Selecting Optimal Locations of Food Trucks: A Case Study for the City of Vancouver *

Benny Wai†, Alex Liu, Lawrence Huen

Department of Mathematics, Simon Fraser University, Burnaby, BC, Canada

Abstract

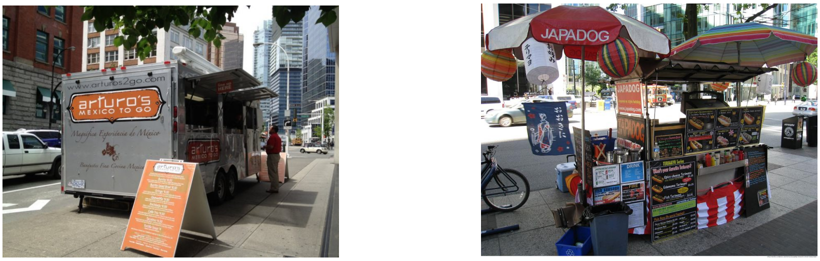
Food trucks offer an exciting alternative to eating out while tailoring to the fast-paced lifestyle of city dwellers, but effective methods to implement this form of dining-out alternative are still non-existent to many cities where it is still a new concept. Cannibalism of local restaurants can occur when food trucks are licensed without informal planning. The conflict between local restaurants and food trucks has been a reoccurring theme in the media for the last few months; the city of Vancouver is now seeking better methods to find optimal locations for the food trucks.

In this paper, we developed discrete optimization models for this problem and solve the model using Open-Solver, an Excel-based optimization engine. The data collected for this paper includes pedestrian data, active food trucks in the year 2012, road information, and licensed restaurants in downtown Vancouver. Our study identified optimal locations for summer 2013. Various alternative formulations are also given and comparative study is performed. While our paper concentrates on the city of Vancouver, the model is general enough to be applicable to other cities that are starting to implement food truck alternatives.

* Awarded First Place in the undergraduate paper competition at the 55th Canadian Operational Research Society Annual Conference in Vancouver, Canada.

† bcwai@sfu.ca

1 Introduction



(a) Food truck (b) Food cart

Figure 1: Examples of food trucks and food carts

Vancouver has always been a place of entertainment, excitement, and progress. One of its many main attractions is food; being such an innovative and multicultural city, there is a large variety of foods of different cultural backgrounds. This makes downtown Vancouver a place of interest for our research as it is home to many diverse local restaurants within a relatively small area. While the models discussed in this paper are made for a specific city, the models are general enough to be easily modified to be applicable for any other city.

Food trucks and food carts are a relatively new concept to Vancouver and are great alternatives to restaurants and food courts. Food carts are defined as carts with wheels which require a motorized vehicle to move itself. Food trucks, on the other hand, are motorized vehicles themselves, which has at least one stove and a sink. For simplicity purposes, this paper will use the term food trucks to refer to both trucks and carts.

Food trucks and food carts are especially popular since they offer a type of fast food for consumers while retaining a fresh and exciting eating experience. As popularity of food trucks increase, the media, such as the 24 Hours News Network as well as CBC News Network, has voiced out the concerns of many local restaurants: they are losing business. Some restaurant owners went as far as to sign a petition about the issue [1]. These conflicts arise as food trucks are placed in positions that are too close to local restaurants. Currently, food truck locations are determined by a one-time food contest: the food trucks are ranked from best to worst by taste, appeal, and originality according to the judges, with the "better" ones getting first pick from the locations chosen by the city. The locations were ultimately decided through experience and are to be investigated if trouble arises. With news of 15 new food vendor licenses planned to be handed out this year, it is clear that the city needs an alternative solution.

This paper focuses on discrete optimization models that pick optimal locations in downtown

Vancouver for each type food trucks based on a scoring system. Each side of the road is given a numerical representation that is based upon the average pedestrian in that area; this value can be said to represent the average potential customers available for the food truck in that location. For the integer linear programming model, this value is negatively influenced by nearby restaurants that serve similar food since it takes a proportion of average potential customers away from the food truck. For the integer non-linear model, nearby food trucks of similar food also influence it. The optimal locations are the locations that have the highest scores with respect to each food trucks respective food type. For this case study, the optimal locations for August 2013 with and without the additional 15 food trucks will be predicted. Naturally, the model would avoid restaurants of that are similar to the food trucks while preferring locations that would give it the most potential customers.

The integer linear programming model and the integer nonlinear programming model will be analyzed and compared to conclude a better model for general purposes as well as for specific circumstances. Alternative models are also constructed and analyzed to see which 15 food trucks would be preferable for the City to license. While this paper focuses on a specific city, this case study based upon downtown Vancouver, due to its high density of restaurants, provides insight information on the effectiveness of the discrete optimization models on other cities as well. These optimization models could possibly help many cities, both currently and considering hosting food trucks, in allocating them in a manner that is friendly for both the existing and new businesses within the community.

1.1 Scope of Project

The only food trucks considered by this project are the ones on the Food Truck App website [15]. This project focuses on planning for August 2013. The month of August was chosen because it was the month with the most number of operating food trucks last year. This project revolves around the assignment of the 55 food trucks that were operating in August of 2012 (Section 9.2). The assumption is that these 55 food trucks will once again be operating in the year 2013. The 15 new food trucks said to be licensed in 2013 will also be included into this model as a different version of our results.

