Optimizing Wedding Venue Selection Process Using Integer Programming

Luis Rodriguez

University of Nebraska at Omaha, lrodriguez2@unomaha.edu

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Optimizing Wedding Venue Selection Process Using Integer Programming

Thesis by
Luis Rodriguez

In Fulfillment of the Requirements for the
University Honors Program Thesis/Capstone/Creative Project

DEPARTMENT OF MATHEMATICAL AND STATISTICAL SCIENCES
UNIVERSITY OF NEBRASKA AT OMAHA
ADVISOR: DR. FABIO VITOR

May 2023
Choosing the right wedding venue can be extremely difficult for the unsuspecting engaged couple. There is a myriad of variables that must be taken into account prior to the illustrious wedding date; these variables include the option for a reception, the location, and food requirements, to name a few. Consequently, the typical couple seems to spend multiple months researching and visiting many wedding spaces. However, even though months go into planning, it still is not a guarantee that all variables are accounted for. Furthermore, without a wedding planner, these couples may second-guess their chosen site due to seemingly arduous issues with their venue. Even when a wedding planner is available, their services can be extremely expensive, and this still does not guarantee the perfect wedding; these issues add a layer of difficulty to the wedding planning process—due to the differing values of couples. This project aims to use a mathematical framework to model and generalize the wedding venue selection process. The resulting model can be used to model the venue selection process in the future and help the planning process become more efficient and repeatable. The model follows numerous constraints in order to maximize the utility gained by the author and his fiancé. This model is implemented on the IBM ILOG CPLEX Optimization Studio. The results from this model provide an optimal wedding venue and the number of guests that should be invited.
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Chapter 1

INTRODUCTION

In March of 2021, the author, Luis, proposed to his now fiancé, Madi. They did not fully anticipate the amount of work involved in wedding planning. After many months of researching various wedding locations, they put a deposit down on a venue. Unexpectedly, just a few months later, their chosen reception space was permanently closing, and they were back at square one. Although they were initially disappointed, they realized that this was a blessing in disguise. The venue they selected seemed too expensive for the amenities it offered, so Luis took his circumstances as an opportunity to optimize his wedding.

1.1 Description of Problem

When a typical couple selects their dream wedding location, they tend to focus on the visual appeal and some other miscellaneous features. When a venue is selected in this way, there is minimal (if any) optimization that can be included in the decision-making process. The main way that a modern couple could optimize their search is by enlisting a wedding planner. A wedding planner is the closest way to getting an optimal venue since they have industry experience in the local community and line your vision with previous couples’ final products. The downfall to using a wedding planner is that there is no guarantee that they will choose the best venue; additionally, they can be very expensive with the average wedding planner in the United States costing roughly $1,700 (Forrest, 2022).

1.2 Purpose of Paper

This paper will discuss the development and implementation of a mathematical framework to solve this problem. Operations research, the field of mathematics involving optimization, will be used in order to generalize and abstract the selection process. This project will attempt to optimize Luis’ own wedding venue selection process by building a mathematical optimization model. The model will attempt to minimize cost while maximizing Luis and Madi’s happiness at the selected venue.
1.3 Organization of Paper

The remainder of this paper is as follows: Chapter 2 describes a literature review. Chapter 3 briefly discusses the reasoning behind the selected parameters for the model and describes the factors that Luis and Madi deemed most important when selecting a venue. Chapter 4 details the mathematical model extensively and each of its components, including the parameters, decision variables, objective function, and constraints. Chapter 5 gives the results of such implementation and alternative solutions. Finally, Chapter 6 concludes the paper and discusses future work that can be done to expand this research.
CHAPTER 2

LITERATURE REVIEW

The literature review section of this paper extensively covers the research findings on the wedding planning process. Throughout the review, it was discovered that there is a myriad of research on the attributes that couples consider when selecting the optimal wedding venue. Research on attributes affecting a couple’s optimal wedding venue selection extends globally. The literature review will focus on research studies examining the most important attributes affecting a couple’s venue selection preferences. It will cover research studies from three primary regions: the United States, Africa (South Africa & Egypt), and Eastern Asia (China, Hong Kong, and Indonesia).

