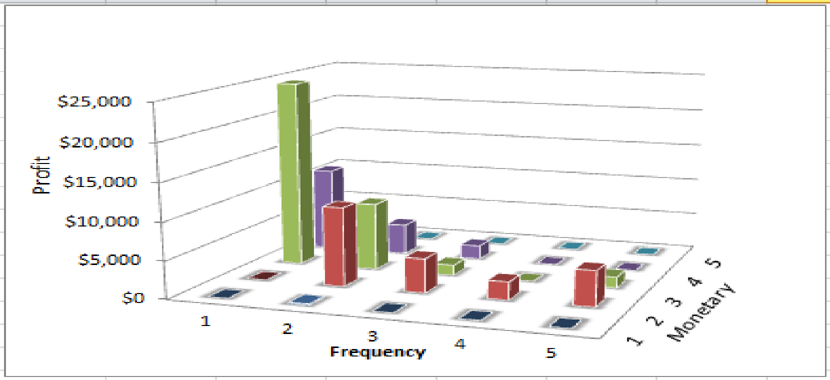
		Monetary: Vij					Monetary: pij					Monetary: Nij				
Frequency Cutoffs		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	1	$31.78	$84.44	$152.76	$221.26	$320.45	0.52	0.50	0.50	0.51	0.49	406	1,285	359	108	90
10	2	$355.81	$494.77	$817.10	$1,139.87	$1,716.62	0.57	0.49	0.54	0.53	0.46	1	45	21	7	3
20	3	$0.00	$842.80	$1,272.02	$2,207.58	$6,794.70	-	0.50	0.37	0.85	0.68	-	11	3	1	1
30	4	$0.00	$1,325.23	$0.00	$0.00	$0.00	-	0.46	-	-	-	-	4	-	-	-
40	5	$0.00	$1,846.19	$2,209.58	$0.00	$0.00	-	0.86	0.67	-	-	-	3	1	-	-

Parameters for the Frequency-Monetary Model

Decision Variables		Frequency Score				
	Xij	1	2	3	4	5
Monetary	1	0	1	0	0	0
	2	0	1	1	1	1
	3	1	1	1	0	1
	4	1	1	1	0	0
	5	0	0	0	0	0

Cost of Compaign		Frequency Score				
		1	2	3	4	5
Monetary	1	$0	$8	$0	$0	$0
	2	$0	$338	$83	$30	$23
	3	$2,693	$158	$23	$0	$8
	4	$810	$53	$8	$0	$0
	5	$0	$0	$0	$0	$0
					Total Budget	$4,230.00

Total Revenue		Frequency Score				
		1	2	3	4	5
Monetary	1	$0	$195	$0	$0	$0
	2	$0	$10,518	$4,561	$2,382	$4,722
	3	$24,857	$9,059	$1,389	$0	$1,473
	4	$11,339	$4,142	$1,869	$0	$0
	5	$0	$0	$0	$0	$0
						$76,508



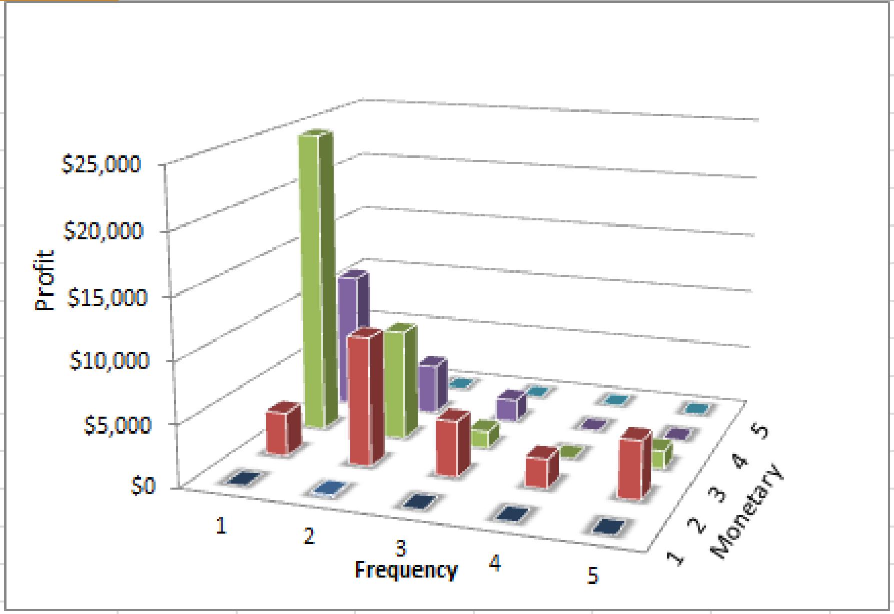
Solution for the Binary LP Frequency-Monetary Model

