INTRODUCTION

The dataset consists of various information for each product such as the product id, brand id, width, height, depth, weight, monthly demand, price, and unit margin. Further, there will also be a new brand id to be added in our analysis along with the initial requirement to have at least three products per brand. The purpose of analyzing this dataset is to determine the optimize number of products as well as its product id to be displayed in the shelf to maximize the profit with certain space limitation. As a result, we will integer linear programming using solver tool in Microsoft Excel. The methodology and solution will be further explained below.

DEFINING THE PROBLEM

The problem will be divided into three steps. Firstly, we will select products for display striving to attain maximum profit per month with the **shelf width of 3,600 mm**. Secondly, still striving to maximize the profit with this additional constraint in place, for the same shelf width, we have to display **at least three products per brand id**. Lastly, to consider **at least eight new product id** to be put in the same shelf considering all other constraints above remain unchanged. Eventually, we will compare and determine the best shelf allocation to maximize the profit.

METHODOLOGY

Integer Linear Programming is a method to achieve the best outcome (such as maximum profit) in a mathematical model whose requirements are represented by linear relationships where the decision variables are restricted to be integers. To calculate this, we will use solver tools in Microsoft Excel. The step by step will be explained as below.

- **Set decision variables**
  We will set our decision variables (binary) which are 0 to not put in the shelf and 1 to put in the shelf. We name the column as "Facing or No Facing"

- **Objective Function**
  As the objective function is to maximize profit, we create a new column called "Profit" with formula as below. Then, we will sum up the total profit to be compared for the three steps above.
  monthly demand * unit margin * binary (facing or no facing)

- **Constraints**
  Constraints will be divided into three steps as mention above, step 1 will need to consider shelf width of maximum 3,600 mm. Step 2, we are required to put at least 3 products per brand while still considering profit maximization and last step, we need to include additional new brand (brand 48) with at least eight products to be put in display.

Methodology is shown in appendix 1 to appendix 6.

SOLUTION

Having the right space allocation for products and categories plays a critical role in its retail success. From retailer's perspective, given the value of shelf space positions, it is very critical to ensure that retail space is working for value maximization for the store. As we can see from the analysis, step 1, with only width constraint to be considered, brings the best profit to the company **($1,492.30)** as sometimes, not all products worth to be put in the same amount in the display. Further, in the step 2, as Manager wants to have at least three products per brand, our result is shown the maximum profit of **$1,468.97.** Lastly, if we need to have at least eight products of brand 48, our analysis shows that the profit will decrease by **$64.28** with eight products to be put in display for maximum profit. Finally, all the product_id to be displayed will be shown in our appendix based on the step-by-step requirement.