2.1 United States

Myung & Smith (2018) researched the preferences of Millennial women regarding the wedding venue selection process. Religious spaces were the most popular options for ceremonies; hotels (with banquet areas) were the most popular for receptions. Additionally, they determined that Pinterest was one of the most effective ways for companies to “interact with Millennial women regarding wedding-related information, inspiration, products, and services”. This article was an extremely valuable insight into the intricate wedding planning process. Even though research on essential attributes in the wedding venue selection process exists, to the best of the author’s knowledge, there does not appear to be literature on a generalized, repeatable process to select a location for a wedding.

2.2 Africa

According to Daniels, et. al (2012), the authors intended to look at the decisions that influence couples’ selection of a wedding site. Additionally, the authors ranked the importance of an assortment of variables regarding this selection process—these include the following: price, location, and access to the venue. These results were supported by principal component analysis. Additionally, Van der Baan (2019) gave an in-depth look into consumer behavior in the South African wedding industry. After analyzing this complex industry, the author enacted an empirical study examining the main metrics that couples search for in a wedding location. To determine these, the author utilized various statistical tests, including ANOVA and t-tests. They concluded that couples mainly consider the accessibility of the location and the cleanliness/status of the venue.
Mahmoud (2015) also studied the wedding venue attribute selection process. Mahmoud’s abstract starts by making the claim that “while the festive events industry attracted researchers in the last decades, there is a shortage of studies focusing on wedding venue attributes selection.” It is clear from this literature review that Mahmoud’s claim is false as it pertains to global research on attributes affecting wedding venue selection. However, this does not take away from Mahmoud’s findings, as they corroborate the research discussed previously and extends the findings to Egypt. Mahmoud’s research aimed to examine Egyptian newlywed couples’ perceptions of wedding venues in Alexandria, Egypt. His study focused on the following factors: price, food and beverages, atmosphere, entertainment, facilities, location, availability, and decoration. Mahmoud found that all nine factors were significantly related to a couple’s satisfaction; more specifically, women had a greater preference for the attributes when compared to men. Moreover, it is important to keep in mind that all of the research studies in this literature review only take heterosexual marriages into account, so there may be future research opportunities to conduct any of these studies on non-heterosexual wedding processes.

2.3 Eastern Asia

Semesta, Fahmi, and Jahroh (2020) studied the wedding venue selection process from the vendors’ perspective in Indonesia. It tried to find marketing opportunities for vendors who want to attract more couples to their venues. Specifically, they aimed to find “an effective marketing strategy for wedding vendors in influencing consumer purchasing decisions.” The researchers found that some of the most important factors affecting a couple’s venue decision were the price, location, and the venue’s promotion.

Guan et al. (2015) delved into some push and pull factors that couples consider when selecting a wedding venue. More specifically, they conducted a study in the Chonqing metropolitan area in China. They determined that the budget, atmosphere of the venue, wedding services, service quality, transportation, and facilities were the most important aspects of a venue. A majority of those surveyed stated that their ideal budget was between $8,131 and $16,260. When explaining these results, Guan et al. stated “when a couple selects a venue for their wedding banquet, they might select a place that reflects their personalities and ensure the physical and emotional comfort of the guests.” These results were consistent with past research, but the authors stated that they would like to have further studies in rural areas of China—since their study focused on people in Chonqing.

Conversely, Lau & Hui (2010) conducted a study to determine important aspects of a wedding venue for newlyweds in Hong Kong. They found that one of the most important attributes is the quality of service given by staff. More specifically, Lau & Hui state that the staff’s attitude is
extremely relevant in the wedding venue selection process. They determined that other important attributes include cleanliness and the quality of food served. The authors created a decision-making model that those in Hong Kong follow when selecting a wedding venue. This is represented in a flowchart (see Figure 2.1) that takes demographic differences and intrinsic and extrinsic attributes. Lau & Hui (2010) suggest that these results should be replicated using a larger sample, and they also hope to conduct a longitudinal study on the same topic in the future. As such, this project attempts to create such a framework. The following section will discuss current methods for selecting the ideal wedding location.

Source: Lau & Hui (2010)

Figure 2.1: Hong Kong Decision-Making Model.
DATA COLLECTION PROCESS

As stated in the literature review, past research suggests that the most important attribute that couples consider when selecting a wedding venue is proximity and aesthetics. Therefore, it was important to allow the couple to narrow down the list of wedding venues manually. As a result, before the mathematical model was created for this project, Luis contacted a variety of wedding venues. A majority of these companies were connected through a wedding planning website—TheKnot.com—and the services that they provided were given. Once the information was gathered on over fifty wedding venues, this list needed to be reduced. As such, it was mainly narrowed down by focusing on the overall appearance and ambiance. This was done at the discretion of Luis and his fiancé to account for the aesthetic attribute stated in the literature review. The next step was to quantify the variables so that they could be compared.

