FORM FOR THE SUBMISSION OF ASSESSED GROUP COURSEWORK

This form must be completed and attached to **all** assessed work. Please include all group members' examination numbers below.

Examination Number	B230613
Examination Number	B249929
Examination Number	B241290
Examination Number	B230334
Examination Number	B255931

Course Code and Title: BUST08032 Business Analytics and Information System
Team: 14
Word Count: 2090

We understand that all marks are provisional until ratified by the Faculty Examination Board.

Team Contract

How we will work together

- All team members are committed to developing a spirit of collaboration and cooperation.
- Everyone should feel free to speak their minds in an open and respectful climate.
- We will respond promptly to team communications (within 24 hours)
- We will attend all team meetings on time or notify our teammates in advance if we cannot make it for good reason.
- We will always obey the project manager without question.
- Any dispute will be resolved by a majority vote of the team, and we will all abide by that decision.

How we will resolve conflicts

<A specific and sufficiently detailed policy and process for how you will deal with major disagreements or failures of team members to live up to their commitments and responsibilities. What will you do if a team member is 'free riding' or failing to contribute as needed? Make sure your policy and procedures for dealing with conflict and problems are open and fair, allowing people time and ability to ask for guidance or to 'appeal' to your tutor. Something to think about: should it be possible to 'fire' a team member who is not contributing? Should team members receive marks according to their level of effort? How could that work in a fair way? Whatever policy you decide, you must all agree to it.>

Contract agreed by all team members

<You must include the following, which all team members agree to as part of this contract>

In addition to the principles, policies, and processes above, we the undersigned also:

1. recognise that individual team members may receive different marks from each other based on their level of contribution to the coursework.
2. will notify the course organiser immediately if a team member is not contributing as needed, or if there are significant unresolved conflicts within the team that threaten our project.
3. will document any cases of significant conflict and its resolution, clearly in writing for the benefit of transparency, and as a record for team members and course organiser.
4. recognise that course organiser will not intervene to resolve conflict unless we notify them at least two weeks before the submission deadline if we wish them to intervene. This encourages us to raise issues early. The course organiser will of course act in the event of any problems under the university's code of conduct or well-being policies.

Signed agreement

EXAMINATION NUMBER	DATE SIGNED & AGREED
B230613	March 18 Agreed
B249929	March 18 Agreed
B241290	March 18 Agreed
B230334	March 18 Agreed
B255931	March 18 Agreed

Project Report

1. Introduction

1) Background

Our theoretical problem focuses on online advertising for St James Quarter. The shopping centre opened in June of 2021, after the pandemic. Online advertising can be utilised in this context to increase footfall in shops, especially in an age where online shopping is of ever-growing convenience and preferentiality. Digital marketing can boost popularity and increase profits, however, there are risks when allocating a budget towards the online marketing team. Using a DSS to optimise budget costs can help solve some of these issues.

One problem is the lack of a clear marketing strategy. Using a DSS can help to clearly state objectives and make the goals of the scheme clear, avoiding unmet targets. A DSS can be used to effectively allocate resources, or in this case a budget, into an optimal solution that produces an optimal output. Navigating issues such as overspending on strategies that are cost ineffective or unsuccessful can also be supported through using a DSS to correctly allocate a budget in the most cost-effective way whilst simultaneously meeting the desired targets.

2) Objectives

This report aims to minimise costs of online advertising for St James Quarter over the time period of 5 months using Google as the advertising platform, and providing an allocation of strategies that is optimal in the short run and minimises total cost. The objective function of the DSS therefore takes the form of minimising Z (total advertising cost) with respect to 30 decision variables. The decision variables are the different strategies for advertising. These are summarised in *table 5.0* of this report.

The DSS includes 5 functional constraints which must also be satisfied in order to find the optimal allocation of advertising strategies. These focus on total cost in relation to total budget, the Click Through Rate (CTR), the mobile and desktop budget allocation and the CTR of the mobile group. The final constraint is a non-negativity constraint for all decision variables, ensuring all values are positive. These constraints are formulated officially in section 5.

2. Data Collection and Preparation

In the initial stages of our data gathering process, we began with a straightforward search on engines like Google. This search yielded a number of financial statements that were relevant to our study. However, the data was not comprehensive and presented challenges in terms of compatibility with our Decision Support System ("DSS"). Seeking a more suitable dataset, we turned to established data sharing platforms, among which Kaggle was a primary resource. By using targeted keywords such as "digital marketing" and "mall", we were able to find and evaluate various datasets. This process led us to select a dataset that was particularly well-suited to our research focus on the intersection of shopping malls and online advertising. This dataset (Marcello, 2022) then formed the foundation for the subsequent analytical phase, providing context for our model parameters and their function as either predictive or deterministic variables.

Model Parameter Name	Where They Were Sourced	Predictive or Deterministic
Cost Per Click	Kaggle	Predictive
Click Through Rate	Kaggle	Predictive
Mobile Budget Allocation	Kaggle	Deterministic
Desktop Budget Allocation	Kaggle	Deterministic
Total Cost in relation to total budget	Kaggle	Deterministic
Non-Negativity Constraint	Kaggle	Deterministic

The chart above details our model parameters, where they were sourced, and whether they act as predictive or deterministic variables. As seen, cost per click and click-through rate act as the predictive variables and are used as estimates to ultimately predict the future budget allocation and cost of the optimal minimized advertising budget for the St. James Quarter mall. More in-depth, cost per click acts as a predictive method despite not being a traditional predictive model like regression by providing valuable insights and a predictive metric in regard to estimating future costs and, ultimately, the performance and success of the online advertising campaign

when you consider the determined budget. Click-through rate acts similarly because when considering the two parameters together, it is now possible to forecast the campaign's future performance and see the most successful combination of coefficients to achieve that optimal target.

3. Database Creation with MySQL
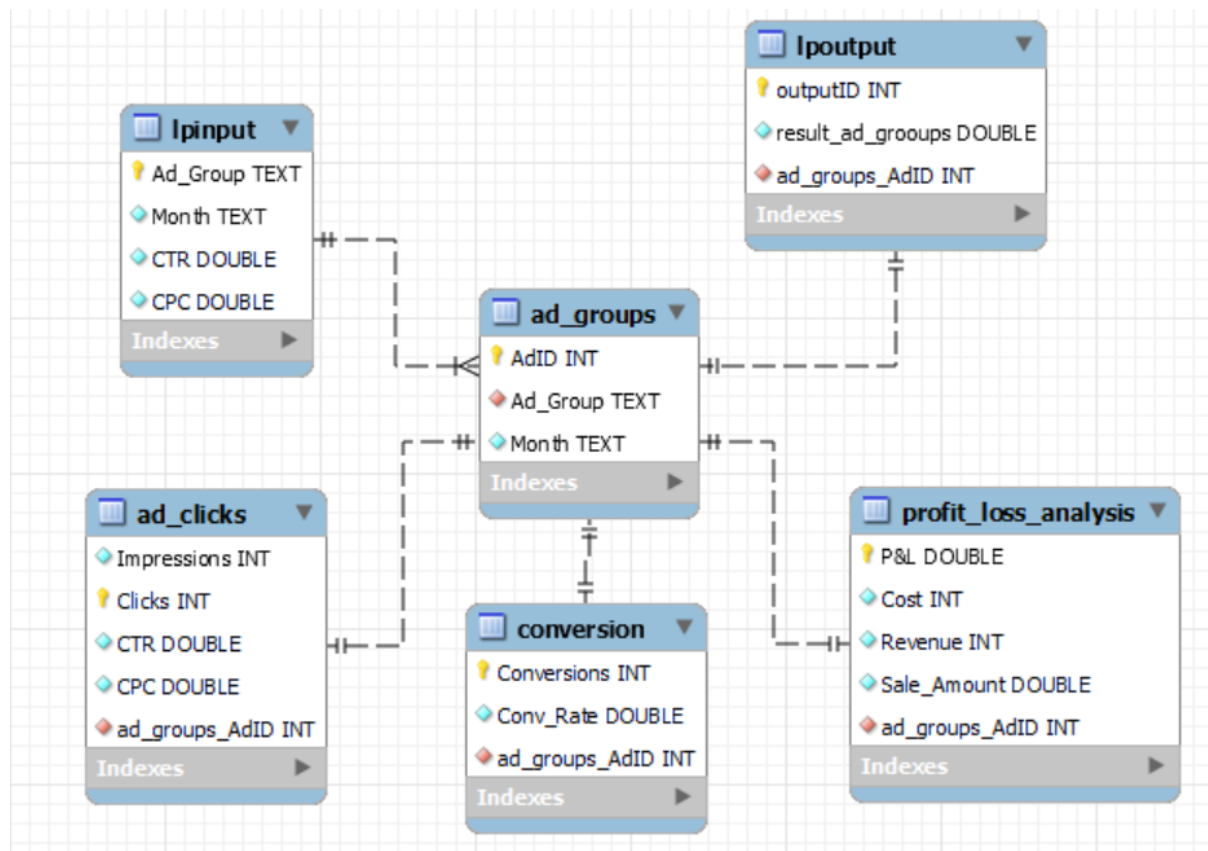
The schema comprises several key entities, as listed below. Central to the schema is the ad_groups entity, which operates as a junction entity.