APPENDIX

Appendix 1: Product_id to be displayed for STEP 1

product_id	category_id	brand_id	width	height	depth	weight	monthly_demand	price	unit_margin	Facing/ No Facing	Profit
22063	212	35	97.28	77.70	121.95	1.20	4.33	15.22	8.41	1	$ 36.46
103984	212	35	99.59	76.32	76.68	1.07	3.67	9.24	9.24	1	$ 33.86
22064	212	35	117.04	80.86	120.89	0.80	7.67	15.58	9.95	1	$ 76.28
21822	212	35	91.15	105.66	98.10	0.84	11.67	15.25	5.75	1	$ 67.06
101120	212	35	116.10	84.73	121.18	0.86	6.33	14.45	10.79	1	$ 68.30
21824	212	35	116.02	90.85	104.06	1.16	7.67	14.97	7.59	1	$ 58.20
113790	212	35	88.80	118.20	104.04	0.97	2.33	16.52	7.80	1	$ 18.20
24214	212	35	121.96	98.94	89.91	0.98	4.33	15.39	6.43	1	$ 27.84
32857	212	35	123.95	112.41	76.65	0.83	2.67	16.25	10.64	1	$ 28.38
21823	212	35	117.99	75.59	108.86	0.88	11.67	15.28	8.17	1	$ 95.36
28643	212	35	80.34	113.27	103.57	1.05	14.33	14.94	8.33	1	$ 119.34
32858	212	35	103.88	83.38	92.34	0.93	10.00	15.39	8.83	1	$ 88.29
19493	212	128	89.02	87.01	79.77	0.95	50.00	1.09	0.59	1	$ 29.71
31269	212	128	88.77	120.00	113.94	0.92	37.33	1.04	0.59	1	$ 21.88
31266	212	128	76.48	117.07	118.76	1.02	54.33	1.09	0.62	1	$ 33.58
31267	212	128	114.08	104.63	107.47	1.06	46.00	1.08	0.61	1	$ 28.09
32785	212	348	82.04	91.13	76.53	1.16	42.00	1.11	0.60	1	$ 25.27
32791	212	348	95.91	100.30	86.85	0.96	50.67	1.09	0.50	1	$ 25.29
32820	212	348	103.63	113.18	102.07	1.13	8.33	4.27	2.64	1	$ 22.01
32818	212	348	93.74	94.38	101.46	1.15	13.00	4.38	2.48	1	$ 32.21
32804	212	348	104.73	100.50	95.21	1.07	36.33	1.08	0.55	1	$ 20.00
32817	212	348	95.84	99.55	123.30	0.93	11.33	4.38	2.49	1	$ 28.26
32783	212	348	112.11	92.85	90.48	1.16	37.00	1.10	0.65	1	$ 24.17
32813	212	348	82.11	123.71	98.81	1.25	28.67	1.37	0.73	1	$ 20.94
32819	212	348	120.74	81.57	93.44	0.85	15.33	4.38	2.47	1	$ 37.92
34541	212	371	101.95	117.47	123.94	1.13	79.33	1.19	0.62	1	$ 49.29
34538	212	371	94.82	88.80	118.20	1.04	117.67	1.21	0.68	1	$ 79.87
34537	212	371	82.24	121.95	120.08	0.78	107.67	1.22	0.66	1	$ 70.87
34540	212	371	87.78	84.46	78.87	0.83	69.00	1.21	0.67	1	$ 46.26
113016	212	371	92.00	146.00	157.00	0.01	8.33	9.84	5.64	1	$ 47.00
109675	212	423	105.00	95.00	370.00	0.00	47.33	0.92	0.42	1	$ 19.94
109661	212	424	100.00	150.00	110.00	0.00	30.00	1.29	0.76	1	$ 22.73
109656	212	424	100.00	150.00	110.00	0.00	25.00	1.26	0.78	1	$ 19.53
109659	212	424	100.00	150.00	110.00	0.00	25.00	1.39	0.86	1	$ 21.50
109660	212	424	100.00	150.00	110.00	0.00	27.33	1.24	0.77	1	$ 20.97
109658	212	424	100.00	150.00	110.00	0.00	33.00	1.39	0.83	1	$ 27.43
											$ 1,492.30

Appendix 2: Methodology for STEP 1

OBJECTIVE FUNCTION				
MAX PROFIT	$ 1,492.30			

CONSTRAINTS	LHS		RHS	Profit per Brand
Width	3597.095	<=	3600	
Binary				
Brand 35	12			$ 717.58
Brand 128	4			$ 113.26
Brand 348	9			$ 236.07
Brand 371	5			$ 293.28
Brand 423	1			$ 19.94
Brand 424	5			$ 112.16