3.1 Conversion of Categorical Variables to Quantitative Variables

To account for non-quantitative preferences, monetary values were assigned to each categorical variable. The creation of the mathematical model started by deciding which factors mattered the most. The following variables were created for this purpose, and include (but are not limited to): catering options, location, ceremony options, the number of guests, etc. Utility means the happiness or satisfaction gained from something. The utility for each categorical variable was based on a monetary value determined by the willingness to pay for the amenity.

When hosting a wedding, attendance is paramount, so Luis decided that the most important variable was the number of guests. For the first 25 guests, the assigned utility value was $1200. For each tranche of 25 guests thereafter, the marginal utility decreased by $75, up to 300 guests. As seen in Table 3.1, the marginal utility for each additional guest over 300 guests is 0.

Table 3.1: Marginal Utility (Willingness to Pay) for Each Set of 25 Guests.

<table>
<thead>
<tr>
<th>Number of Guests</th>
<th>0-25</th>
<th>26-50</th>
<th>...</th>
<th>251 - 275</th>
<th>276 - 300</th>
<th>301+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginal Utility</td>
<td>$900</td>
<td>$825</td>
<td>...</td>
<td>$150</td>
<td>$75</td>
<td>$0</td>
</tr>
</tbody>
</table>

The second most important variable was the location, as Luis and Madi would be willing to pay $500 to have a venue in their hometown. Thus, for each venue in Omaha, the location utility value was $500. The further a venue was from Omaha, the lower its location utility, as seen in Table 3.2.
Table 3.2: *Utility for Each Location.*

<table>
<thead>
<tr>
<th>Location</th>
<th>Utility (Willingness to Pay)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omaha</td>
<td>$500</td>
</tr>
<tr>
<td>Valley</td>
<td>$475</td>
</tr>
<tr>
<td>Bellevue</td>
<td>$450</td>
</tr>
<tr>
<td>Fremont</td>
<td>$375</td>
</tr>
<tr>
<td>Louisville</td>
<td>$300</td>
</tr>
<tr>
<td>Plattsmouth</td>
<td>$250</td>
</tr>
<tr>
<td>Lincoln</td>
<td>$200</td>
</tr>
<tr>
<td>Union</td>
<td>$50</td>
</tr>
</tbody>
</table>

The third and fourth most important variables were the ability to cater (catering options) and ceremony availability (ceremony options); these two variables were given utility values of $150 and $100, respectively. To view all data, refer to Tables A.2 through A.4. For a full list of variable names and descriptions, refer to Table A.1.
Chapter 4

MATHEMATICAL MODEL

This project utilizes an integer program, which is defined as

\[
\begin{align*}
\text{maximize} & \quad z = c^T x \\
\text{subject to} & \quad Ax \leq b, \\
& \quad x \geq 0, \\
& \quad x \in \mathbb{Z}^n
\end{align*}
\]

where \( c \in \mathbb{R}^n, b \in \mathbb{R}^m \) are vectors and \( A \in \mathbb{R}^{m \times n} \) is a matrix. \( A, b, \) and \( c \) represent the parameters (inputted data), \( x \) represents the decision variables (choices to be made), \( z = c^T x \) represents the objective function (the aim of the model), and \( Ax \leq b \) along with \( x \geq 0 \) and \( x \in \mathbb{Z}^n \) represent the constraints (restrictions on the model). When an optimal solution is reached, the decision variables represent the values that satisfy all of the constraints and provide the best value for the objective function.

Sections 4.1 through 4.4 outline the specified ranges, parameters, decision variables, objective function, and constraints for this problem. Figure A.1, Figure A.2, and Figure A.3 in the Appendix outline the implementation of the code on the IBM ILOG CPLEX Optimization Studio.

4.1 Ranges

The ranges define countable sets that are used to generalize the model. Two ranges are used in this model.

Ranges

- Let the set of all venues be defined by \( V = \{1, 2, \ldots, 30\} \).
- Let the number of guests at the wedding, in sets of 25, be defined by \( D = \{1, 2, \ldots, 12\} \) as illustrated in Table 4.1.