A large portion of downtown Vancouver was covered in order to ensure reproducible and accurate results, but only roads that are large enough to accommodate food trucks were considered. Our designated area of downtown Vancouver was chosen to be everything in between Denman Street and Beatty Street. This area was used in order to simplify the scope of the project while retaining most of the areas that were frequent by food trucks last year.

Two different variations were explored in the creation of this proposal. The original version tackles only in assignment of the original 55 food trucks from last year. A second version includes the additional 15 food trucks to be released with their estimated food types.

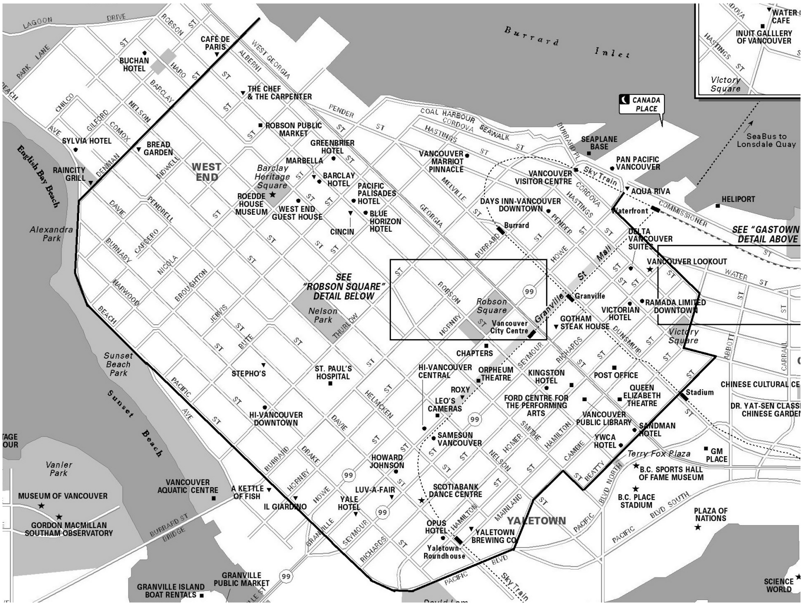


Figure 2: Project deals with everything within the black lines of downtown Vancouver.

1.2 Related Literatures

In Michael F. Goodchild's article "ILACS: A Location Allocation Model for Retail Site Selection", he discussed his objective function in two cases. In the first case, Goodchild talks about how the objective revolves around competitive locations while maximizing the objective in the clients' point of view. In his second case, Goodchild ignored the competitive locations potential for competion. He then decided to go with the first case, saying that there is competitive potentials between food trucks. For our project's purpose, competitions between restaurants and food trucks are included as well; however, it not only considers the client's sites but also the food trucks' location and its link to restaurants' benefits as well. Goodchild's article gives useful insight on how to construct an effective objective function. [8]

In his paper, Jesus Alberto Hermosillo provided a very clear and specific distinction between loncheras, which are stationary food trucks, and industrial lunch trucks, food trucks which tend to move frequently. Because operating food trucks within Vancvouer are, under regulations, unable to relocate, it is analogous to Hermosillo's definition of a stationary allocation problem. [10]

In "Plan Review and Approval for Mobile Food Units", a report done by the Delaware Health and Social Services, numerous specific methods for food trucks were listed, such as water problems and trash problems. Based on their methods, a very important assumption for the model was made; that food trucks on the road only affect certain groups of restaurants. All the higher class restaurants, defined by which requires suits and dresses codes, are not considered to be affected by food trucks. This article gave us a greater understanding of assigning categories to the variables with food trucks and carts [5].

2 Project Methods

2.1 Factors

1. Local restaurants

   Food vendors placed near restaurants that serve similar types of food have a negative impact on other vendors and restaurants due to competition.

2. Pedestrians on average

   Food trucks tend to situate in areas with higher consumer density, taking into account ranging densities is highest at different time frames. This includes lunch hours during working days (as it is included in the pedestrian count data given to us by the Vancouver map database website [4]) and the amount of people going for recreational events throughout the week. Transit accessibility was not separated in the data because the increase of people in an area is directly influenced by transit.

3. Proximity of other food vendors (Only a factor for alternate version of the model)

   The goal is to relocate food vendors in such a way where both food vendors and restaurant owners are content with the amount of consumers they get. Food trucks placed too close to each other limit each other's businesses.

2.2 Constraints

1. There are currently regulations based on food vendor locations and their distance to other similar food vendors/restaurants — food vendors cannot be within 60 meters of similar foods [3]; only one type of food truck can be on the same side of any street at all times.

2. There is another regulation set by the City of Vancouver stating that a food truck should be 2 meters away from anything on the road (information provided by Alan Rockett, City of Vancouver street vendor coordinator), any road that has a sidewalk width of 2 meters or less is not considered.

3. Having too many food trucks and carts in one section of the city is undesirable (regardless of food type) as they have a negative impact on local restaurants and encourage streets to be more crowded. No more than 5 food trucks can be located within the walking distance of 200m, or 2.5 minutes, in diameter [18].

4. A viable location cannot be constructed if there is lack of data on density of pedestrians at a given location.

2.3 Assumptions

The following assumptions were implemented to simplify the model:

1. A consumer who considers a meal from a food truck is less likely to dine in expensive restaurants or bars and pubs as price ranges of these locations are generally higher than a food vendor's. These restaurants are therefore not incorporated in this project as they will have minimal influence by food trucks.

2. If the type of food is in the same category for this project, people interested in one specific type of food in a certain category will be just as interested in eating another food of the same category. Therefore having a restaurant and a food truck of the same type close to each other lowers that average amount of customers they are expected to have.