Solution for the Continuous LP Frequency-Monetary Model

Decision Variables		Frequency Score				
	Xij	1	2	3	4	5
Monetary	1	0%	100%	0%	0%	0%
	2	8%	100%	100%	100%	100%
	3	100%	100%	100%	0%	100%
	4	100%	100%	100%	0%	0%
	5	0%	0%	0%	0%	0%

Cost of Compaign		Frequency Score				
		1	2	3	4	5
Monetary	1	$0	$8	$0	$0	$0
	2	$770	$338	$83	$30	$23
	3	$2,693	$158	$23	$0	$8
	4	$810	$53	$8	$0	$0
	5	$0	$0	$0	$0	$0
					Total Budget	$5,000.00

Total Revenue		Frequency Score				
		1	2	3	4	5
Monetary	1	$0	$195	$0	$0	$0
	2	$3,583	$10,518	$4,561	$2,382	$4,722
	3	$24,857	$9,059	$1,389	$0	$1,473
	4	$11,339	$4,142	$1,869	$0	$0
	5	$0	$0	$0	$0	$0
						$80,091



LP Model with Three Dimensions
(ch9_RFM_LP_three_dimensions.xlsx)

- The LP model includes three variables of the RFM framework: Recency, frequency, and monetary value.
- The objective remains the same—to maximize the expected revenue from potential customer purchases while not exceeding the budget constraints.

$$Maximize\colon Z_{rfm} = \sum_{i=1}^{R}\sum_{j=1}^{F}\sum_{k=1}^{M} N_{ijk}(p_{ijk}V_{ijk} - C)x_{ijk}$$

$$subject\ to\colon$$

$$\sum_{i=1}^{R}\sum_{j=1}^{F}\sum_{k=1}^{M} N_{ijk}Cx_{ijk} \le B$$

$$x_{ijk} = \{0,1\} \qquad i = 1,\dots,R \qquad j = 1,\dots,F \qquad k = 1,\dots,M$$

Solving the RFM Model with Three Dimensions

Recency Score

Vij		1	2	3	4	5
Frequency	1	$23	$57	$60	$79	$77
	2	$0	$0	$0	$0	$356
	3	$0	$0	$0	$0	$0
	4	$0	$0	$0	$0	$0
	5	$0	$0	$0	$0	$0

Recency Score

Pij		1	2	3	4	5
Frequency	1	0.52	0.39	0.56	0.49	0.53
	2	0.00	0.00	0.00	0.00	0.57
	3	0.00	0.00	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.00	0.00
	5	0.00	0.00	0.00	0.00	0.00

Recency Score

		1	2	3	4	5
Frequency	1	330	19	18	15	24
	2	0	0	0	0	1
	3	0	0	0	0	0
	4	0	0	0	0	0
	5	0	0	0	0	0

Raw_data | RFM Summary | start | RF1 | RF2 | RF3

Parameters for LP Recency, Frequency and M=1 Model

Decision Variables — Recency Score

Xij		1	2	3	4	5	
Frequency	1	1	1	1	1	1	<---=Overall!I9:M13
	2	1	1	1	1	1	
	3	1	1	1	1	1	
	4	1	1	1	1	1	
	5	1	1	1	1	1	