<table>
<thead>
<tr>
<th>D</th>
<th>1</th>
<th>2</th>
<th>...</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Guests</td>
<td>&gt;25</td>
<td>&gt;50</td>
<td>...</td>
<td>&gt;275</td>
<td>&gt;300</td>
</tr>
</tbody>
</table>

Table 4.1: Map of Range D.
4.2 Parameters

Parameters are the inputted, known data in the model. The variables that contain "..." in their IBM ILOG CPLEX Optimization Studio code were read through a Microsoft Excel spreadsheet. Figure 4.3 is the IBM ILOG CPLEX Optimization Studio code that reads the parameters from the Microsoft Excel spreadsheet. Furthermore, Figures A.4 and A.5 show the entire Microsoft Excel spreadsheet containing the data. In this model, there are 16 parameters.

```plaintext
SheetConnection mySheet("C:\\Users\\Luis Rodriguez\\Desktop\\DTRM OR\\Thesis\\HonorsThesis.xlsx");
x from SheetRead(mySheet, "maxGuest");
c from SheetRead(mySheet, "baseCost");
f from SheetRead(mySheet, "foodPref");
r from SheetRead(mySheet, "H2");
m from SheetRead(mySheet, "foodMin");
p from SheetRead(mySheet, "FoodGuest");
b from SheetRead(mySheet, "bevMin");
a from SheetRead(mySheet, "bevGuest");
l from SheetRead(mySheet, "locUtility");
s from SheetRead(mySheet, "serCharge");
y from SheetRead(mySheet, "ceremony");
u from SheetRead(mySheet, "O2");
g from SheetRead(mySheet, "P2");
```

Figure 4.1: Parameter Connections on the IBM ILOG CPLEX Optimization Studio.

Parameters

- Let $x_i$ be the maximum number of guests allowed at venue $i \in V$.
- Let $c_i$ be the base cost at venue $i \in V$.
- Let $f_i$ be the catering options available at venue $i \in V$, where $f_i$ is defined by
  \[
  f_i = \begin{cases} 
  1, & \text{if a preferred caterer is not required at venue } i \in V \\
  0, & \text{otherwise}
  \end{cases}
  \]
- Let $r = $1000 be the utility gained if a venue does not require a preferred caterer.
- Let $m_i$ be the minimum required to be spent on food at venue $i \in V$.
- Let $p_i$ be the average price spent on food for each guest at venue $i \in V$.
- Let $b_i$ be the minimum required to be spent on beverages at venue $i \in V$.
- Let $a_i$ be the average price spent on beverages for each guest at venue $i \in V$.
- Let $l_i$ be the utility gained from the location of venue $i \in V$. 
• Let $y_i$ be the ceremony option available at venue $i \in V$, where $y_i$ is defined by

$$y_i = \begin{cases} 
1, & \text{if there is an option to have a ceremony at venue } i \in V \\
0, & \text{if else}
\end{cases}$$

• Let $u = \$750$ be the utility gained by having a ceremony option at a venue.

• Let $s_i$ be the service charge on food and beverages at venue $i \in V$.

• Let $g = \$75$ be the diminishing marginal utility from having 25 additional guests at a venue.

• Let $q = 1$ be the weight of costs.

• Let $k = 1$ be the weight of utilities.

• Let $n = \$10,000$ be the budget (maximum dollar amount spent at the optimal venue).

4.3 Decision Variables

Decision variables are the unknown variables that the model selects. In this problem, binary and integer variables are present. Binary variables take the value of either 0 or 1, showing whether something is present or not. Integer variables take the value of a whole number; these variables typically represent the amount of something. This project contains one integer decision variable and two binary decision variables.

**Decision Variables**

• Let $t_i \in \mathbb{Z}$ be the number of guests invited to venue $i \in V$.

• Let $h_{i,j}$ be defined by

$$h_{i,j} = \begin{cases} 
1, & \text{at least } 25 \cdot j \text{ guests are invited to venue } i \in V, \text{ where } j \in D \\
0, & \text{otherwise}
\end{cases}$$

• Let $w_i$ be the selected venue, where $w_i$ is defined by

$$w_i = \begin{cases} 
1, & \text{venue } i \in V \text{ is selected} \\
0, & \text{otherwise}
\end{cases}$$
4.4 Objective Function

The main goal of the objective function is to determine the optimal solution that maximizes the utility of the couple at the wedding while minimizing the cost. To do this, the model maximizes the sum of a negative cost function and a positive utility function.