Entity	Attributes
lpinput: Contains all decision variables used in the linear programming.	**Ad_Group (Primary Key):** Category of the advert (1:1, exact, phrase | desktop/ mobile | coupon code, offer, promo code, sale, discount code). **Month:** Months of the advertising campaign, from July to August. **CTR:** Click Through Rate. The ratio of clicks an ad receives to the number of times it is displayed. **CPC:** Cost Per Click. Determined by dividing the total expenditure for the ads by the number of clicks received.
lpoutput:	**outputID (Primary Key):** ID for all outputs.

Contains key results of the linear programming.	**result_ad_groups:** The result of objective function and the allocation we decided to put under different decision variables. **ad_groups_AdID (Foreign Key from ad_groups):** Same as above.
ad_groups: To determine different ad groups.	**Composite primary key:** AdID (Primary Key) + AdGroup (Foreign Key from lpinput entity) To distinguish each ad groups using both their id and name. **Month:** Same as above.
ad_clicks: To determine click-related performance indicators.	**Clicks (Primary Key):** How many clicks each ad received. Used to differentiate each group in ad_click entity. **Impressions:** Quantifies how often an ad is interacted with. **CTR:** Same as above. **CPC:** Same as above. **ad_groups_AdID (Foreign Key from ad_groups entity):** Same as above.
conversion: For storing conversion data.	**Conversions (Primary Key) :** Valuable actions that users take on our website such as making purchases. **Conv_Rate:** Percentage of people who clicks into an ad after seeing it. **ad_groups_AdID (Foreign Key from ad_groups):** Same as above.
profit_loss_analysis: To analyse profit & loss related index.	**P&L (Primary Key):** Profit and Loss, an indicator calculated by formula (Revenue - Cost). **Cost:** Total expenditure incurred for advertising. **Revenue:** Total income generated by advertising. **Sale_Amount:**

	Denotes the total revenue generated as a result of advertising efforts. **ad_groups_AdID (Foreign Key from ad_groups):** Same as above.

4. Data Integration with Excel

In order to obtain the optimal online advertising strategy via Excel linear programming, the NET Connector was applied to connect the MySQL dataset and Excel decision-making model. The query applied to the Net Connector can be expressed as:

$$SELECT \; * \; FROM \; shopping\_mall.\,lpinput;$$

By using this query in Net Connector, the necessary parameters and relevant data are selected and extracted from MySQL dataset and are imported into excel sheet, which can be shown as:

	Ad Group	Month	CTR	CPC
1				
2	Shop - 1:1 - Desk - Coupon Code	November	0.37	1.3
3	Shop - 1:1 - Desk - Coupon Code	July	0.41	1.23
4	Shop - 1:1 - Desk - Coupon Code	August	0.4	1.23
5	Shop - 1:1 - Desk - Coupon Code	October	0.4	1.2
6	Shop - 1:1 - Desk - Coupon Code	September	0.4	1.27
7	Shop - 1:1 - Desk - Discount Code	November	0.42	1.08
8	Shop - 1:1 - Desk - Discount Code	July	0.42	1.21
9	Shop - 1:1 - Desk - Discount Code	August	0.4	1.04
10	Shop - 1:1 - Desk - Discount Code	October	0.42	1.21
11	Shop - 1:1 - Desk - Discount Code	September	0.39	0.99
12	Shop - 1:1 - Desk - Offer	November	0.38	1.17
13	Shop - 1:1 - Desk - Offer	July	0.4	1.1
14	Shop - 1:1 - Desk - Offer	August	0.38	1.41
15	Shop - 1:1 - Desk - Offer	October	0.37	1.27
16	Shop - 1:1 - Desk - Offer	September	0.4	1.35
17	Shop - 1:1 - Desk - Promo Code	November	0.37	1.3
18	Shop - 1:1 - Desk - Promo Code	July	0.4	1.27
19	Shop - 1:1 - Desk - Promo Code	August	0.39	1.3
20	Shop - 1:1 - Desk - Promo Code	October	0.38	1.25
21	Shop - 1:1 - Desk - Promo Code	September	0.4	1.3
22	Shop - 1:1 - Desk - Sale	November	0.35	1.47
23	Shop - 1:1 - Desk - Sale	October	0.29	1.51
24	Shop - 1:1 - Desk - Sale	August	0.32	1.5
25	Shop - 1:1 - Desk - Sale	July	0.35	1.55
26	Shop - 1:1 - Desk - Sale	September	0.36	1.45
27	Shop - 1:1 - Mob - Coupon Code	November	0.43	1.27
28	Shop - 1:1 - Mob - Coupon Code	July	0.27	1.16
29	Shop - 1:1 - Mob - Coupon Code	October	0.34	1.28
30	Shop - 1:1 - Mob - Coupon Code	August	0.41	1.29
31	Shop - 1:1 - Mob - Coupon Code	September	0.45	1
32	Shop - 1:1 - Mob - Discount Code	November	0.36	1.38
33	Shop - 1:1 - Mob - Discount Code	October	0.39	1.34
34	Shop - 1:1 - Mob - Discount Code	July	0.39	1.13
35	Shop - 1:1 - Mob - Discount Code	August	0.3	1.33
36	Shop - 1:1 - Mob - Discount Code	September	0.45	1.27
37	Shop - 1:1 - Mob - Offer	November	0.44	1.1
38	Shop - 1:1 - Mob - Offer	July	0.43	1.3
39	Shop - 1:1 - Mob - Offer	October	0.34	1.1