Recency Score

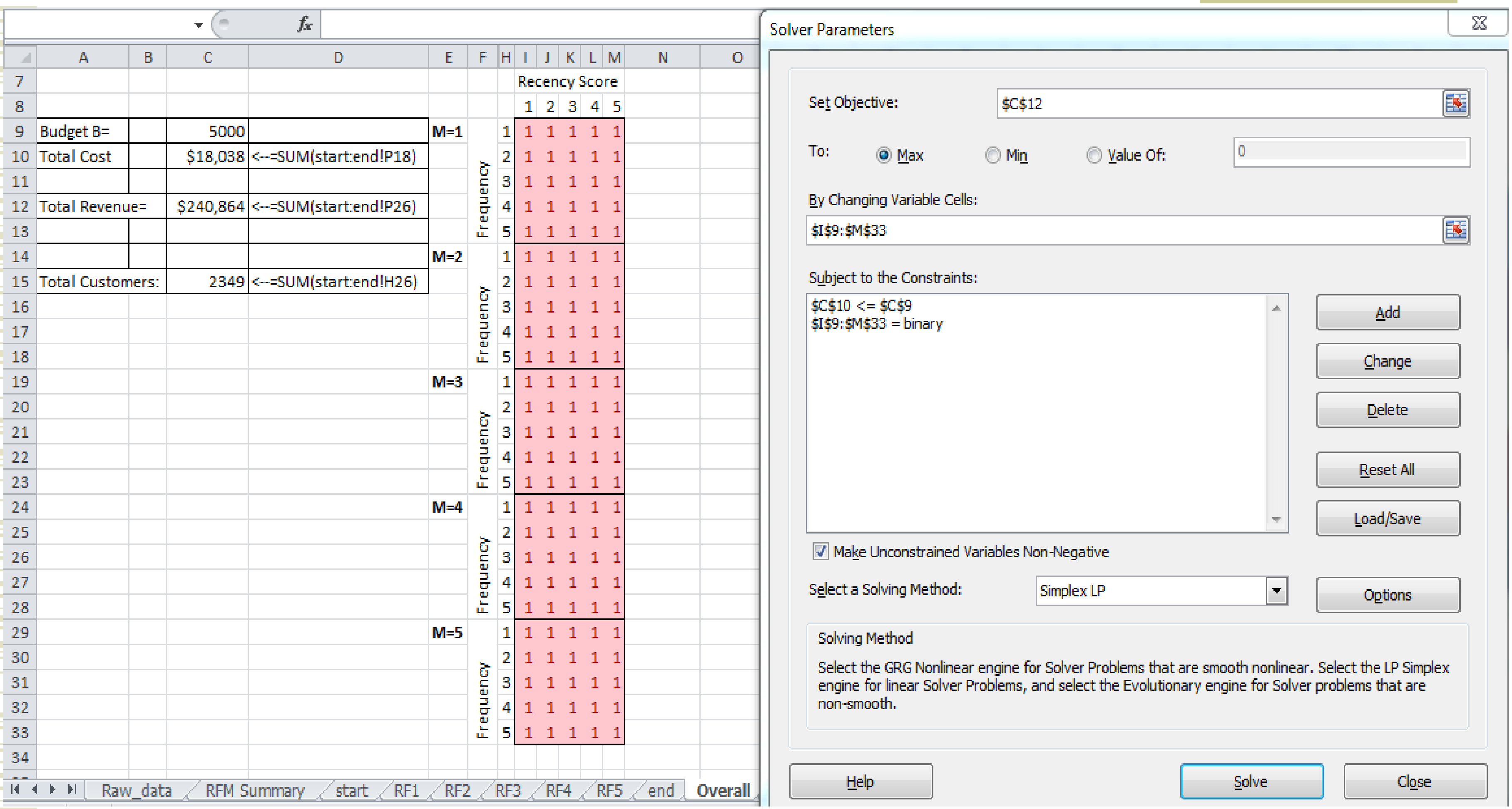
Cost of Compaign		1	2	3	4	5	
Frequency	1	$2,475	$143	$135	$113	$180	<---=$E$2*G21*P5
	2	$0	$0	$0	$0	$8	
	3	$0	$0	$0	$0	$0	
	4	$0	$0	$0	$0	$0	
	5	$0	$0	$0	$0	$0	
					Total Budget	$3,052.50	