Negative Cost Function

This section outlines the derivation of the total cost function. The first step is to multiply the base cost at venue $i$ with the binary variable representing whether venue $i$ is picked—$w_i \cdot c_i$. The second step is to sum the products of the binary variable representing whether venue $i$ is picked, the number of guests invited to venue $i$, and the sum of food and beverage costs at venue $i$—$w_i \cdot t_i \cdot (p_i + a_i)$. The third step is to multiply this product by the service charge, $(1 + s_i)$. The fourth step is to sum over all venues, $i \in V$, and multiply the resulting sum by the weight, $q$. Finally, the function is made negative. This results in the following negative cost function:

$$-q \cdot \sum_{i \in V} ((w_i \cdot c_i + w_i \cdot t_i \cdot (p_i + a_i)) \cdot (1 + s_i))$$

Positive Utility Function

This section focuses on the utility function. This paragraph derives the utility gained from the couple’s preferences. The first step is calculating the product of the binary variable representing venue $i$’s catering option with its corresponding utility—$f_i \cdot r$. The second step is to sum the result with the product of the binary variable representing venue $i$’s ceremony option and its corresponding utility—$y_i \cdot u$. The third step is to sum the result with the location utility, $l_i$. The fourth step is to multiply the result by the binary variable which denotes whether or not venue $i$ was chosen—$w_i \cdot (f_i \cdot r + l_i + y_i \cdot u)$. Finally, this is summed over all venues, $i \in V$.

This paragraph derives the utility gained from guests. The first step is adding the utility for the first $0 - 25$ guests since every venue will have at least 0 guests. From Table 3.1, we can see that the utility for the first 25 guests is $g \cdot 12 = $900. The second step is to aggregate the marginal utility of each additional tranche of 25 guests (as shown in Table 3.1). Finally, the result from this paragraph and the previous paragraph are combined and multiplied by a weight, $k$. This results in the following positive utility function:

$$k \cdot \left( \sum_{i \in V} ((w_i \cdot (f_i \cdot r + l_i + y_i \cdot u)) + g \cdot 12 + \sum_{j \in D} (g \cdot (12 - j) \cdot h_{i,j})) \right)$$
Finally, the negative cost function can be combined with the positive utility function to obtain the complete objective function:

\[
\text{maximize } z = -q \cdot \sum_{i \in V} (w_i \cdot c_i + t_i \cdot (p_i + a_i) \cdot (1 + s_i)) + k \cdot \left( \sum_{i \in V} (w_i \cdot (f_i \cdot r + l_i + y_i \cdot u) + g \cdot 12 + \sum_{j \in D} (g \cdot (12 - j) \cdot h_{i,j}) \right)
\]

4.5 Constraints
Constraints act as requirements that must be met in order for a solution to be feasible. If a solution meets all constraints, it can be considered a feasible solution. This project contains 7 constraints.

**Constraints**

- Let \( w_i \cdot c_i \geq t_i \ \forall i \in V \) be the constraint ensuring that the number of guests invited does not exceed the maximum guest capacity of venue \( i \).
- Let \( t_i \geq 0 \ \forall i \in V \) be the constraint ensuring that the number of guests invited to venue \( i \) is non-negative.
- Let \( t_i \cdot p_i \geq w_i \cdot m_i \ \forall i \in V \) be the constraint ensuring that the food minimum at venue \( i \) is satisfied.
- Let \( t_i \cdot b_i \geq w_i \cdot a_i \ \forall i \in V \) be the constraint ensuring that the beverage minimum at venue \( i \) is satisfied.
- Let \( \sum_{i \in V} w_i = 1 \) be the constraint ensuring that only one venue is selected.
- Let \( \sum_{i \in V} (w_i \cdot c_i + t_i \cdot (p_i + a_i) \cdot (1 + s_i)) \leq n \) be the constraint ensuring that the total cost is less than the budget.
- Let \( 25 \cdot j \cdot h_{i,j} \leq t_i \ \forall i \in V, \forall j \in D \) be the constraint that ensures that

\[
h_{i,j} = \begin{cases} 
1, \text{ at least } 25 \cdot j \text{ guests are invited to venue } i \in V, \text{ where } j \in D \\
0, \text{ otherwise}
\end{cases}
\]
Chapter 5

RESULTS

The solution to the mathematical optimization model developed for this project was found using the IBM ILOG CPLEX Optimization Studio. After running the model, the resulting optimal solution indicated that Elk City Town Hall and Church should be the selected venue. Given the results from the model, it is also optimal to invite 125 guests to the wedding. It is important to note that this specific venue had a guest capacity of 175, which seems to indicate that the optimal utility was not limited by the number of guests that the venue could hold. The wedding would have $3,200 in venue costs and $5,975 in utility. See table 5.1 for a list of the results. Luis and Madi preferred a cheaper venue over a luxurious one since they had a lower budget than the traditional couple, who spend anywhere between $12,343 and $14,006 on average (Price, 2022). Due to this, sensitivity analysis is discussed in section 5.1 to show how the model result would have changed if the couple’s preferences were different.