40	Shop - 1:1 - Mob - Offer	August	0.33	1.1
41	Shop - 1:1 - Mob - Offer	September	0.4	1.23
42	Shop - 1:1 - Mob - Promo Code	November	0.41	1.26
43	Shop - 1:1 - Mob - Promo Code	July	0.47	1.15
44	Shop - 1:1 - Mob - Promo Code	October	0.45	1.42
45	Shop - 1:1 - Mob - Promo Code	August	0.43	0.69
46	Shop - 1:1 - Mob - Promo Code	September	0.44	0.66
47	Shop - 1:1 - Mob - Sale	November	0.4	1.17
48	Shop - 1:1 - Mob - Sale	July	0.45	1.19
49	Shop - 1:1 - Mob - Sale	October	0.4	1.21
50	Shop - 1:1 - Mob - Sale	August	0.4	1.14
51	Shop - 1:1 - Mob - Sale	September	0.35	1.32
52	Shop - Exact - Desk - Coupon Code	November	0.3	1.08
53	Shop - Exact - Desk - Coupon Code	July	0.5	1.05
54	Shop - Exact - Desk - Coupon Code	August	0.45	1.12
55	Shop - Exact - Desk - Coupon Code	October	0.31	1.12
56	Shop - Exact - Desk - Coupon Code	September	0.42	1.12
57	Shop - Exact - Desk - Discount Code	November	**0.31**	0.98
58	Shop - Exact - Desk - Discount Code	August	0.35	1.13
59	Shop - Exact - Desk - Discount Code	October	0.4	1.19
60	Shop - Exact - Desk - Discount Code	July	0.44	1.07
61	Shop - Exact - Desk - Discount Code	September	0.39	1.06
62	Shop - Exact - Desk - Offer	November	0.25	1.28
63	Shop - Exact - Desk - Offer	August	0.4	1.02
64	Shop - Exact - Desk - Offer	September	0.35	1.4
65	Shop - Exact - Desk - Offer	October	0.4	1.2
66	Shop - Exact - Desk - Offer	July	0.33	1.3
67	Shop - Exact - Desk - Promo Code	November	0.3	1.41
68	Shop - Exact - Desk - Promo Code	August	0.35	1.29
69	Shop - Exact - Desk - Promo Code	October	0.33	1.23
70	Shop - Exact - Desk - Promo Code	July	0.37	1.2
71	Shop - Exact - Desk - Promo Code	September	0.37	1.49
72	Shop - Exact - Desk - Sale	November	0.39	1.66
73	Shop - Exact - Desk - Sale	July	0.28	0.7
74	Shop - Exact - Desk - Sale	September	0.42	1.29
75	Shop - Exact - Desk - Sale	October	0.23	1.59
76	Shop - Exact - Desk - Sale	August	0.45	0.8
77	Shop - Exact - Mob - Coupon Code	November	0.35	1.49
78	Shop - Exact - Mob - Coupon Code	July	0.34	1.23
79	Shop - Exact - Mob - Coupon Code	October	0.38	1.38
80	Shop - Exact - Mob - Coupon Code	August	0.3	1.42
81	Shop - Exact - Mob - Coupon Code	September	0.36	0.37
82	Shop - Exact - Mob - Discount Code	November	0.27	1.52
83	Shop - Exact - Mob - Discount Code	October	0.3	1.44
84	Shop - Exact - Mob - Discount Code	August	0.4	1.44
85	Shop - Exact - Mob - Discount Code	September	0.45	1.44
86	Shop - Exact - Mob - Discount Code	July	0.24	0.54
87	Shop - Exact - Mob - Offer	November	0.3	1.11
88	Shop - Exact - Mob - Offer	October	0.33	1.33
89	Shop - Exact - Mob - Offer	July	0.4	1.22
90	Shop - Exact - Mob - Offer	August	0.32	1.22
91	Shop - Exact - Mob - Offer	September	0.26	1.45
92	Shop - Exact - Mob - Promo Code	November	0.37	1.64
93	Shop - Exact - Mob - Promo Code	October	0.42	1.61
94	Shop - Exact - Mob - Promo Code	July	0.37	1.66
95	Shop - Exact - Mob - Promo Code	August	0.2	1.2

96	Shop - Exact - Mob - Promo Code	September	0.39	0.59
97	Shop - Exact - Mob - Sale	November	0.13	1.25
98	Shop - Exact - Mob - Sale	July	0.45	1.41
99	Shop - Exact - Mob - Sale	August	0.44	1.41
100	Shop - Exact - Mob - Sale	September	0.32	1.33
101	Shop - Exact - Mob - Sale	October	0.27	0.9
102	Shop - Phrase - Desk - Coupon Code	July	0.35	1.11
103	Shop - Phrase - Desk - Coupon Code	November	0.26	1.32
104	Shop - Phrase - Desk - Coupon Code	August	0.51	1.08
105	Shop - Phrase - Desk - Coupon Code	September	0.33	1.31
106	Shop - Phrase - Desk - Coupon Code	October	0.26	1.13
107	Shop - Phrase - Desk - Discount Code	November	0.16	1.13
108	Shop - Phrase - Desk - Discount Code	October	0.36	1.23
109	Shop - Phrase - Desk - Discount Code	September	0.55	1.09
110	Shop - Phrase - Desk - Discount Code	August	0.45	1.4
111	Shop - Phrase - Desk - Discount Code	July	0.14	1.92
112	Shop - Phrase - Desk - Offer	November	0.14	1.3
113	Shop - Phrase - Desk - Offer	October	0.55	1.17
114	Shop - Phrase - Desk - Offer	September	0.34	1.5
115	Shop - Phrase - Desk - Offer	August	0.44	1.23
116	Shop - Phrase - Desk - Offer	July	0.14	1.09
117	Shop - Phrase - Desk - Promo Code	November	0.3	1.31
118	Shop - Phrase - Desk - Promo Code	July	0.33	1.23
119	Shop - Phrase - Desk - Promo Code	October	0.4	1.24
120	Shop - Phrase - Desk - Promo Code	August	0.35	1.36
121	Shop - Phrase - Desk - Promo Code	September	0.34	1.4
122	Shop - Phrase - Desk - Sale	August	0.28	0.77
123	Shop - Phrase - Desk - Sale	July	0.35	1.72
124	Shop - Phrase - Desk - Sale	November	0.44	1.2
125	Shop - Phrase - Desk - Sale	September	0.38	1.76
126	Shop - Phrase - Desk - Sale	October	0.33	0.76
127	Shop - Phrase - Mob - Coupon Code	July	0.37	1.54
128	Shop - Phrase - Mob - Coupon Code	September	0.35	1.51
129	Shop - Phrase - Mob - Coupon Code	August	0.31	1.46
130	Shop - Phrase - Mob - Coupon Code	November	0.27	1.47
131	Shop - Phrase - Mob - Coupon Code	October	0.32	0.51
132	Shop - Phrase - Mob - Discount Code	November	0.4	0.56
133	Shop - Phrase - Mob - Discount Code	October	0.23	1.42
134	Shop - Phrase - Mob - Discount Code	September	0.43	1.49
135	Shop - Phrase - Mob - Discount Code	August	0.4	1.48
136	Shop - Phrase - Mob - Discount Code	July	0.4	1.53
137	Shop - Phrase - Mob - Offer	November	0.23	1.2
138	Shop - Phrase - Mob - Offer	October	0.36	1.49
139	Shop - Phrase - Mob - Offer	September	0.4	1.6
140	Shop - Phrase - Mob - Offer	August	0.4	1.1
141	Shop - Phrase - Mob - Offer	July	0.36	1.1
142	Shop - Phrase - Mob - Promo Code	November	0.2	1.57
143	Shop - Phrase - Mob - Promo Code	July	0.36	1.5
144	Shop - Phrase - Mob - Promo Code	August	0.4	1.23
145	Shop - Phrase - Mob - Promo Code	October	0.4	1.3
146	Shop - Phrase - Mob - Promo Code	September	0.34	1.3
147	Shop - Phrase - Mob - Sale	August	0.3	1.42
148	Shop - Phrase - Mob - Sale	July	0.3	1.48
149	Shop - Phrase - Mob - Sale	September	0.34	1.39
150	Shop - Phrase - Mob - Sale	October	0.34	1.41
151	Shop - Phrase - Mob - Sale	November	0.34	1.41

It is clear that, for this decision-making model, the decision variables for decision-making model would be each advertisement group, and we have 30 decision variables in total. In addition, the coefficient for each decision variable would be the unit cost of each advertisement group, which can be calculated by:

$$Click\ Through\ Rate\ (CTR) * Cost\ Per\ Click\ (CPC)$$

Aim to better prepare for running excel solver add-in, the unit cost for each advertisement group collected throughout the months were averaged, so that the data are further integrated, and the final result can be summarised as *table 5*.

			1	2	3	4	5
			Coupon Code	Discount Code	Offer	Promo Code	Sale
x	01:01	desktop	0.49	0.45	0.49	0.5	0.5
y	01:01	mobile	0.45	0.49	0.45	0.46	0.48
z	exact	desktop	0.43	0.41	0.43	0.46	0.42
w	exact	mobile	0.4	0.44	0.41	0.47	0.42
v	phrase	desktop	0.4	0.42	0.41	0.45	0.45
u	phrase	mobile	0.42	0.48	0.46	0.46	0.46

Table 5.0

Therefore, the strong connection between the MySQL dataset and the Excel was built and the preparation for Excel linear programming was done.