Appendix 3: Product_id to be displayed for STEP 2

product_id	category_id	brand_id	width	height	depth	weight	monthly_demand	price	unit_margin	Facing/ No Facing	Profit
22063	212	35	97.28	77.70	121.95	1.20	4.33	15.22	8.41	1	$ 36.46
103984	212	35	99.59	76.32	76.68	1.07	3.67	9.24	9.24	1	$ 33.86
22064	212	35	117.04	80.86	120.89	0.80	7.67	15.58	9.95	1	$ 76.28
21822	212	35	91.15	105.66	98.10	0.84	11.67	15.25	5.75	1	$ 67.06
101120	212	35	116.10	84.73	121.18	0.86	6.33	14.45	10.79	1	$ 68.30
21824	212	35	116.02	90.85	104.06	1.16	7.67	14.97	7.59	1	$ 58.20
24214	212	35	121.96	98.94	89.91	0.98	4.33	15.39	6.43	1	$ 27.84
32857	212	35	123.95	112.41	76.65	0.83	2.67	16.25	10.64	1	$ 28.38
21823	212	35	117.99	75.59	108.86	0.88	11.67	15.28	8.17	1	$ 95.36
28643	212	35	80.34	113.27	103.57	1.05	14.33	14.94	8.33	1	$ 119.34
32858	212	35	103.88	83.38	92.34	0.93	10.00	15.39	8.83	1	$ 88.29
19493	212	128	89.02	87.01	79.77	0.95	50.00	1.09	0.59	1	$ 29.71
31269	212	128	88.77	120.00	113.94	0.92	37.33	1.04	0.59	1	$ 21.88
31266	212	128	76.48	117.07	118.76	1.02	54.33	1.09	0.62	1	$ 33.58
31267	212	128	114.08	104.63	107.47	1.06	46.00	1.08	0.61	1	$ 28.09
32785	212	348	82.04	91.13	76.53	1.16	42.00	1.11	0.60	1	$ 25.27
32791	212	348	95.91	100.30	86.85	0.96	50.67	1.09	0.50	1	$ 25.29
32820	212	348	103.63	113.18	102.07	1.13	8.33	4.27	2.64	1	$ 22.01
32818	212	348	93.74	94.38	101.46	1.15	13.00	4.38	2.48	1	$ 32.21
32806	212	348	78.74	88.92	95.57	0.88	29.33	1.16	0.58	1	$ 16.95
32817	212	348	95.84	99.55	123.30	0.93	11.33	4.38	2.49	1	$ 28.26
32783	212	348	112.11	92.85	90.48	1.16	37.00	1.10	0.65	1	$ 24.17
32813	212	348	82.11	123.71	98.81	1.25	28.67	1.37	0.73	1	$ 20.94
32819	212	348	120.74	81.57	93.44	0.85	15.33	4.38	2.47	1	$ 37.92
34541	212	371	101.95	117.47	123.94	1.13	79.33	1.19	0.62	1	$ 49.29
34538	212	371	94.82	88.80	118.20	1.04	117.67	1.21	0.68	1	$ 79.87
34537	212	371	82.24	121.95	120.08	0.78	107.67	1.22	0.66	1	$ 70.87
34540	212	371	87.78	84.46	78.87	0.83	69.00	1.21	0.67	1	$ 46.26
113016	212	371	92.00	146.00	157.00	0.01	8.33	9.84	5.64	1	$ 47.00
109678	212	423	105.00	95.00	370.00	0.00	17.67	0.96	0.44	1	$ 7.77
109669	212	423	105.00	95.00	370.00	0.00	21.67	1.02	0.45	1	$ 9.67
109675	212	423	105.00	95.00	370.00	0.00	47.33	0.92	0.42	1	$ 19.94
109661	212	424	100.00	150.00	110.00	0.00	30.00	1.29	0.76	1	$ 22.73
109659	212	424	100.00	150.00	110.00	0.00	25.00	1.39	0.86	1	$ 21.50
109660	212	424	100.00	150.00	110.00	0.00	27.33	1.24	0.77	1	$ 20.97
109658	212	424	100.00	150.00	110.00	0.00	33.00	1.39	0.83	1	$ 27.43
										$	1,468.97

Appendix 4: Methodology for STEP 2

OBJECTIVE FUNCTION				
MAX PROFIT	$ 1,468.97			

CONSTRAINTS	LHS		RHS	Profit per Brand
Width	3592.313	<=	3600	
Binary				
Brand 35	11	>=	3	$ 699.39
Brand 128	4	>=	3	$ 113.26
Brand 348	9	>=	3	$ 233.02
Brand 371	5	>=	3	$ 293.28
Brand 423	3	>=	3	$ 37.39
Brand 424	4	>=	3	$ 92.63