Table 5.1: Results.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venue</td>
<td>Elk City Town Hall and Church</td>
</tr>
<tr>
<td>Guests</td>
<td>125</td>
</tr>
<tr>
<td>Venue Max Capacity</td>
<td>175</td>
</tr>
<tr>
<td>Venue Cost</td>
<td>$3,200</td>
</tr>
<tr>
<td>Utility</td>
<td>$5,975</td>
</tr>
</tbody>
</table>

5.1 Sensitivity Analysis

To ensure that reasonable values were picked for utility, a sensitivity analysis was performed. Sensitivity analysis works by changing set values to see what alternate results are apparent. This analysis helped identify how the final solution could be affected by changes in the set utility values. To do this, the values of the utility (food preference utility, ceremony utility, guest utility, and location utility) were modified by 10% increments. Each utility value was changed independent of all other variables to help with consistency. When each of the four variables was increased by 10% only guest utility affected the final solution. Similarly, the utility values were also decreased by 10% which resulted in none of the four variables changing the final solution.
Table 5.2: Sensitivity Analysis.

<table>
<thead>
<tr>
<th>Variable Changed</th>
<th>Amount Changed</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Preference Utility</td>
<td>10% increase</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Ceremony Utility</td>
<td>10% increase</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Guest Utility</td>
<td>10% increase</td>
<td>Optimal venue stays the same and the number of guests increases by 25</td>
</tr>
<tr>
<td>Location Utility</td>
<td>10% increase</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Food Preference Utility</td>
<td>10% decrease</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Ceremony Utility</td>
<td>10% decrease</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Guest Utility</td>
<td>10% decrease</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Location Utility</td>
<td>10% decrease</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Food Preference Utility</td>
<td>100% increase</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Ceremony Utility</td>
<td>100% increase</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Guest Utility</td>
<td>1% increase</td>
<td>Optimal venue stays the same and the number of guests increases by 25</td>
</tr>
<tr>
<td>Location Utility</td>
<td>100% increase</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Food Preference Utility</td>
<td>100% decrease</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Ceremony Utility</td>
<td>100% decrease</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
<tr>
<td>Guest Utility</td>
<td>13% decrease</td>
<td>Optimal venue stays the same and the number of guests decreases by 25</td>
</tr>
<tr>
<td>Location Utility</td>
<td>100% decrease</td>
<td>Optimal venue and number of guests remains the same</td>
</tr>
</tbody>
</table>

To further explore, each utility variable was increased and decreased to see what percentage change in the variable would result in a change in the final solution. This was limited to no more than a 100% increase or decrease. When this analysis was performed, food preference utility, ceremony utility, and Location utility being increased or decreased by 100% did not result in a change to the final solution. This could tell us that these variables are outweighed by the low cost of the optimal venue. When Gugest utility was increased by 1%, the optimal venue remained the same but the number of guests invited increased by 25. When guest utility was decreased by 13%, the optimal
venue remained the same but the number of guests invited decreased by 25. Thus, guest utility is the most sensitive variable. Table 5.2 has a list of all of the changes and their impact on the final solution.
This paper presented a new solution to the problem of selecting a wedding venue. A mathematical model was produced to decide on an optimal wedding venue and an optimal number of wedding guests. After reviewing the model’s recommendation and conducting sensitivity analysis, Luis and Madi decided to take the model’s recommendation, as it satisfied their budget, preferences, and had a lot of power based on the sensitivity analysis. However, if there would have been more time to select a venue, more outside research could be done to more accurately decide the parameters of the mathematical model. In this project, the parameters were chosen based on Luis and Madi’s personal preferences, but this is likely not the case for the general public.

6.1 Future Work

This research paper found a linear model to optimize the selection of a wedding venue. This could be used in future research studies to optimize the selection of other events, such as a corporate meeting, a school trip, or a vacation getaway. Additionally, other aspects of the wedding planning process could be optimized; some parts that could be optimized could be the seating chart, the food selection process, or the guests that should be invited. On the other hand, if someone wanted to expand on the methodology, they could do an empirical study on couples’ willingness to pay for certain categorical variables, as well as a system that more accurately decides the parameters that the model should consider.