5. Linear Programming in Excel

The objective of this advertising strategy is achieving cost minimisation while ensuring constraint to the following 6 conditions. The first two constraints are that the total cost of this strategy does not exceed the total budget, which is £732,469 and that the sum of CTR for each decision variable is not lower than the set target of 600,000. Additional constraints have to do with customer preferences which is why the mobile advertisement budget needs to be larger or equal to £366,234.5 (or half of the total budget). Simultaneously, a fourth constraint is introduced to help ensure that customers with different watching habits are all able to watch the advertisements, stating that the total cost of desktop advertisement groups should be larger than or equal to £183,117.25, equal to one quarter of the total budget. Furthermore, to ensure the mobile advertisement's effectiveness, a constraint is placed requiring the sum of CTR of mobile advertising groups to be larger or equal to 450,000. Finally, all unconstrained decision variables should be non-negative. Therefore, there are 6 functional constraints in this decision-making model.

The formulation of our Linear Programming model can be written as:

$$x1 = The\ Number\ of\ 01{:}01\ Desktop\ Coupon\ Code\ Advertised$$

$$x2 = The\ Number\ of\ 01{:}01\ Desktop\ Discount\ Code\ Advertised$$

$$x3 = The\ Number\ of\ 01{:}01\ Desktop\ Offer\ Advertised$$

$$x4 = The\ Number\ of\ 01{:}01\ Desktop\ Promo\ Code\ Advertised$$

$$x5 = The\ Number\ of\ 01{:}01\ Desktop\ Sale\ Advertised$$

$$y1 = The\ Number\ of\ 01{:}01\ Mobile\ Coupon\ Code\ Advertised$$

$$y2 = The\ Number\ of\ 01{:}01\ Mobile\ Discount\ Code\ Advertised$$

$$y3 = The\ Number\ of\ 01{:}01\ Mobile\ Offer\ Advertised$$

$$y4 = The\ Number\ of\ 01{:}01\ Mobile\ Promo\ Code\ Advertised$$

$$y5 = The\ Number\ of\ 01{:}01\ Mobile\ Sale\ Advertised$$

$z1 = \textit{The Number of Exact Desktop Coupon Code Advertised}$

$z2 = \textit{The Number of Exact Desktop Discount Code Advertised}$

$z3 = \textit{The Number of Exact Desktop Offer Advertised}$

$z4 = \textit{The Number of Exact Desktop Promo Code Advertised}$

$z5 = \textit{The Number of Exact Desktop Sale Advertised}$

$w1 = \textit{The Number of Exact Mobile Coupon Code Advertised}$

$w2 = \textit{The Number of Exact Mobile Discount Code Advertised}$

$w3 = \textit{The Number of Exact Mobile Offer Advertised}$

$w4 = \textit{The Number of Exact Mobile Promo Code Advertised}$

$w5 = \textit{The Number of Exact Mobile Sale Advertised}$

$v1 = \textit{The Number of Phrase Desktop Coupon Code Advertised}$

$v2 = \textit{The Number of Phrase Desktop Discount Code Advertised}$

$v3 = \textit{The Number of Phrase Desktop Offer Advertised}$

$v4 = \textit{The Number of Phrase Desktop Promo Code Advertised}$

$v5 = \textit{The Number of Phrase Desktop Sale Advertised}$

$u1 = \textit{The Number of Phrase Mobile Coupon Code Advertised}$

$u2 = \textit{The Number of Phrase Mobile Discount Code Advertised}$

$u3 = \textit{The Number of Phrase Mobile Offer Advertised}$

$u4 = \textit{The Number of Phrase Mobile Promo Code Advertised}$

$u5 = \textit{The Number of Phrase Mobile Sale Advertised}$

$Z = \textit{The Total Online Advertising Cost}$

$$\min_{xj,yj,zj,wj,vj,uj} Z = 0.49x1 + 0.45x2 + 0.49x3 + 0.50x4 + 0.50x5 +$$
$$0.45y1 + 0.49y2 + 0.45y3 + 0.46y4 + 0.49y5 +$$
$$0.43z1 + 0.41z2 + 0.43z3 + 0.46z4 + 0.42z5 +$$
$$0.40w1 + 0.44w2 + 0.41w3 + 0.47w4 + 0.42w5 +$$
$$0.40v1 + 0.42v2 + 0.41v3 + 0.45v4 + 0.45v5 +$$

$$0.42u_1 + 0.48u_2 + 0.46u_3 + 0.46u_4 + 0.46u_5$$

$s.t.$ $0.49x_1 + 0.45x_2 + 0.49x_3 + 0.50x_4 + 0.50x_5 +$

$0.45y_1 + 0.49y_2 + 0.45y_3 + 0.46y_4 + 0.49y_5 +$

$0.43z_1 + 0.41z_2 + 0.43z_3 + 0.46z_4 + 0.42z_5 +$

$0.40w_1 + 0.44w_2 + 0.41w_3 + 0.47w_4 + 0.42w_5 +$

$0.40v_1 + 0.42v_2 + 0.41v_3 + 0.45v_4 + 0.45v_5 +$

$0.42u_1 + 0.48u_2 + 0.46u_3 + 0.46u_4 + 0.46u_5 \leq 732,469$

$0.40x_1 + 0.41x_2 + 0.39x_3 + 0.39x_4 + 0.33x_5 +$

$0.38y_1 + 0.38y_2 + 0.39y_3 + 0.44y_4 + 0.40y_5 +$

$0.40z_1 + 0.38z_2 + 0.35z_3 + 0.32z_4 + 0.35z_5 +$

$0.35w_1 + 0.33w_2 + 0.32w_3 + 0.35w_4 + 0.32w_5 +$

$0.34v_1 + 0.33v_2 + 0.32v_3 + 0.34v_4 + 0.36v_5 +$

$0.32u_1 + 0.37u_2 + 0.35u_3 + 0.34u_4 + 0.32u_5 \geq 600,000$

$0.45y_1 + 0.49y_2 + 0.45y_3 + 0.46y_4 + 0.49y_5 +$

$0.40w_1 + 0.44w_2 + 0.41w_3 + 0.47w_4 + 0.42w_5 +$

$0.42u_1 + 0.48u_2 + 0.46u_3 + 0.46u_4 + 0.46u_5 \geq 466,234.5$

$0.49x_1 + 0.45x_2 + 0.49x_3 + 0.50x_4 + 0.50x_5 +$

$0.43z_1 + 0.41z_2 + 0.43z_3 + 0.46z_4 + 0.42z_5 +$

$0.40v_1 + 0.42v_2 + 0.41v_3 + 0.45v_4 + 0.45v_5 \geq 183,117.25$

$0.38y_1 + 0.38y_2 + 0.39y_3 + 0.44y_4 + 0.40y_5 +$

$0.35w_1 + 0.33w_2 + 0.32w_3 + 0.35w_4 + 0.32w_5 +$

$0.32u_1 + 0.37u_2 + 0.35u_3 + 0.34u_4 + 0.32u_5 \geq 450,000$

$x_j, y_j, z_j, w_j, u_j, v_j \geq 0, where\ j = 1,2,3,4,5$

Excel Solver Add-in obtains the optimal result (*table 6.0*).

objective function	650135							
			1	**2**	**3**	**4**	**5**	
			Coupon Code	Discount Code	Offer	Promo Code	Sale	
x	01:01	desktop	0	259504.6831	0	0	130548.144
y	01:01	mobile	0	0	0	1022727.27	0
z	exact	desktop	0	0	0	0	0
w	exact	mobile	0	0	0	0	0
v	phrase	desktop	0	0	0	0	0
u	phrase	mobile	0	0	0	0	0

Table 6.0 – Excel Solver Add-in solution for Linear Program.