Recency Score

Total Profit		1	2	3	4	5	
Frequency	1	$1,545	$277	$474	$468	$807	<---=G5*G13*G21*P5-P13
	2	$0	$0	$0	$0	$195	
	3	$0	$0	$0	$0	$0	
	4	$0	$0	$0	$0	$0	
	5	$0	$0	$0	$0	$0	
						$3,767	

Decision Variables, Cost, and Expected revenue in the RF1 Worksheet

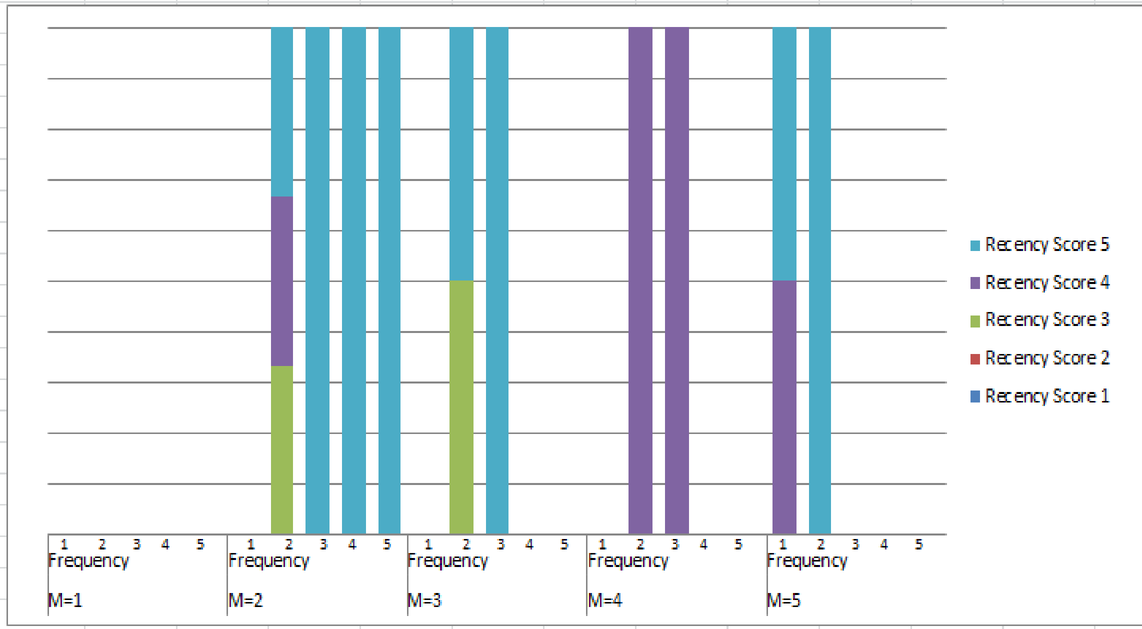
Template and Solver Setup for the RFM LP Model



Solution for the three dimensional LP RFM Model

Budget B=	5000	
Total Cost	$4,995	<--=SUM(start:end!P18)
Total Revenue=	$230,493	<--=SUM(start:end!P26)
Total Customers:	2349	<--=SUM(start:end!H26)

	Frequency	Recency Score 1	2	3	4	5
M=1	1	0	0	0	0	0
	2	0	0	0	0	0
	3	0	0	0	0	0
	4	0	0	0	0	0
	5	0	0	0	0	0
M=2	1	0	0	0	0	0
	2	0	0	1	1	1
	3	0	0	0	0	1
	4	0	0	0	0	1
	5	0	0	0	0	1
M=3	1	0	0	0	0	0
	2	0	0	1	0	1
	3	0	0	0	0	1
	4	0	0	0	0	0
	5	0	0	0	0	0
M=4	1	0	0	0	0	0
	2	0	0	0	1	0
	3	0	0	0	1	0
	4	0	0	0	0	0
	5	0	0	0	0	0
M=5	1	0	0	0	1	1
	2	0	0	0	0	1
	3	0	0	0	0	0
	4	0	0	0	0	0
	5	0	0	0	0	0