3. A large majority of customers eating at a hotel restaurants are also hotel customers. For simplicity, we assume that the hotel restaurants are not affected by food trucks.

4. Different types of food have no influence on the others' profit nor the number of average expected customers. Therefore scores are not impacted by restaurants and food trucks of different type.

5. Deli's and places of special catering (cake bakery) are not affected by food trucks for they do not belong to any of the food categories, as listed in the Indices (4.2).

6. Big coffee corporations that sell mainly coffee (Starbucks, Blenz) attract customers mainly for their coffee not their food products. Hence, we assume coffee corporations are not affected by food trucks.

7. A major assumption made is that the increase in total population throughout Canada from years 2008 to 2013 is parallel to the increase in pedestrian population; that is, if total population of Canadians is increased by 10% from 2008 to 2013, it is then assumed that the number of pedestrians frequenting the streets will also have increased by 10% through the same 5 years.

8. All pedestrians at any time is a potential customer to both local restaurants and food vendors. Therefore if street A has a higher score than street B, we consider street A a better location for operating food trucks.

9. Food types "African" and "Brazilian" were eliminated after noticing there were less than 5 restaurants and 0 food trucks that fall under those categories. They are therefore assumed to not have influence in the scores.

2.4 Data Collection Methods

A food truck Vancouver representative has already been phoned and information about food truck locations over the past 12 months have been received [15]. Greg Nowak, a traffic database representative, was also contacted; he provided valuable information on where to collect traffic data as well as pedestrian data [4]. Interviews with food truck operators and food courts employees were also conducted in order to get a better understanding of how restaurants and nearby food trucks can affect each other.

Amy Smith, "The Food Queen", is an avid blogger that has gone to many restaurants all around Vancouver. Based on her experience, Smith was able to contribute to this project by categorizing the 44 different food types of the restaurants and food trucks into 11 (Indices 4.2). Alan Rockett, a street vendor coordinator working for the City of Vancouver, was also contacted in order to gather more information about the process of choosing a viable food truck location.

Restaurant data were obtained from the license data of all organizations in Vancouver and we manually deleted data that either did not satisfy this project's constraints or did not fit the requirement of a restaurant. We then categorized each of the 458 restaurants of downtown Vancouver (Appendix 9.3).

2.5 Interview Observations

Numerous food truck owners and restaurant employees were interviewed in this project to have a better understanding of how food trucks have an impact on local restaurants (Appendix 9.2). Food vendors are less worried about competition with other food vendors, even if the type of food served were the same. Restaurant owners seem to be moderately worried about the food trucks taking their customers. One food truck owner talked about reports they had from other restaurants which complained about their presence in the neighborhood. Based on these ideas, it is assumed that food trucks close to each other but in different locations do not affect each other. The average number of pedestrians on the street is a good way to represent the score of a location simply because most customers just find food trucks more convenient. With their information, there is a better insight on how serious the problem is. This allows enough data in order to assign values for the restaurant influence levels accordingly.

2.6 Excel and Open Solver

In the study, Microsoft Excel and Open Solver were used for implementation. Microsoft Excel stores all data obtained from different sources into one file with different spreadsheets for easy access. Open Solver, a mathematical problem solver, then builds the mathematical model onto Excel and computes for optimal solutions. Results were later interpreted using the solutions from Open Solver.

3 Integer Linear Programming Model

3.1 Description

The objective in the integer linear model is to maximize the total score based on the number of pedestrian count at the locations of the food trucks placed. The score at the location of a food truck is affected only by nearby restaurants of the same food types. As a result, two or more food trucks of the same food type can be placed beside each other without any negative impact on the score of a location; only nearby restaurants with the same food types have a negative impact on the score.

3.2 Indices

Let $X =$ Horizontal Streets, $X = 1, ..., m$

Let $Y =$ Vertical Streets, $Y = 1, ..., n$

Let $S =$ Side of the Street, $S = 1, 2, 3, 4$

Let $T =$ Type of Food, $T = 1, ..., 11$ For the 11 Food Categories

T	Categories
1	Cafes (Coffee and Desserts)
2	Canadian/American Style Food
3	Mediterranean/Middle Eastern
4	South East Asian
5	Japanese
6	Mexican
7	Italian
8	Indian
9	European
10	Chinese
11	Korean

Table 1: Types of Food

3.3 Constants

$P_{X,Y,S} =$ Number of Pedestrians at Location (X,Y) with Side S

$C_T =$ Total Number of Food Trucks/Carts of Food Type T needed to be allocated

$R_{X,Y,S,T}$ = Number of Restaurants of Type T at Location (X,Y) with Side S

$$M_B = \text{Restaurant Modifier} = \begin{cases} 0.4 & \text{B = 1; Same Street \& Side} \\ 0.3 & \text{B = 2; Same Street, Different Side} \\ 0.2 & \text{B = 3; Different Street, Same Side} \\ 0.1 & \text{B = 4; Different Street \& Side} \\ 0.05 & \text{B = 5; Far Away, Far Away} \end{cases}$$