Therefore, 259504.6831, 1022727.27, and 130548.144 are the optimal number of 01:01 desktop discount code, 01:01 mobile promo code, and 01:01 desktop sale groups respectively. The advertising cost will total £650,135. The *table 7.0* provides part of the sensitivity report for the objective function coefficient in the model:

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
U13	x1	0	0	0.49306	1E+30	0
V13	x2	259504.6831	0	0.45442	0	0
W13	x3	0	0	0.48606	1E+30	0
X13	x4	0	0	0.4982	1E+30	0
Y13	x5	130548.1435	0	0.49938	0	7.62615E-16
U14	y1	0	0.060309091	0.45468	1E+30	0.060309091
V14	y2	0	0.093824727	0.48612	1E+30	0.093824727
W14	y3	0	0.051726545	0.4544	1E+30	0.051726545
X14	y4	1022727.273	0	0.45664	0.057956532	0.45664
Y14	y5	0	0.065972727	0.4811	1E+30	0.065972727
U15	z1	0	5.55112E-17	0.43412	1E+30	5.55112E-17
V15	z2	0	4.16334E-17	0.4119	1E+30	4.16334E-17
W15	z3	0	0	0.4254	1E+30	0
X15	z4	0	0	0.45514	1E+30	0
Y15	z5	0	0	0.42218	1E+30	0
U16	w1	0	0.045574909	0.40466	1E+30	0.045574909
V16	w2	0	0.094644364	0.4392	1E+30	0.094644364
W16	w3	0	0.071282545	0.40546	1E+30	0.071282545
X16	w4	0	0.110223636	0.47346	1E+30	0.110223636
Y16	w5	0	0.083022545	0.4172	1E+30	0.083022545
U17	v1	0	9.15934E-16	0.40172	1E+30	9.15934E-16
V17	v2	0	0	0.42438	1E+30	0
W17	v3	0	8.67362E-16	0.40586	1E+30	8.67362E-16
X17	v4	0	2.77556E-17	0.44938	1E+30	2.77556E-17
Y17	v5	0	6.93889E-18	0.45304	1E+30	6.93889E-18
U18	u1	0	0.085946909	0.4222	1E+30	0.085946909
V18	u2	0	0.092991636	0.47906	1E+30	0.092991636
W18	u3	0	0.094443636	0.45768	1E+30	0.094443636
X18	u4	0	0.108741818	0.4616	1E+30	0.108741818
Y18	u5	0	0.124026909	0.46028	1E+30	0.124026909

Table 7.0

The allowable range of objective coefficient can be calculated by:

$$Objective\ Coefficient - Allowable\ Decrease, Objective\ Coefficient + Allowable\ Increase$$

For instance, the allowable range for y4 is [0.45664-0.45664, 0.45664+0.057956532] = [0, 0.51459653], indicating that changing the coefficient of decision variable y4 within [0, 0.51459653] will not alter the optimal solution values.

Furthermore, the reduced cost of x2 is zero, meaning x2 is already on the verge of entering the solution, and further improvement in its coefficient would be an optimal solution.

The *table 8.0* shows another part of the sensitivity report for the constraints in the decision-making model:

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
S2	Constraint 1 LHS	650135.4318	0	732469	1E+30	82333.56818
S3	Constraint 2 LHS	600000	0	600000	15217.35949	27525.809
S4	Constraint 3 LHS	467018.1818	0	366234.5	100783.6818	1E+30
S5	Constraint 4 LHS	183117.25	1	183117.25	41155.20509	16866.03049
S6	Constraint 5 LHS	450000	1.037818182	450000	27525.809	15217.35949

Table 8.0

Constraints 1, 2, and 3 have a shadow price of zero, indicating that relaxing them will not affect the optimal solution. But constraints 4 and 5 have a positive shadow price, which means that relaxing them will improve the optimal objective value. In addition, the allowable range of a RHS coefficient can be calculated by:

$$RHS\ Coefficient - Allowable\ Decrease, RHS\ Cofficient + Allowable\ Increase$$

For instance, for constraint 1, the allowable range can be obtained as: [732469-82333.56818, 732469+∞] = [650135.43182, ∞], indicating that if the change is within [650135.432, ∞], then the solution from the original linear programming is still feasible. When considering constraint 4, its allowable range is calculated as [183117.25-16866.03049, 183117.25+41155.20509] =

[166251.21951, 224272.45509], so that if the change goes beyond this range, then the shadow price of constraint 4 is affected.

Based on the sensitivity analysis, the constraints for the total cost of the desktop advertisements groups, and the sum of the CTR of mobile advertisement groups, can be relaxed as to improve optimal objective value.

6. Data Visualization and Interpretation

Optimal advertisement strategy allocation
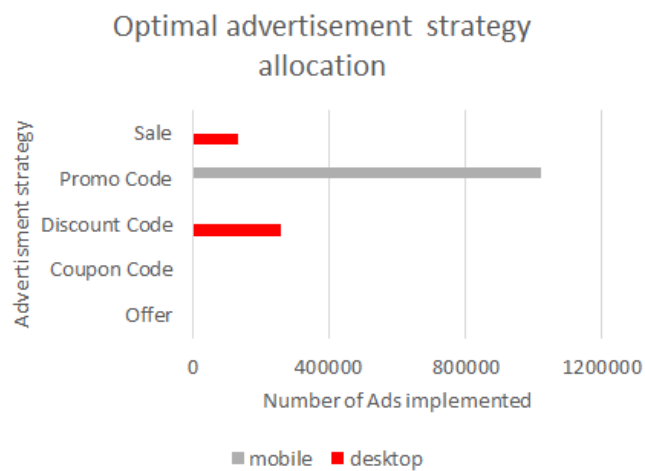
£650135

Minimised total cost when optimal advertisement allocation implemented

Budget alloaction mobile vs desktop
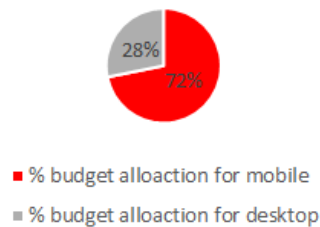
% of total budget remaining after optimal allocation
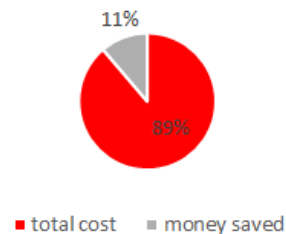
1:1 Destop Discount Code Unit cost change
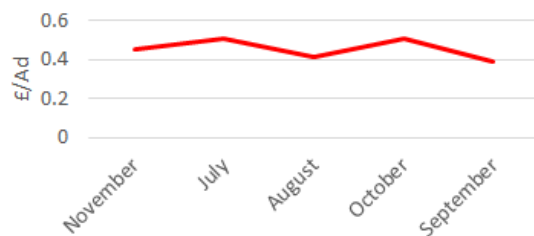
1:1 Desktop Sale Unit cost change
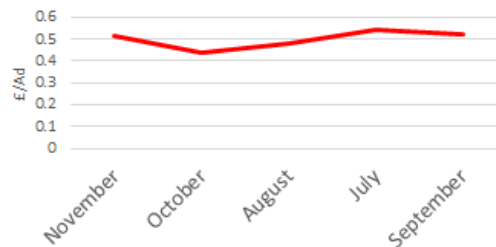
1:1 Mobile Promo Code Unit cost change
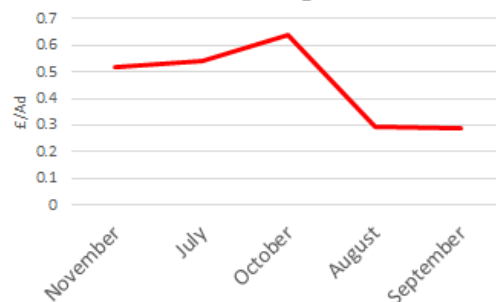
The dashboard above shows bold contrasting colours to make the visuals clear and comprehensible. Additionally, the 1:1.5 rule has been used for font sizing to make the graphs legible and easy to understand.