Raw_data | RFM Summary | start | RF1 | RF2 | RF3 | RF4 | RF5 | end | Overall

Solution for the three dimensional LP RFM Model

The solution indicates that the company should target the following groups of customers:

- For monetary value 1, the company should not contact any customers.
- For monetary value 2, the company should reach customers with recency 3 and frequency 2, recency 4 and frequency 2, recency 5 and frequencies 2, 3, 4, and 5.
- For monetary value 3, the company should contact customers with recency 3 and frequency 2. Also in this group, customers with recency 5 and frequencies 2 and 3 should be reached.
- For monetary value 4, only customers with recency 4 and frequencies 2 and 3 should be contacted.
- Finally, for monetary value 5, the company should contact customers with recency 4 and frequency 1, and customers with recency 5 and frequencies 1 and 2.

This solution is achieved under the budget constraint ($4,995) and maximizes the expected revenue ($230,493).

A Goal Programming Model for RFM (ch9_RFM_GP.xlsx)

A marketing analyst wants to extend the previous LP models by adding priorities in each of the dimensions of the RFM approach:

- One-dimensional LP models are solved (see Chapter 8) and the maximum expected revenue is respectively V_R for recency, V_F for frequency, and V_M for monetary.
- Ideally, the decision maker wants to achieve all these goals; however, because it might not be possible, the modeler will create a set of priorities.
- Assume that the analyst values recency (R) more than frequency (F), and frequency more than monetary value (M), so the priorities could be: $P_R = 3$, $P_F = 2$ and $P_M = 1$.
- The modeler will create a set of deviational variables S_R, S_F, and S_M to represent a failure of meeting each priority.

GP Model Formulation

$$Minimize\ Z = 3S_R + 2S_F + S_M$$

$Subject\ to:$

$$\sum_{i=1}^{R} N_i(p_iV_i - C)x_i + S_R = V_R$$

$$\sum_{j=1}^{F} N_j(p_jV_j - C)x_j + S_F = V_F$$

$$\sum_{k=1}^{M} N_k(p_kV_k - C)x_k + S_M = V_M$$

$$\sum_{i=1}^{R} N_iCx_i + \sum_{j=1}^{F} N_jCx_j + \sum_{k=1}^{M} N_kCx_k \leq B$$

$$x_i = \{0,1\}\ or\ 0 \leq x_i \leq 1\ \ for\ i = 1 \ldots R$$

$$x_j = \{0,1\}\ or\ 0 \leq x_j \leq 1\ \ for\ j = 1 \ldots F$$

$$x_k = \{0,1\}\ or\ 0 \leq x_k \leq 1\ \ for\ k = 1 \ldots M$$

A Goal Programming Model for RFM
(ch9_RFM_GP.xlsx)

Recency Cutoffs		Vi	pi	Ni
1/1/2013	1	$49.02	0.50	1373
4/1/2013	2	$171.06	0.50	164
7/1/2013	3	$164.62	0.52	169
11/1/2013	4	$211.57	0.56	176
2/1/2014	5	$335.36	0.51	467
			Total:	2349
Frequency Cutoffs		Vj	pj	Nj
0	1	$101.86	0.50	2248
10	2	$687.12	0.50	77
20	3	$1,380.57	0.51	16
30	4	$1,325.23	0.46	4
40	5	$1,937.04	0.81	4
			Total:	2349
Monetary Cutoffs		Vk	pk	Nk
$0	1	$32.57	0.52	407
$25	2	$111.92	0.50	1348
$50	3	$203.20	0.50	384
$75	4	$293.81	0.51	116
$100	5	$433.88	0.49	94
			Total:	2349