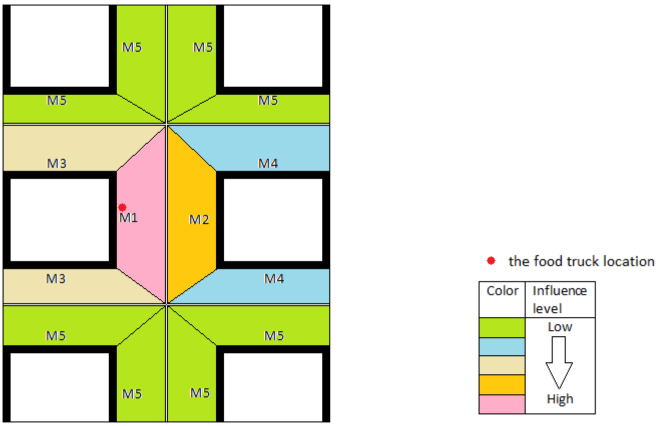


Figure 3: Diagram of restaurant effect at location (X,Y) for food type T

3.4 Variables

$$F_{X,Y,S,T} = \begin{cases} 1 & \text{If a Food Truck of Type T at Location (X,Y) with Side S} \\ 0 & \text{Otherwise} \end{cases}$$

$L_{X,Y,S,T}$ = Score of the Location (X,Y) with Side S and Food Type T

$$= \begin{cases} \text{S = 1,} \\ P_{X,Y,S}[1 - M_1 R_{X,Y,S,T} - M_2 R_{X,Y,S+1,T} \\ -M_3[R_{X,Y-1,S+2,T} + R_{X+1,Y-1,S+2,T}] \\ -M_4[R_{X,Y,S+3,T} + R_{X+1,Y,S+3,T}] \\ -M_5[R_{X,Y-1,S+2,T} + R_{X-1,Y,S,T} + R_{X-1,Y,S+1,T} + R_{X,Y,S+1,T} \\ +R_{X+1,Y-1,S+3,T} + R_{X+1,Y,S,T} + R_{X+1,Y,S+1,T} + R_{X+1,Y,S+3,T}]] \end{cases}$$

$$
= \begin{cases}
\text{S = 2,} \\
P_{X,Y,S}[1 - M_1 R_{X,Y,S,T} - M_2 R_{X,Y,S-1,T} \\
-M_4[R_{X,Y-1,S+1,T} + R_{X+1,Y-1,S+1,T}] \\
-M_3[R_{X,Y,S+2,T} + R_{X+1,Y,S+2,T}] \\
-M_5[R_{X,Y-1,S+1,T} + R_{X-1,Y,S-1,T} + R_{X-1,Y,S,T} + R_{X,Y,S,T} \\
+R_{X+1,Y-1,S+2,T} + R_{X+1,Y,S-1,T} + R_{X+1,Y,S,T} + R_{X+1,Y,S+2,T}]] \\
\\
\text{S = 3,} \\
P_{X,Y,S}[1 - M_1 R_{X,Y,S,T} - M_2 R_{X,Y,S+1,T} \\
-M_3[R_{X-1,Y,S-1,T} + R_{X-1,Y+1,S-2,T}] \\
-M_4[R_{X,Y,S-1,T} + R_{X,Y+1,S-2,T}] \\
-M_5[R_{X,Y-1,S,T} + R_{X-1,Y,S-2,T} + R_{X-1,Y+1,S-1,T} + R_{X,Y+1,S,T} \\
+R_{X,Y-1,S+1,T} + R_{X,Y,S-2,T} + R_{X,Y+1,S-1,T} + R_{X,Y+1,S+1,T}]] \\
\\
\text{S = 4,} \\
P_{X,Y,S}[1 - M_1 R_{X,Y,S,T} - M_2 R_{X,Y,S-1,T} \\
-M_4[R_{X-1,Y,S-2,T} + R_{X-1,Y+1,S-3,T}] \\
-M_3[R_{X,Y,S-2,T} + R_{X,Y+1,S-3,T}] \\
-M_5[R_{X,Y-1,S-1,T} + R_{X-1,Y,S-3,T} + R_{X-1,Y+1,S-2,T} + R_{X,Y+1,S-1,T} \\
+R_{X,Y-1,S,T} + R_{X,Y,S-3,T} + R_{X,Y+1,S-2,T} + R_{X,Y+1,S,T}]]
\end{cases}
$$

Note that the construction of this variable varies depending on S, the direction the street is facing, due to how each adjacent street influences the score differently.

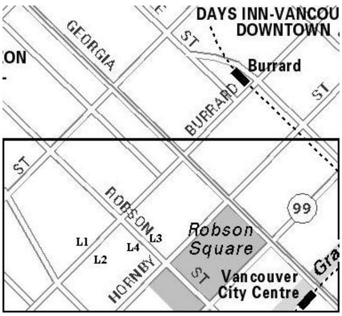


Figure 4: Diagram of score system at location (X,Y) for food type T

3.5 Objective Function

Maximize $\sum_{X=1}^{x} \sum_{Y=1}^{y} \sum_{S=1}^{s} \sum_{T=1}^{t} F_{X,Y,S,T} L_{X,Y,S,T}$

3.6 Constraints

1. No more than 5 food trucks within 2.5 min walking radius.

$$\sum_{S=1}^{4} F_{X-1Y-1S} + F_{X-1YS} + F_{X-1Y+1S} + F_{XY-1S} + F_{XYS} + F_{XY+1S}$$

$$+F_{X+1Y-1S} + F_{X+1YS} + F_{X+1Y+1S} \leq 5 \; \forall \text{ location (X,Y)}$$