The top left of the dashboard shows the results in a horizontal bar chart that displays the most efficient budgetary allocation whilst remaining within the constraints. The choice to use a horizontal bar chart was done in order to best display the stark differences that were found between the mobile and desktop strategies when considering optimal advertisement group allocation. The total minimized cost is shown as the largest figure on the dashboard as it gives a concise overview of the projected cost of this project and the result of the objective function.

The two pie charts further break down the budgetary analysis and show how this solution meets the functional constraints set in the LP model. The trio of line graphs display the relevant advertising groups 'unit cost' over their implementation period which enhances a cost breakdown for the optimal allocation in the DSS.

7. Reflection

Mintel is currently hiring a technical leader within their global data science and analytics teams (Holloway, 2024). The role requires many skills, some of which were acquired during this course, and highlights areas where further exploration into data analytics is required.

This course emphasized skills in both the technical and interpersonal arenas. This course furthered an understanding of analytics and linear formulation, using both excel and SQL as an external medium for more advanced calculations. These skills are mentioned in the job posting as required qualities, and this course has provided the foundation for success in these areas. The job listing also mentions that this is a client facing role and excellent communication and presentation skills are required. A large part of this course's curriculum was based around a group project where skills in teamwork, efficiency and cooperation were fostered through weekly meetings, presentations, and consistent progress check-ins.

Further skills required that are not covered in the course for a role such as the one advertised include a proficiency in Python and another BI tool such as Locker development. Python uses a different coding language to anything required in this project, and therefore may need further experience or qualification to gain proficiency in. An optional supplementary course such as the PCAP by the Python Institute (REFERENCE) may allow such skills to be developed in order for a candidate to be more suited to such a role in the field of Data Analytics.

Overall, this project has formed a foundation for success in a career in the field of Business Analytics and provides students a data science core that can carry into their future career. Skillsets such as presentation abilities, data visualisation, MySQL and proficiency in Excel are all vital for a career in the data dependent future.

References

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Marcello, D. (2022) *Shopping mall paid search campaign dataset*, *Kaggle*. Available at:
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Appendices