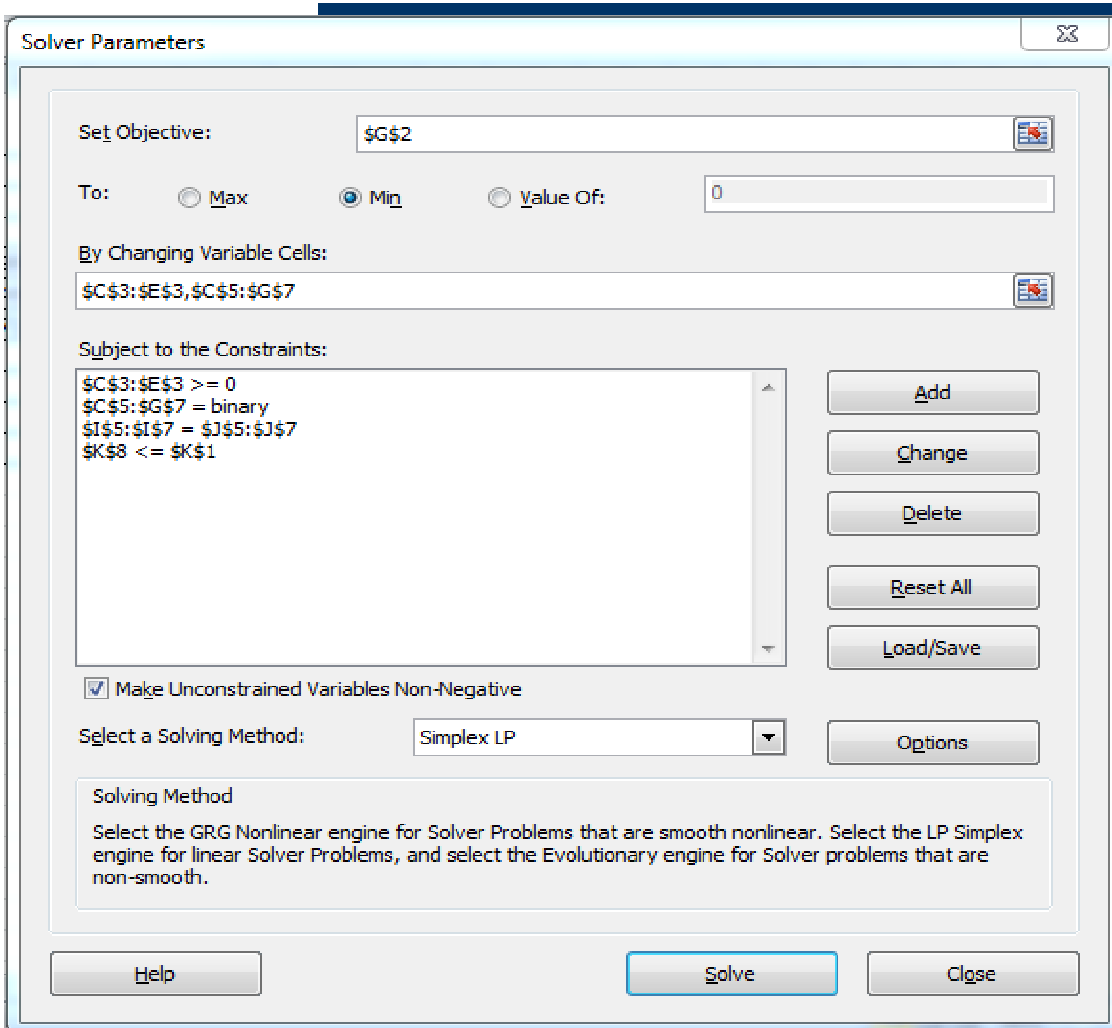
Cut-off Points, Revenues, Probabilities, and Numbers of Customers for Each Category