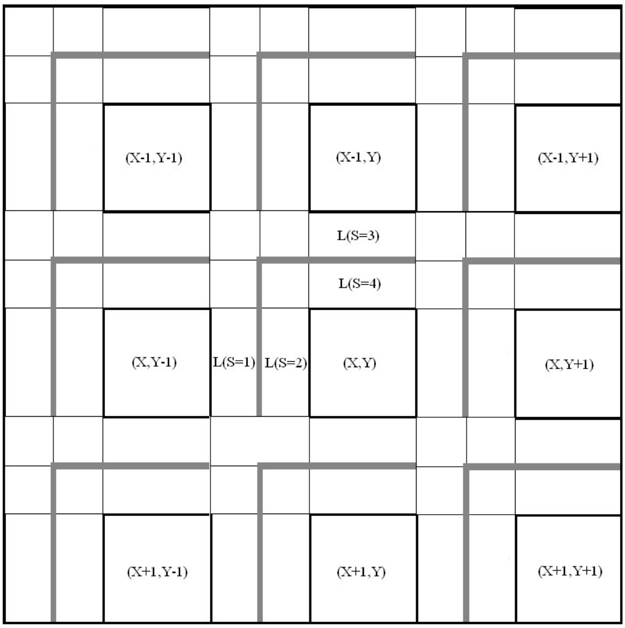


Figure 5: Example of a 3x3 Block Constraint

2. All of the food trucks/carts must be allocated.

$\sum_{X=1}^{x} \sum_{Y=1}^{y} \sum_{S=1}^{s} F_{X,Y,S,T} = C_T$ For all T

3. No more than 1 food truck at each location (X,Y,S).

$\sum_{T=1}^{11} F_{X,Y,S,T} \leq 1$ For all (X,Y,S)

4 Integer Non-linear Programming Model

4.1 Description

The objective in the integer non-linear programming model is to maximize the total score based on the number of pedestrian count at the locations of the food trucks placed. However, the score at the location of a food truck is affected not only by nearby restaurants of the same food types but also by nearby food trucks. As a result, the score for a food truck decreases as the number of nearby restaurants and food trucks of the same food type increases.

This model is non-linear because both the presence of a food truck and the score value of the location depend on the number of food trucks nearby.

4.2 New Objective Function

Maximize $\sum_{X=1}^{x} \sum_{Y=1}^{y} \sum_{S=1}^{s} \sum_{T=1}^{t} F_{X,Y,S,T} L_{X,Y,S,T}$

The objective function is non-linear due to $F_{X,Y,S,T} F_{X,Y,S,T}$.

4.3 New Constants

G_B = Food Truck Modifier

$$= \begin{cases} 0.3 & \text{B = 1; Same Street, Same Side} \\ 0.2 & \text{B = 2; Same Street, Different Side} \\ 0.1 & \text{B = 3; Different Street, Same Side} \\ 0.05 & \text{B = 4; Different Street, Different Side} \\ 0 & \text{B = 5; Far Away, Far Away} \end{cases}$$

4.4 New Variables

The new score variables consist of G_B's.

$L_{X,Y,S,T} =$ Score of the Location (X,Y) with Side S & Food Type T

$$
= \begin{cases}
\text{S = 1,} \\
P_{X,Y,S}[1 - M_1 R_{X,Y,S,T} - M_2 R_{X,Y,S+1,T} \\
-M_3[R_{X,Y-1,S+2,T} + R_{X+1,Y-1,S+2,T}] \\
-M_4[R_{X,Y,S+3,T} + R_{X+1,Y,S+3,T}] \\
-M_5[R_{X,Y-1,S+2,T} + R_{X-1,Y,S,T} + R_{X-1,Y,S+1,T} + R_{X,Y,S+1,T} \\
+R_{X+1,Y-1,S+3,T} + R_{X+1,Y,S,T} + R_{X+1,Y,S+1,T} + R_{X+1,Y,S+3,T}] \\
-G_1 F_{X,Y,S,T} - M_2 F_{X,Y,S+1,T} \\
-G_3[F_{X,Y-1,S+2,T} + F_{X+1,Y-1,S+2,T}] \\
-G_4[F_{X,Y,S+3,T} + F_{X+1,Y,S+3,T}] \\
-G_5[F_{X,Y-1,S+2,T} + F_{X-1,Y,S,T} + F_{X-1,Y,S+1,T} + R_{X,Y,S+1,T} \\
+F_{X+1,Y-1,S+3,T} + R_{X+1,Y,S,T} + F_{X+1,Y,S+1,T} + R_{X+1,Y,S+3,T}]] \\
\\
\text{S = 2,} \\
P_{X,Y,S}[1 - M_1 R_{X,Y,S,T} - M_2 R_{X,Y,S-1,T} \\
-M_4[R_{X,Y-1,S+1,T} + R_{X+1,Y-1,S+1,T}] \\
-M_3[R_{X,Y,S+2,T} + R_{X+1,Y,S+2,T}] \\
-M_5[R_{X,Y-1,S+1,T} + R_{X-1,Y,S-1,T} + R_{X-1,Y,S,T} + R_{X,Y,S,T} \\
+R_{X+1,Y-1,S+2,T} + R_{X+1,Y,S-1,T} + R_{X+1,Y,S,T} + R_{X+1,Y,S+2,T}] \\
-G_1 F_{X,Y,S,T} - G_2 F_{X,Y,S-1,T} \\
-G_4[F_{X,Y-1,S+1,T} + F_{X+1,Y-1,S+1,T}] \\
-G_3[F_{X,Y,S+2,T} + F_{X+1,Y,S+2,T}] \\
-G_5[F_{X,Y-1,S+1,T} + F_{X-1,Y,S-1,T} + F_{X-1,Y,S,T} + R_{X,Y,S,T} \\
+F_{X+1,Y-1,S+2,T} + R_{X+1,Y,S-1,T} + F_{X+1,Y,S,T} + R_{X+1,Y,S+2,T}]] \\
\\
\text{S = 3,} \\
P_{X,Y,S}[1 - M_1 R_{X,Y,S,T} - M_2 R_{X,Y,S+1,T} \\
-M_3[R_{X-1,Y,S-1,T} + R_{X-1,Y+1,S-2,T}] \\
-M_4[R_{X,Y,S-1,T} + R_{X,Y+1,S-2,T}] \\
-M_5[R_{X,Y-1,S,T} + R_{X-1,Y,S-2,T} + R_{X-1,Y+1,S-1,T} + R_{X,Y+1,S,T} \\
+R_{X,Y-1,S+1,T} + R_{X,Y,S-2,T} + R_{X,Y+1,S-1,T} + R_{X,Y+1,S+1,T}] \\
-G_1 F_{X,Y,S,T} - M_2 F_{X,Y,S+1,T} \\
-G_3[F_{X-1,Y,S-1,T} + F_{X-1,Y+1,S-2,T}] \\
-G_4[F_{X,Y,S-1,T} + F_{X,Y+1,S-2,T}] \\
-G_5[F_{X,Y-1,S,T} + F_{X-1,Y,S-2,T} + F_{X-1,Y+1,S-1,T} + F_{X,Y+1,S,T} \\
+F_{X,Y-1,S+1,T} + F_{X,Y,S-2,T} + F_{X,Y+1,S-1,T} + F_{X,Y+1,S+1,T}]]
\end{cases}
$$