Full dataset

Ad Group	Month	Impressions	Clicks	Conversions	Conv Rate	Cost	Revenue	Sale Amount	P&L	CTR	CPC
Shop - 1:1 - Desk - Coupon Code	November	38523	14393	2713	0.12	18641	16555	345891.4	-2086.3	0.37	1.3
Shop - 1:1 - Desk - Coupon Code	July	16038	6504	1166	0.1	6669	6402	136770.1	-267.086	0.41	1.23
Shop - 1:1 - Desk - Coupon Code	August	12790	4983	897	0.1	6123	5590	123475.5	-532.537	0.4	1.23
Shop - 1:1 - Desk - Coupon Code	October	10826	4021	725	0.1	4812	4627	96617	-184.857	0.4	1.2
Shop - 1:1 - Desk - Coupon Code	September	9759	3904	593	0.08	4949	3973	87840.47	-975.676	0.4	1.27
Shop - 1:1 - Desk - Discount Code	November	73448	25283	4080	0.1	27336	23857	497790.8	-3478.64	0.42	1.08
Shop - 1:1 - Desk - Discount Code	July	36462	14367	2188	0.09	13746	13262	283215.2	-483.951	0.42	1.21
Shop - 1:1 - Desk - Discount Code	August	28499	10141	1509	0.08	10586	8859	192105.7	-1727.14	0.4	1.04
Shop - 1:1 - Desk - Discount Code	October	24598	8693	1421	0.09	9461	8186	171724.6	-1274.75	0.42	1.21
Shop - 1:1 - Desk - Discount Code	September	20879	8135	1034	0.07	8069	6153	132508.1	-1915.53	0.39	0.99
Shop - 1:1 - Desk - Offer	November	7254	2725	512	0.11	3182	3227	66672.29	45.468	0.38	1.17
Shop - 1:1 - Desk - Offer	July	3635	1458	248	0.09	1606	1723	39165.46	117.136	0.4	1.1
Shop - 1:1 - Desk - Offer	August	2938	1111	197	0.09	1571	1203	27608.55	-368.016	0.38	1.41
Shop - 1:1 - Desk - Offer	October	2336	855	173	0.1	1081	1179	25104.24	97.764	0.37	1.27
Shop - 1:1 - Desk - Offer	September	2163	866	139	0.08	1165	1073	24921.42	-92.089	0.4	1.35
Shop - 1:1 - Desk - Promo Code	November	64067	23538	5782	0.15	37729	34518	725773.9	-3211.12	0.37	1.3
Shop - 1:1 - Desk - Promo Code	July	26185	10418	2294	0.12	13278	13042	284823.5	-235.921	0.4	1.27
Shop - 1:1 - Desk - Promo Code	August	19648	7673	1622	0.11	11235	9928	216628.5	-1307.27	0.39	1.3
Shop - 1:1 - Desk - Promo Code	October	16953	6484	1499	0.12	10080	9553	210096.1	-527.249	0.38	1.25
Shop - 1:1 - Desk - Promo Code	September	15673	6199	1242	0.11	9163	7264	158674.1	-1899.42	0.4	1.3
Shop - 1:1 - Desk - Sale	November	2506	708	137	0.12	1039	910	19932.69	-129.125	0.35	1.47
Shop - 1:1 - Desk - Sale	October	965	280	59	0.12	422	446	9021.68	24.122	0.29	1.51
Shop - 1:1 - Desk - Sale	August	745	240	52	0.11	343	346	7835.88	3.171	0.32	1.5
Shop - 1:1 - Desk - Sale	July	808	282	61	0.15	391	337	7717.77	-53.604	0.35	1.55
Shop - 1:1 - Desk - Sale	September	548	200	39	0.11	279	251	5241.81	-28.119	0.36	1.45
Shop - 1:1 - Mob - Coupon Code	November	99258	42283	4349	0.08	24149	24071	500400.9	-77.73	0.43	1.27
Shop - 1:1 - Mob - Coupon Code	July	46507	21756	1665	0.05	13157	8550	185824.5	-4606.71	0.27	1.16
Shop - 1:1 - Mob - Coupon Code	October	28102	12485	1393	0.07	7192	7955	166656.1	762.921	0.34	1.28
Shop - 1:1 - Mob - Coupon Code	August	34189	13905	1218	0.06	8146	6766	148681.2	-1380.32	0.41	1.29
Shop - 1:1 - Mob - Coupon Code	September	26710	11918	921	0.05	6628	5604	124194.9	-1023.59	0.45	1
Shop - 1:1 - Mob - Discount Code	November	276568	99526	5961	0.05	38273	32668	677188.1	-5605.3	0.36	1.38
Shop - 1:1 - Mob - Discount Code	October	93406	36068	2444	0.05	12236	13744	285638.3	1507.685	0.39	1.34
Shop - 1:1 - Mob - Discount Code	July	152394	59177	2666	0.04	19371	13699	294536.9	-5672.27	0.39	1.13
Shop - 1:1 - Mob - Discount Code	August	105966	32005	1530	0.04	10713	8473	185757.9	-2240.08	0.3	1.33
Shop - 1:1 - Mob - Discount Code	September	90806	40622	1421	0.03	10904	7891	170418.9	-3012.91	0.45	1.27
Shop - 1:1 - Mob - Offer	November	18275	8012	808	0.07	5651	4773	99420.38	-877.986	0.44	1.1
Shop - 1:1 - Mob - Offer	July	9950	4283	347	0.05	2637	2038	46026.32	-598.993	0.43	1.3
Shop - 1:1 - Mob - Offer	October	5789	2510	269	0.07	1546	1889	40122.76	342.979	0.34	1.1
Shop - 1:1 - Mob - Offer	August	7591	2523	216	0.05	1590	1591	35605.11	1.36	0.33	1.1
Shop - 1:1 - Mob - Offer	September	5471	2169	170	0.05	1302	1153	25744.04	-149.243	0.4	1.23
Shop - 1:1 - Mob - Promo Code	November	138811	57405	7563	0.1	43542	42440	886095.3	-1101.9	0.41	1.26
Shop - 1:1 - Mob - Promo Code	July	57373	27121	2940	0.07	16946	14565	321387.9	-2380.62	0.47	1.15
Shop - 1:1 - Mob - Promo Code	October	34929	15595	2193	0.09	11258	12025	252296.3	766.859	0.45	1.42
Shop - 1:1 - Mob - Promo Code	August	40627	17655	1968	0.07	12262	10303	230817.8	-1958.96	0.43	0.69
Shop - 1:1 - Mob - Promo Code	September	32462	14427	1510	0.06	9562	8838	196210.9	-724.153	0.44	0.66
Shop - 1:1 - Mob - Sale	November	5828	1975	214	0.09	1118	1121	22936.4	3.104	0.4	1.17
Shop - 1:1 - Mob - Sale	July	1875	706	69	0.07	485	409	8946.99	-75.734	0.45	1.19
Shop - 1:1 - Mob - Sale	October	1706	676	72	0.07	412	372	7875.81	-40.219	0.4	1.21
Shop - 1:1 - Mob - Sale	August	1489	472	61	0.08	347	295	6494.87	-52.103	0.4	1.14
Shop - 1:1 - Mob - Sale	September	1255	439	38	0.06	272	207	4232.7	-64.595	0.35	1.32
Shop - Exact - Desk - Coupon Code	November	18526	5553	919	0.1	5982	6047	129556.9	64.552	0.3	1.08
Shop - Exact - Desk - Coupon Code	July	8053	2678	392	0.08	2814	2475	56017.16	-348.63	0.5	1.05
Shop - Exact - Desk - Coupon Code	August	6244	2020	327	0.09	2267	2115	51885.05	-151.631	0.45	1.12
Shop - Exact - Desk - Coupon Code	October	5044	1555	267	0.1	1734	1654	34980.16	-79.595	0.31	1.12
Shop - Exact - Desk - Coupon Code	September	5304	1702	216	0.07	1912	1451	34236.93	-461.198	0.42	1.12
Shop - Exact - Desk - Discount Code	November	7365	1348	164	0.09	1315	1061	22711.98	-253.801	0.31	0.98
Shop - Exact - Desk - Discount Code	August	2263	556	74	0.13	627	516	11853.27	-111.385	0.35	1.13
Shop - Exact - Desk - Discount Code	October	1770	412	79	0.11	488	481	11375.79	-7.255	0.4	1.19
Shop - Exact - Desk - Discount Code	July	2181	539	70	0.08	577	449	10689.01	-128.102	0.44	1.07
Shop - Exact - Desk - Discount Code	September	1650	432	48	0.06	457	406	9718.82	-50.676	0.39	1.06
Shop - Exact - Desk - Offer	November	2760	434	71	0.12	553	496	1027.61	-56.945	0.25	1.28
Shop - Exact - Desk - Offer	August	613	163	39	0.12	329	274	5752.61	-54.539	0.4	1.02
Shop - Exact - Desk - Offer	September	628	148	21	0.09	240	202	4050.38	-37.973	0.35	1.4
Shop - Exact - Desk - Offer	October	649	151	25	0.12	282	165	3293.63	-117.279	0.4	1.2
Shop - Exact - Desk - Offer	July	490	115	26	0.12	221	149	3058.02	-71.829	0.33	1.3
Shop - Exact - Desk - Promo Code	November	25592	7726	1731	0.14	10914	11223	236665.6	308.975	0.3	1.41
Shop - Exact - Desk - Promo Code	August	6561	2328	498	0.11	3467	3316	78661	-150.503	0.35	1.29
Shop - Exact - Desk - Promo Code	October	6254	2064	456	0.12	3012	3180	69872.95	168.373	0.33	1.23
Shop - Exact - Desk - Promo Code	July	7366	2693	536	0.11	3469	3089	68146.26	-380.31	0.37	1.2
Shop - Exact - Desk - Promo Code	September	5480	2003	371	0.1	2984	3013	73096.84	29.101	0.37	1.49
Shop - Exact - Desk - Sale	November	19335	1689	85	0.06	422	422	8962.23	-696.152	0.39	1.66
Shop - Exact - Desk - Sale	July	6318	598	46	0.07	416	278	5552.73	-138.325	0.28	0.7
Shop - Exact - Desk - Sale	September	9989	1176	43	0.05	574	249	4979.44	-325.007	0.42	1.29
Shop - Exact - Desk - Sale	October	7385	756	37	0.07	447	198	3967.4	-248.605	0.23	1.59
Shop - Exact - Desk - Sale	August	3187	341	24	0.04	273	162	3895.73	-110.746	0.45	0.8
Shop - Exact - Mob - Coupon Code	November	54501	19058	1345	0.05	9302	8134	171895.9	-1168.01	0.35	1.49
Shop - Exact - Mob - Coupon Code	July	27672	9335	478	0.04	4105	2783	62357.68	-1321.61	0.34	1.23
Shop - Exact - Mob - Coupon Code	October	15769	6046	440	0.05	2318	2655	55815.23	337.125	0.38	1.38
Shop - Exact - Mob - Coupon Code	August	16969	5126	340	0.05	2176	1992	44234.46	-184.295	0.3	1.42
Shop - Exact - Mob - Coupon Code	September	16362	5876	302	0.04	2199	1970	44401.87	-229.336	0.36	0.37
Shop - Exact - Mob - Discount Code	November	20699	5540	320	0.05	2893	2003	44985.83	-890.164	0.27	1.52
Shop - Exact - Mob - Discount Code	October	4715	1397	93	0.05	615	587	12245.37	-27.854	0.3	1.44
Shop - Exact - Mob - Discount Code	August	3973	933	52	0.04	406	470	11817.23	64.046	0.4	1.44