As stated in the literature review, Myung & Smith (2018) found that Pinterest was one of the most effective ways for companies to “interact with Millennial women regarding wedding-related information, inspiration, products, and services.” This is important for future researchers to keep in mind, as it would be another avenue to collect data. As stated in the data collection & process, this paper uses the website Knot.com in order to collect each venue’s information. However, it would be valuable to explore other websites such as Pinterest.
BIBLIOGRAPHY


Table A.1: *Variable Names and Meanings.*

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venue ID</td>
<td>The number that corresponds to a specific venue for the duration of the model.</td>
</tr>
<tr>
<td>Venue Name</td>
<td>The name of the venue. If a venue had multiple packages that made the top 30 venues, each package was considered individually.</td>
</tr>
<tr>
<td>Max Guest</td>
<td>The max capacity of the venue.</td>
</tr>
<tr>
<td>Fixed Cost</td>
<td>The base cost of the venue.</td>
</tr>
<tr>
<td>Preferred Caterer</td>
<td>If food preference has a value of 1, then a preferred caterer is not required at the venue. If food preference has a value of 0, then the wedding venue requires a preferred caterer.</td>
</tr>
<tr>
<td>Food Minimum</td>
<td>The minimum that must be spent on food at the venue. If the food minimum is $0 then the venue has no minimum listed.</td>
</tr>
<tr>
<td>Food Per Person</td>
<td>The average price spent on food for each guest at the venue.</td>
</tr>
<tr>
<td>Food Preference Utility</td>
<td>The utility gained if the venue does not require a preferred caterer.</td>
</tr>
<tr>
<td>Beverage Minimum</td>
<td>The minimum that must be spent on beverages at the venue. If the beverage minimum is $0 then the venue has no minimum listed.</td>
</tr>
<tr>
<td>Beverage Per Person</td>
<td>The average price spent on beverages for each guest at the venue.</td>
</tr>
<tr>
<td>Location</td>
<td>The city the venue is located in.</td>
</tr>
<tr>
<td>Location Utility</td>
<td>The utility gained from the location of the venue.</td>
</tr>
<tr>
<td>Service Charge</td>
<td>The service charge for food and beverages at the venue.</td>
</tr>
<tr>
<td>Ceremony</td>
<td>If the value is 1, then the venue has an option for a ceremony if it is 0, then the venue has no ceremony option.</td>
</tr>
<tr>
<td>Ceremony Utility</td>
<td>The utility gained by having a ceremony option.</td>
</tr>
<tr>
<td>Guest Utility</td>
<td>The diminishing marginal utility from having 25 additional guests.</td>
</tr>
</tbody>
</table>
Table A.2: Data Part 1a.

<table>
<thead>
<tr>
<th>Venue ID</th>
<th>Venue Name</th>
<th>Max Guest</th>
<th>Fixed Cost ($)</th>
<th>Preferred Caterer</th>
<th>Food Minimum ($)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Graduate Lincoln -Emerald Package</td>
<td>500</td>
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<td>0</td>
<td>8,000</td>
</tr>
<tr>
<td>2</td>
<td>Graduate Lincoln -Ruby Package</td>
<td>500</td>
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<td>0</td>
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</tr>
<tr>
<td>3</td>
<td>Graduate Lincoln -Sapphire Package</td>
<td>500</td>
<td>500</td>
<td>0</td>
<td>8,000</td>
</tr>
<tr>
<td>4</td>
<td>Graduate Lincoln -Diamond Package</td>
<td>500</td>
<td>500</td>
<td>0</td>
<td>8,000</td>
</tr>
<tr>
<td>5</td>
<td>DC Centre Banquet Facility - Ballroom</td>
<td>400</td>
<td>1,250</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>DC Centre Banquet Facility - Suite</td>
<td>200</td>
<td>650</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Elk City Town Hall and Church</td>
<td>190</td>
<td>1,100</td>
<td>1</td>
<td>0</td>
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<tr>
<td>8</td>
<td>Omaha Press Club</td>
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<td>1,500</td>
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<td>0</td>
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<tr>
<td>9</td>
<td>The Steppe Center</td>
<td>400</td>
<td>1,700</td>
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</tr>
<tr>
<td>10</td>
<td>Founder One Nine</td>
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<td>11</td>
<td>Falconwood Park</td>
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<td>120</td>
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<td>0</td>
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<tr>
<td>13</td>
<td>The Post Event Center</td>
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<td>Countryside Venue</td>
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<td>Durham Museum - Suzanne &amp; Walter Scott Great Hall</td>
<td>350</td>
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<tr>
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<td>Durham Museum - Trish &amp; Dick Davidson Gallery</td>
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<td>2,500</td>
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</tr>
</tbody>
</table>
Table A.3: *Data Part 1b.*