$$
= \begin{cases} \text{S = 4,} \\ P_{X,Y,S}[1 - M_1 R_{X,Y,S,T} - M_2 R_{X,Y,S-1,T} \\ -M_4[R_{X-1,Y,S-2,T} + R_{X-1,Y+1,S-3,T}] \\ -M_3[R_{X,Y,S-2,T} + R_{X,Y+1,S-3,T}] \\ -M_5[R_{X,Y-1,S-1,T} + R_{X-1,Y,S-3,T} + R_{X-1,Y+1,S-2,T} + R_{X,Y+1,S-1,T} \\ +R_{X,Y-1,S,T} + R_{X,Y,S-3,T} + R_{X,Y+1,S-2,T} + R_{X,Y+1,S,T}] \\ -G_1 F_{X,Y,S,T} - M_2 F_{X,Y,S-1,T} \\ -G_4[F_{X-1,Y,S-2,T} + F_{X-1,Y+1,S-3,T}] \\ -G_3[F_{X,Y,S-2,T} + F_{X,Y+1,S-3,T}] \\ -G_5[F_{X,Y-1,S-1,T} + F_{X-1,Y,S-3,T} + F_{X-1,Y+1,S-2,T} + F_{X,Y+1,S-1,T} \\ +F_{X,Y-1,S,T} + F_{X,Y,S-3,T} + F_{X,Y+1,S-2,T} + F_{X,Y+1,S,T}]] \end{cases}
$$

5 Programming Models With the 15 Additional Licensed Food Trucks

5.1 Description

The City of Vancouver will be licensing 15 new food trucks into the downtown area in 2013 [1]. Because there is no additional information describing whether vendors are pending for licenses or vendors are still in selection stage, there is still, possibly, time for the City council to decide whether or not the types of food being sold should be a factor to be taken into consideration.

With this question in mind, two new models, which were based on the previous integer linear and integer non-linear models, were made. The result gave us not only which 15 food truck types the City should consider licensing, but also where the total 70 (55 active food trucks in August 2012 + 15 new food trucks) optimal locations should be.

5.2 New Variables and Constraints

Let $N_T =$ # food trucks of type T preferable for the city of Vancouver to license.

The total number of new food trucks equals to 15.

$\sum_{T=1}^{11} N_T = 15$

The total number of food truck of type T that needs to be allocated is now equal to the total number of food trucks of type T from August 2012 plus the total number of food trucks of type T that is preferable to license.

$\sum_{X=1}^{x} \sum_{Y=1}^{y} \sum_{S=1}^{s} F_{X,Y,S,T} = C_T + N_T$ For all T

6 Results

Total	Restaurant Groups Categorized
69	Cafés: Bakery, Dessert, Coffee
141	Canadian/American: Seafood, bagels, BBQ, Breakfast, Pastries, Burger, Pancakes, Sandwiches, Steak
8	Mediterranean/Middle Eastern: Greek, Poruguese, Spanish, Mediterranean
32	South East Asian: Malaysian, Thai, Vietnamase, Mogolian, Vegetarian
74	Japanese: Sushi, Hotpot
15	Mexican
34	Italian: Pizza
11	Indian: Himalayan, Indian
29	European: British, European, Seafood, French
20	Chinese: Chinese, Taiwanese
13	Korean

Figure 6: Food classifications with total number of restaurants of each type on the left side

It is important to note that food trucks operate on specific days and time depending on the owners preference, so they do not operate at the same time. To make the results easier to read, we have colour coded each food type.