Shop - Exact - Mob - Discount Code	September	4224	1181	54	0.03	519	327	6664.23	-192.354	0.45	1.44
Shop - Exact - Mob - Discount Code	July	6278	1506	59	0.03	817	313	6420.67	-504.332	0.24	0.54
Shop - Exact - Mob - Offer	November	6838	1235	85	0.07	641	676	14020.86	34.512	0.3	1.11
Shop - Exact - Mob - Offer	October	1408	463	42	0.07	290	295	6331.84	5.253	0.33	1.33
Shop - Exact - Mob - Offer	July	1029	256	24	0.07	212	208	4425.49	-3.509	0.4	1.22
Shop - Exact - Mob - Offer	August	986	248	24	0.06	177	162	3563.44	-14.789	0.32	1.22
Shop - Exact - Mob - Offer	September	1288	340	20	0.04	239	143	2960.84	-96.196	0.26	1.45
Shop - Exact - Mob - Promo Code	November	51335	19009	2095	0.08	12189	12145	256314.9	-44.189	0.37	1.64
Shop - Exact - Mob - Promo Code	October	13525	5656	621	0.07	3435	3487	74522.54	51.685	0.42	1.61
Shop - Exact - Mob - Promo Code	July	17771	6635	590	0.06	4404	3444	78127.29	-959.718	0.37	1.66
Shop - Exact - Mob - Promo Code	August	13488	4605	435	0.06	2884	2678	60074.53	-205.997	0.2	1.2
Shop - Exact - Mob - Promo Code	September	10938	4247	343	0.05	2486	2410	57157.19	-76.263	0.39	0.59
Shop - Exact - Mob - Sale	November	15422	2078	62	0.03	2597	427	8733.41	-2170.04	0.13	1.25
Shop - Exact - Mob - Sale	July	9812	1008	42	0.04	413	202	4242.7	-210.844	0.45	1.41
Shop - Exact - Mob - Sale	August	3884	565	27	0.04	229	173	3888.51	-55.92	0.44	1.41
Shop - Exact - Mob - Sale	September	8902	661	25	0.04	216	173	4259.42	-42.99	0.32	1.33
Shop - Exact - Mob - Sale	October	8454	726	26	0.04	277	115	2300.72	-161.951	0.27	0.9
Shop - Phrase - Desk - Coupon Code	July	9751	3402	579	0.1	3792	3547	75564.22	-244.797	0.35	1.11
Shop - Phrase - Desk - Coupon Code	November	7475	1977	382	0.12	2616	2368	50293.23	-248.203	0.26	1.32
Shop - Phrase - Desk - Coupon Code	August	5283	1632	226	0.08	1767	1455	33678.17	-312.263	0.51	1.08
Shop - Phrase - Desk - Coupon Code	September	3255	1077	166	0.08	1413	1391	35526.39	-22.432	0.33	1.31
Shop - Phrase - Desk - Coupon Code	October	1398	361	58	0.09	407	340	7222.9	-66.82	0.26	1.13
Shop - Phrase - Desk - Discount Cod	November	6200	975	108	0.08	1102	844	19822.4	-257.638	0.16	1.13
Shop - Phrase - Desk - Discount Cod	October	1074	190	22	0.07	190	184	4345.15	-6.287	0.36	1.23
Shop - Phrase - Desk - Discount Cod	September	810	123	17	0.09	134	121	2514.88	-12.744	0.55	1.09
Shop - Phrase - Desk - Discount Cod	August	1088	159	15	0.06	163	87	1955.08	-76.294	0.45	1.4
Shop - Phrase - Desk - Discount Cod	July	1062	147	13	0.06	135	67	1682.55	-68.055	0.14	1.92
Shop - Phrase - Desk - Offer	November	12209	1663	182	0.1	1600	1164	25635.15	-435.967	0.14	1.3
Shop - Phrase - Desk - Offer	October	2065	427	73	0.11	499	472	9859.2	-27.457	0.55	1.17
Shop - Phrase - Desk - Offer	September	1498	377	55	0.09	546	303	6071.61	-242.84	0.34	1.5
Shop - Phrase - Desk - Offer	August	618	149	25	0.09	182	106	2205.34	-76.222	0.44	1.23
Shop - Phrase - Desk - Offer	July	389	54	10	0.19	58	63	1264.52	5.229	0.14	1.09
Shop - Phrase - Desk - Promo Code	November	39649	8281	1640	0.13	10823	10223	215898.8	-600.456	0.3	1.31
Shop - Phrase - Desk - Promo Code	July	5919	1954	408	0.12	2396	2400	50958.58	3.585	0.33	1.23
Shop - Phrase - Desk - Promo Code	October	6908	1874	337	0.1	2325	2329	49148.43	-4.066	0.4	1.24
Shop - Phrase - Desk - Promo Code	August	4729	1635	315	0.11	2229	2010	44479.12	-218.804	0.35	1.36
Shop - Phrase - Desk - Promo Code	September	3939	1321	205	0.09	1845	1678	40606.65	-166.708	0.34	1.4
Shop - Phrase - Desk - Sale	August	6770	629	37	0.06	486	240	5356.52	-245.86	0.28	0.77
Shop - Phrase - Desk - Sale	July	8180	593	34	0.07	426	232	4631.94	-194.385	0.35	1.72
Shop - Phrase - Desk - Sale	November	10262	667	30	0.05	386	165	3302.8	-220.842	0.44	1.2
Shop - Phrase - Desk - Sale	September	6314	526	26	0.06	400	157	3144.2	-242.776	0.38	1.76
Shop - Phrase - Desk - Sale	October	3023	228	14	0.06	172	108	2152.46	-64.371	0.33	0.76
Shop - Phrase - Mob - Coupon Code	July	18457	6762	380	0.04	3660	2262	49153.07	-1397.73	0.37	1.54
Shop - Phrase - Mob - Coupon Code	September	6231	2152	143	0.04	1096	947	20744.22	-149.269	0.35	1.51
Shop - Phrase - Mob - Coupon Code	August	8203	2504	146	0.04	1148	851	19110.69	-297.275	0.31	1.46
Shop - Phrase - Mob - Coupon Code	November	6765	1844	88	0.04	861	573	13341.64	-288.085	0.27	1.47
Shop - Phrase - Mob - Coupon Code	October	2524	819	82	0.07	418	535	10694.68	116.783	0.32	0.51
Shop - Phrase - Mob - Discount Code	November	24726	5216	277	0.05	2916	1981	42318.64	-935.295	0.4	0.56
Shop - Phrase - Mob - Discount Code	July	3323	752	43	0.05	316	498	10932.34	181.597	0.23	1.42
Shop - Phrase - Mob - Discount Code	September	1848	447	28	0.05	217	179	3765.3	-38.448	0.43	1.49
Shop - Phrase - Mob - Discount Code	August	1303	233	9	0.03	111	51	1025.91	-59.699	0.4	1.48
Shop - Phrase - Mob - Discount Code	July	1813	264	4	0.01	138	21	419.62	-117.017	0.4	1.53
Shop - Phrase - Mob - Offer	November	31793	7159	532	0.08	5075	3260	66443.24	-1814.56	0.23	1.2
Shop - Phrase - Mob - Offer	October	3279	952	61	0.06	468	423	8585.47	-45.085	0.36	1.49
Shop - Phrase - Mob - Offer	September	2018	621	45	0.05	373	308	6807.69	-65.172	0.4	1.6
Shop - Phrase - Mob - Offer	August	689	172	13	0.05	89	57	1226.22	-31.685	0.4	1.1
Shop - Phrase - Mob - Offer	July	593	109	3	0.04	52	8	168.54	-43.571	0.36	1.1
Shop - Phrase - Mob - Promo Code	November	50422	10147	773	0.06	5764	4472	92805.77	-1291.91	0.2	1.57
Shop - Phrase - Mob - Promo Code	July	9838	3509	282	0.06	2562	1836	41275.06	-725.722	0.36	1.5
Shop - Phrase - Mob - Promo Code	August	7040	2407	214	0.06	1430	1373	31563.25	-56.691	0.4	1.23
Shop - Phrase - Mob - Promo Code	October	9619	2908	199	0.05	1476	1211	25311.15	-265.424	0.4	1.3
Shop - Phrase - Mob - Promo Code	September	4655	1583	110	0.05	826	753	16455.92	-72.812	0.34	1.3
Shop - Phrase - Mob - Sale	August	7044	947	35	0.04	401	285	5960.76	-116.499	0.3	1.42
Shop - Phrase - Mob - Sale	July	17807	2054	35	0.03	981	262	5531.15	-718.568	0.3	1.48
Shop - Phrase - Mob - Sale	September	6444	593	27	0.05	231	221	5500.5	-9.519	0.34	1.39
Shop - Phrase - Mob - Sale	October	4894	551	24	0.05	226	122	2612.68	-104.006	0.34	1.41
Shop - Phrase - Mob - Sale	November	13056	927	20	0.03	376	76	1518.51	-300.066	0.34	1.41

Brainstorming Session Record

- Week 2-5
    1. At the start, we knew we wanted our DSS to be based around online advertising, as we all agreed this would be a relevant and current solution to real world problem. We first discussed the different ways in which the performance of online advertising could be measured, and after our first meeting decided to try and focus our project on the revenue maximisation of from online advertising for an airline.
    2. But after that, we met some problem around the topics. Firstly, we realised that trying to measure revenue maximisation from online advertising came with some issues. But we then realised that optimising revenue and online advertising would actually require 2 different models as they are separate topics and so this idea is inappropriate for our DSS. After discussions with the professor and trial and error we decided that the best step forward would be to focus on cost minimisation. The next main problem we had was the access to data. The only database we could find that had relevant data on all the parameters we wanted to discuss was based on shopping malls rather than airlines. We considered adjusting this data set to fit our model but decided against it for a number of reasons, mainly due to the different demographics between airline passengers and shopping mall customers.

- Week 6 -11
    1. At this point, we decided to our original idea that focused on online advertising for an airline was not viable, as the data we would need for this model was not available. Since we had already found a data set covering all the parameters we wanted to use, we decided to apply our model to online advertising for a shopping mall instead. Our current objective is therefore minimising online marketing costs for a shopping mall, and we are now on the correct pathway.