Solving the GP RFM Model

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1			Recency Priority	Frequency Priority	Monetary Value Priority		Goal	Total Revenue		Budget	$ 5,000.00			v1	v2	v3	v4	v5
2		Weights	3	2	1		0	$ 483,473		C=	$ 7.50		R	$49	$171	$165	$212	$335
3		Slack	0.00	0.00	0.00								F	$102	$687	$1,381	$1,325	$1,937
4		Score	1	2	3	4	5	Optimal Solution	Max		Used Budget		M	$33	$112	$203	$294	$434
5		Recency (Xi)	1	1	1	1	1	$ 162,074	$ 95,295	$ 162,074	$ 17,618							
6		Frequency (Xj)	1	1	1	1	1	$ 162,147	$ 45,884	$ 162,147	$ 17,618			p1	p2	p3	p4	p5
7		Monetary (Xk)	1	1	1	1	1	$ 159,252	$ 72,157	$ 159,252	$ 17,618		R	0.50	0.50	0.52	0.56	0.51
8											$ 52,853		F	0.50	0.50	0.51	0.46	0.81
9		Campaign Cost-R	$ 10,297.50	$ 1,230.00	$ 1,267.50	$ 1,320.00	$ 3,502.50	$ 17,617.50					M	0.52	0.50	0.50	0.51	0.49
10		Campaign Cost-F	$ 16,860.00	$ 577.50	$ 120.00	$ 30.00	$ 30.00	$ 17,617.50										
11		Campaign Cost-M	$ 3,052.50	$ 10,110.00	$ 2,880.00	$ 870.00	$ 705.00	$ 17,617.50						N1	N2	N3	N4	N5
12													R	1373	164	169	176	467
13		Revenue											F	2248	77	16	4	4
14		R	$ 33,368.95	$ 14,122.39	$ 14,464.81	$ 20,839.58	$ 79,278.24	$ 162,074					M	407	1348	384	116	94
15		F	$ 115,506.01	$ 26,701.58	$ 11,251.63	$ 2,411.91	$ 6,276.01	$ 162,147										
16		M	$ 6,850.06	$ 75,789.87	$ 39,297.94	$ 17,464.34	$ 19,850.12	$ 159,252										

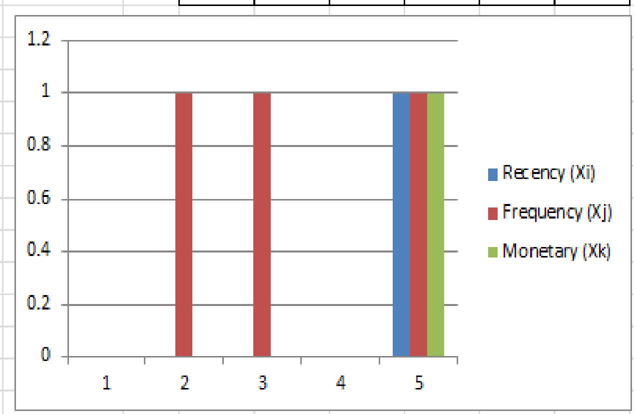
The Initial Template for the GP RFM Model

Solver Parameters for the GP RFM Model



Final Solution for the GP RFM Model

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1			Recency Priority	Frequency Priority	Monetary Value Priority		Goal	Total Revenue		Budget	$ 5,000.00			v1	v2	v3	v4	v5
2		Weights	3	2	1		103667	$ 143,358		C=	$ 7.50		R	$49	$171	$165	$212	$335
3		Slack	16,017	1,654	52,307								F	$102	$687	$1,381	$1,325	$1,937
4		Score	1	2	3	4	5	Optimal Solution	Max		Used Budget		M	$33	$112	$203	$294	$434
5		Recency (Xi)	0	0	0	0	1	$ 79,278	$ 95,295	$ 95,295	$ 3,503							
6		Frequency (Xj)	0	1	1	0	1	$ 44,229	$ 45,884	$ 45,884	$ 728			p1	p2	p3	p4	p5
7		Monetary (Xk)	0	0	0	0	1	$ 19,850	$ 72,157	$ 72,157	$ 705		R	0.50	0.50	0.52	0.56	0.51
8											$ 4,935		F	0.50	0.50	0.51	0.46	0.81
9		Campaign Cost-R	$ -	$ -	$ -	$ -	$ 3,502.50	$ 3,502.50					M	0.52	0.50	0.50	0.51	0.49
10		Campaign Cost-F	$ -	$ 577.50	$ 120.00	$ -	$ 30.00	$ 727.50										
11		Campaign Cost-M	$ -	$ -	$ -	$ -	$ 705.00	$ 705.00						N1	N2	N3	N4	N5
12													R	1373	164	169	176	467
13		Revenue											F	2248	77	16	4	4
14		R	$ -	$ -	$ -	$ -	$ 79,278.24	$ 79,278					M	407	1348	384	116	94
15		F	$ -	$ 26,701.58	$ 11,251.63	$ -	$ 6,276.01	$ 44,229										
16		M	$ -	$ -	$ -	$ -	$ 19,850.12	$ 19,850										