6.1 Integer Linear Programming Model

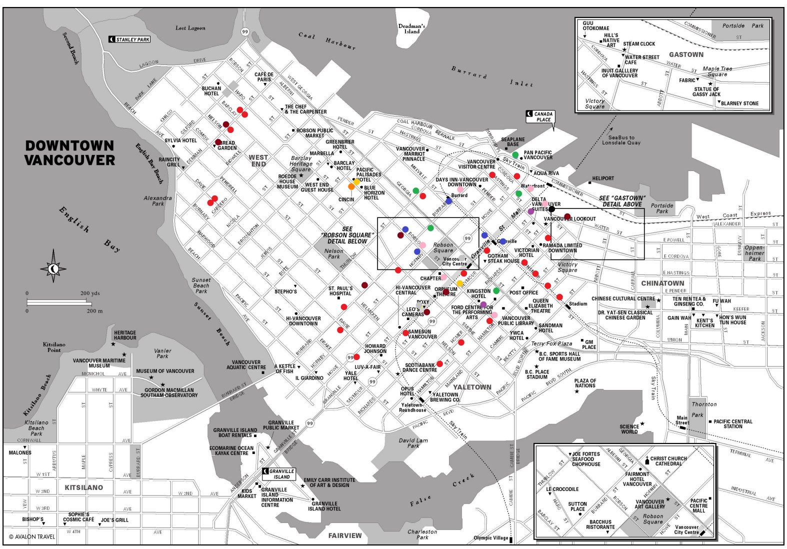


Figure 7: Optimal locations for food trucks: integer linear programming model

It is evident, from Figure 7, that food trucks serving Canadian and American cuisine are placed relatively close to each other. This is due to the lack of negative influence between food trucks of the same type in the model. These trucks are cluttered in the South and South-East primarily due to the existence of many restaurants that serve Canadian and American cuisine all around Robson Square. Because there are less Mediterranean and Middle Eastern type restaurants in downtown Vancouver, it is preferable to place food trucks of this categories near the center, where the pedestrian density is high. As with the previous example, due to the lack of negative influence between food trucks of the same type, Mediterranean and Middle Eastern food trucks are located in the centre area in a circular formation. Overall, food truck tend to gather around areas with the most pedestrians, hence increasing that of potential customers to the truck.

6.2 Integer Non-Linear Programming Model

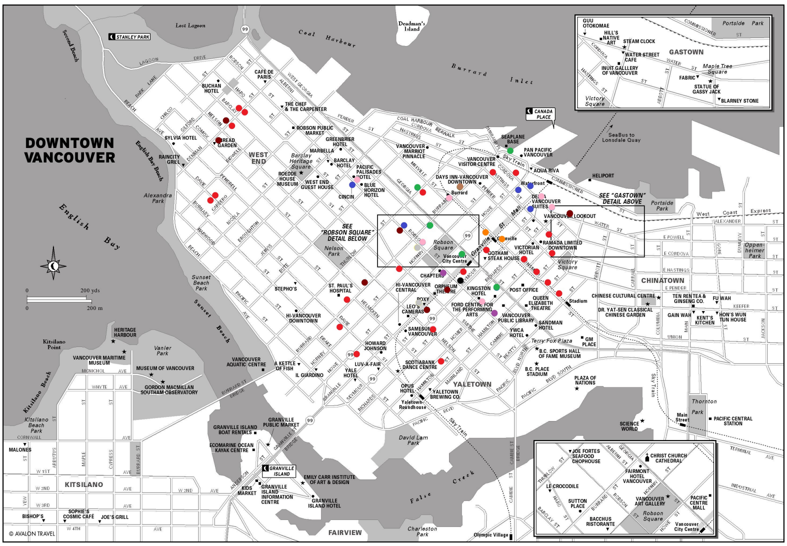


Figure 8: Optimal locations for food trucks: integer non-linear progamming model

There is no real significance between where Canadian and American type food trucks are placed in this model compared to the previous model. This is due to the influential values of restaurants being higher than food trucks. The results reflect this point and show that clustering food vendors with similar food types together is better than having them in closer proximity with local restaurant of the same type; this can potentially damage both parties' sales. This result parallels with our original motivation to tackle the excessive competition with local restaurants. Dunsmuir Street has a relatively high average pedestrian count, yet there are not many restaurants that fall under the category of Canadian/American. Given this fact, this street may be a very appealing location for food trucks of type Canadian/American to set up their business. Compared to the previous model, Mediterranean and Middle Eastern type food trucks, being not very limited due to the lack of similar type restaurants, have spread out a decent amount. Due to the fact that the central area of downtown Vancouver is the most pedestrian dense area but lacks Japanese restaurants, it would be most preferable to locate food trucks there that serve Japanese cuisine.

6.3 Integer Linear Programming Model With 15 Additional Licensed Food Trucks

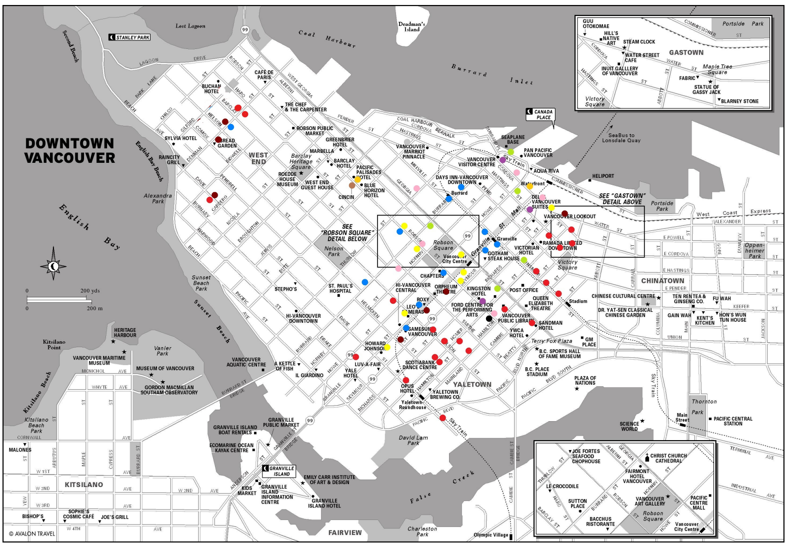


Figure 9: Optimal locations for food trucks with 15 additional: integer linear programming model