Appendix 5: Product_id to be displayed for STEP 3

product_id	category_id	brand_id	width	height	depth	weight	monthly_demand	price	unit_margin	Facing/ No Facing	Profit
22063	212	35	97.28	77.70	121.95	1.20	4.33	$ 15.22	8.41	1	$ 36.46
103984	212	35	99.59	76.32	76.68	1.07	3.67	$ 9.24	9.24	1	$ 33.86
22064	212	35	117.04	80.86	120.89	0.80	7.67	$ 15.58	9.95	1	$ 76.28
21822	212	35	91.15	105.66	98.10	0.84	11.67	$ 15.25	5.75	1	$ 67.06
101120	212	35	116.10	84.73	121.18	0.86	6.33	$ 14.45	10.79	1	$ 68.30
21824	212	35	116.02	90.85	104.06	1.16	7.67	$ 14.97	7.59	1	$ 58.20
32857	212	35	123.95	112.41	76.65	0.83	2.67	$ 16.25	10.64	1	$ 28.38
21823	212	35	117.99	75.59	108.86	0.88	11.67	$ 15.28	8.17	1	$ 95.36
28643	212	35	80.34	113.27	103.57	1.05	14.33	$ 14.94	8.33	1	$ 119.34
32858	212	35	103.88	83.38	92.34	0.93	10.00	$ 15.39	8.83	1	$ 88.29
19493	212	128	89.02	87.01	79.77	0.95	50.00	$ 1.09	0.59	1	$ 29.71
31266	212	128	76.48	117.07	118.76	1.02	54.33	$ 1.09	0.62	1	$ 33.58
31267	212	128	114.08	104.63	107.47	1.06	46.00	$ 1.08	0.61	1	$ 28.09
32785	212	348	82.04	91.13	76.53	1.16	42.00	$ 1.11	0.60	1	$ 25.27
32791	212	348	95.91	100.30	86.85	0.96	50.67	$ 1.09	0.50	1	$ 25.29
32818	212	348	93.74	94.38	101.46	1.15	13.00	$ 4.38	2.48	1	$ 32.21
32817	212	348	95.84	99.55	123.30	0.93	11.33	$ 4.38	2.49	1	$ 28.26
32819	212	348	120.74	81.57	93.44	0.85	15.33	$ 4.38	2.47	1	$ 37.92
34541	212	371	101.95	117.47	123.94	1.13	79.33	$ 1.19	0.62	1	$ 49.29
34538	212	371	94.82	88.80	118.20	1.04	117.67	$ 1.21	0.68	1	$ 79.87
34537	212	371	82.24	121.95	120.08	0.78	107.67	$ 1.22	0.66	1	$ 70.87
34540	212	371	87.78	84.46	78.87	0.83	69.00	$ 1.21	0.67	1	$ 46.26
113016	212	371	92.00	146.00	157.00	0.01	8.33	$ 9.84	5.64	1	$ 47.00
109678	212	423	105.00	95.00	370.00	0.00	17.67	$ 0.96	0.44	1	$ 7.77
109669	212	423	105.00	95.00	370.00	0.00	21.67	$ 1.02	0.45	1	$ 9.67
109675	212	423	105.00	95.00	370.00	0.00	47.33	$ 0.92	0.42	1	$ 19.94
109661	212	424	100.00	150.00	110.00	0.00	30.00	$ 1.29	0.76	1	$ 22.73
109659	212	424	100.00	150.00	110.00	0.00	25.00	$ 1.39	0.86	1	$ 21.50
109658	212	424	100.00	150.00	110.00	0.00	33.00	$ 1.39	0.83	1	$ 27.43
118704	212	48	83.23	109.17	78.56	0.97	11.67	$ 0.79	0.39	1	$ 4.58
118716	212	48	85.24	115.64	97.93	0.86	4.67	$ 1.13	0.64	1	$ 2.99
118700	212	48	85.86	79.73	105.83	0.96	42.00	$ 0.79	0.37	1	$ 15.38
118695	212	48	75.06	122.41	81.71	1.03	8.33	$ 0.72	0.34	1	$ 2.81
118699	212	48	78.36	102.54	120.00	1.14	11.33	$ 0.74	0.39	1	$ 4.45
118697	212	48	80.65	100.99	84.60	0.77	18.67	$ 0.73	0.38	1	$ 7.06
118702	212	48	92.94	124.78	121.10	1.16	70.00	$ 0.81	0.38	1	$ 26.80
118703	212	48	113.40	76.67	122.31	1.04	67.33	$ 0.81	0.39	1	$ 26.43
											$ 1,404.69

Appendix 6: Methodology for STEP 3

OBJECTIVE FUNCTION	
MAX PROFIT	$1,404.69

CONSTRAINTS	LHS		RHS	Profit per Brand	
Width	3599.737	<=	3600		
Binary					
Brand 35	10	>=	3	$	671.55
Brand 128	3	>=	3	$	91.38
Brand 348	5	>=	3	$	148.94
Brand 371	5	>=	3	$	293.28
Brand 423	3	>=	3	$	37.39
Brand 424	3	>=	3	$	71.66
Brand 48 (new)	8	>=	8	$	90.48