<table>
<thead>
<tr>
<th>Venue ID</th>
<th>Venue Name</th>
<th>Max Guest</th>
<th>Fixed Cost ($)</th>
<th>Preferred Caterer</th>
<th>Food Minimum($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>The Joslyn Castle</td>
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<td>2,800</td>
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<td>20</td>
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<td>The Magnolia Hotel Omaha</td>
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<td>The Diamond Room</td>
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<tr>
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<td>WaConDa Woods &amp; Gardens</td>
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Table A.4: Data Part 2.

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<th>Beverage Minimum ($)</th>
<th>Beverage Per Person ($)</th>
<th>Location</th>
<th>Location Utility ($)</th>
<th>Service Charge</th>
<th>Ceremony</th>
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<tr>
<td>15</td>
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<td>475</td>
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<td>1</td>
</tr>
<tr>
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<td>23.00</td>
<td>0</td>
<td>15.00</td>
<td>Omaha</td>
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<td>1</td>
</tr>
<tr>
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<td>Omaha</td>
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</tr>
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</tr>
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<td>Omaha</td>
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<td>0.20</td>
<td>1</td>
</tr>
<tr>
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<td>Omaha</td>
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<td>0.20</td>
<td>1</td>
</tr>
<tr>
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<tr>
<td>30</td>
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<td>15.00</td>
<td>Louisville</td>
<td>300</td>
<td>0.20</td>
<td>1</td>
</tr>
</tbody>
</table>
Figure A.1: Model Implementation on the IBM ILOG CPLEX Optimization Studio.

```plaintext
//Ranges
range V = 1..30;
range D = 1..12;

//Parameters
float q = 1;
float k = 1;
float x[V] = ...;
float c[V] = ...;
float f[V] = ...;
float r = ...;
float m[V] = ...;
float p[V] = ...;
float b[V] = ...;
float o[V] = ...;
float l[V] = ...;
float s[V] = ...;
float y[V] = ...;
float u = ...;
float g = ...;
float n = 10000;

//Decision Variables
dvar boolean w[V];
dvar int t[V];
dvar boolean h[V][D];

//Objective Functions
maximize k*(g^12 + sum(i in V)((w[i]*f[i]*r + l[i] + y[i]*u))
+ sum(j in D)(g*(12 - j)*h[i][j])
- q*(sum(i in V)((c[i]*c[i] + w[i]*w[i] + s[i]*s[i] + a[i] + p[i]) * (1 + s[i])));
```

Figure A.2: Model Implementation on the IBM ILOG CPLEX Optimization Studio - Continued.

```plaintext
//Constraints
subject to
{
  GuestLessThanCapacity:
    forall(i in V) w[i] * x[i] >= t[i];
  CanBeNegativeGuest:
    forall(i in V) t[i] >= 0;
  FoodMinMustBeMet:
    forall(i in V) t[i] * p[i] >= w[i] * m[i];
  BeMaxMustBeMet:
    forall(i in V) t[i] * m[i] >= w[i] * b[i];
  OnlyOneVenue:
    sum(i in V) w[i] == 1;
  CostLessThanBudget:
    sum(i in V)((m[i] * x[i] + t[i] * (a[i] + p[i])) * (1 + s[i])) <= n;
  DiminishingUtilityMoreGuest:
    forall(i in V, j in D)((25 * j) * h[i][j] <= t[i]);
}
```
Figure A.3: Model Implementation on the IBM ILOG CPLEX Optimization Studio Final.

<table>
<thead>
<tr>
<th>Venue ID</th>
<th>Venue Name</th>
<th>Max Guests</th>
<th>Fixed Cost</th>
<th>Food Preference</th>
<th>Food Minimum</th>
<th>Food Per Person</th>
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Figure A.4: Microsoft Excel Data.
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Figure A.5: Microsoft Excel Data - Continued.