Final Solution for the GP RFM Model

The company should reach customers in:

recency group 5,

frequency groups 2, 3, and 5,

monetary value group 5.

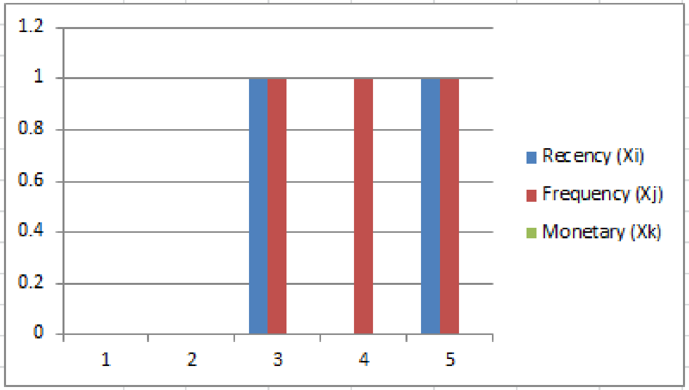
This solution provides the highest priority to recency customers and the least priority to the monetary value customers.

The total expected revenue for this solution is $143,358 and the solution uses $4,935 from the available $5,000 budget.

New Solution with Different Priorities

The data analyst can explore possible scenarios by changing the priority values

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Recency Priority	Frequency Priority	Monetary Value Priority		Goal	Total Revenue		Budget	$ 5,000.00			v1	v2	v3	v4	v5
2	30	10	1		378166	$ 113,683		C=	$ 7.50		R	$49	$171	$165	$212	$335
3	1552.27	25944.08	72157.40								F	$102	$687	$1,381	$1,325	$1,937
4	1	2	3	4	5	Optimal Solution	Max		Used Budget		M	$33	$112	$203	$294	$434
5	0	0	1	0	1	$ 93,743	$ 95,295	$ 95,295	$ 4,770							
6	0	0	1	1	1	$ 19,940	$ 45,884	$ 45,884	$ 180			p1	p2	p3	p4	p5
7	0	0	0	0	0	$ -	$ 72,157	$ 72,157	$ -		R	0.50	0.50	0.52	0.56	0.51
8									$ 4,950		F	0.50	0.50	0.51	0.46	0.81
9	$ -	$ -	$ 1,267.50	$ -	$ 3,502.50	$ 4,770.00					M	0.52	0.50	0.50	0.51	0.49
10	$ -	$ -	$ 120.00	$ 30.00	$ 30.00	$ 180.00										
11	$ -	$ -	$ -	$ -	$ -	$ -						N1	N2	N3	N4	N5
12											R	1373	164	169	176	467
13											F	2248	77	16	4	4
14	$ -	$ -	$ 14,464.81	$ -	$ 79,278.24	$ 93,743					M	407	1348	384	116	94
15	$ -	$ -	$ 11,251.63	$ 2,411.91	$ 6,276.01	$ 19,940										
16	$ -	$ -	$ -	$ -	$ -	$ -										



Exploring Big Data with RFM Analytics

- The critics of the RFM approach: this methodology is less likely to be used successfully in predictive and prescriptive analytics
- The models proposed in the last two chapters, bring the RFM approach into the era of big data:
  - Augment the RFM analysis with predictive modeling, like customer response rates and prescriptive analytics, such as LP and GP models.
- The combination of RFM analysis with predictive and prescriptive analytics utilizes the RFM strengths and avoids its weaknesses.

End of The Lecture

Thank You