Categories	T	N(T)
Cafes (Coffee and Desserts)	1	0
Canadian/American Style Food	2	0
Mediterranean/Middle Eastern	3	6
South East Asian	4	0
Japanese	5	0
Mexican	6	0
Italian	7	1
Indian	8	0
European	9	0
Chinese	10	0
Korean	11	8

Figure 10: Additional food trucks result: integer linear prgramming model

Because of the lack of both restaurants and food trucks serving Korean and Mediterranean/Middle East cuisine, it is suggested that a part of the 15 licenses be handed out to food vendors serving these types of food. As mentioned, food trucks of type Canadian/American are placed near the South-East region, where Mediterranean/Middle Eastern, Japanese, and the newly suggested Korean food trucks are distributed quite densely in the middle area.

6.4 Integer Non-Linear Programming Model With 15 Additional Licensed Food Trucks

Just as the linear model with 15 additional licensed food trucks' result, very similar choices of new licensing food trucks were selected. Regarding the optimal locations, the central area has more variety compared to the linear model. Mediterranean/Middle Eastern and Korean cuisine food trucks now scatter evenly around downtown, listing as top second and third place on what types of food these food trucks offer.

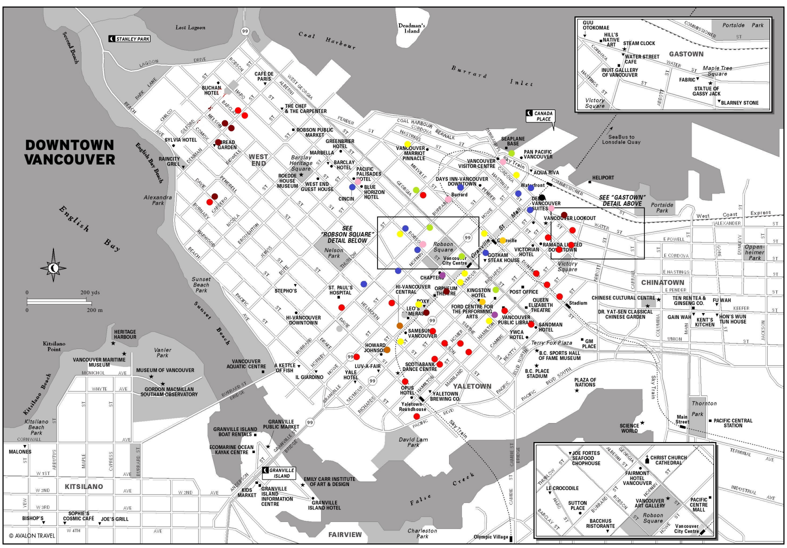


Figure 11: Optimal locations for food trucks with 15 additional: integer non-linear programming model

Categories	T	N(T)
Cafes (Coffee and Desserts)	1	0
Canadian/American Style Food	2	0
Mediterranean/Middle Eastern	3	5
South East Asian	4	0
Japanese	5	0
Mexican	6	0
Italian	7	0
Indian	8	1
European	9	0
Chinese	10	0
Korean	11	9

Figure 12: Additional food trucks result: non-linear programming model

6.5 Programming Models Without Korean Food Trucks

Categories	T	N(T)
Cafes (Coffee and Desserts)	1	0
Canadian/American Style Food	2	0
Mediterranean/Middle Eastern	3	7
South East Asian	4	0
Japanese	5	0
Mexican	6	0
Italian	7	1
Indian	8	2
European	9	1
Chinese	10	4
Korean	11	0

Categories	T	N(T)
Cafes (Coffee and Desserts)	1	0
Canadian/American Style Food	2	0
Mediterranean/Middle Eastern	3	2
South East Asian	4	9
Japanese	5	0
Mexican	6	0
Italian	7	0
Indian	8	2
European	9	0
Chinese	10	2
Korean	11	0

Figure 13: Additional food trucks result without Korean: left = linear, right = non-linear

Due to the lack of Korean restaurants and no food trucks serving Korean food, it is quite obvious that it is a preferable choice to consider. These two models remove Korean type food trucks as a viable choice in order to see if any alternative types would be preferable. The 15 ideal food trucks to license are listed above, and the location results can be found in Appendix 9.3.

In the linear model, Mediterranean/Middle Eastern is still the first choice. Due to the low number of restaurants that serve Chinese or Indian food, our model suggests that these would be good food truck types to license.

Regarding the non-linear model, as restaurants of the same type in close proximity are not preferred, it is no longer viable to license Mediterranean/Middle Eastern food trucks in large quantities when Korean food trucks are no longer a choice. Instead, South East Asian Food is suggested. Just like the linear counterpart, Indian and Chinese food are still good choices to be new food trucks in Vancouver.

6.6 Comparison With Current Locations

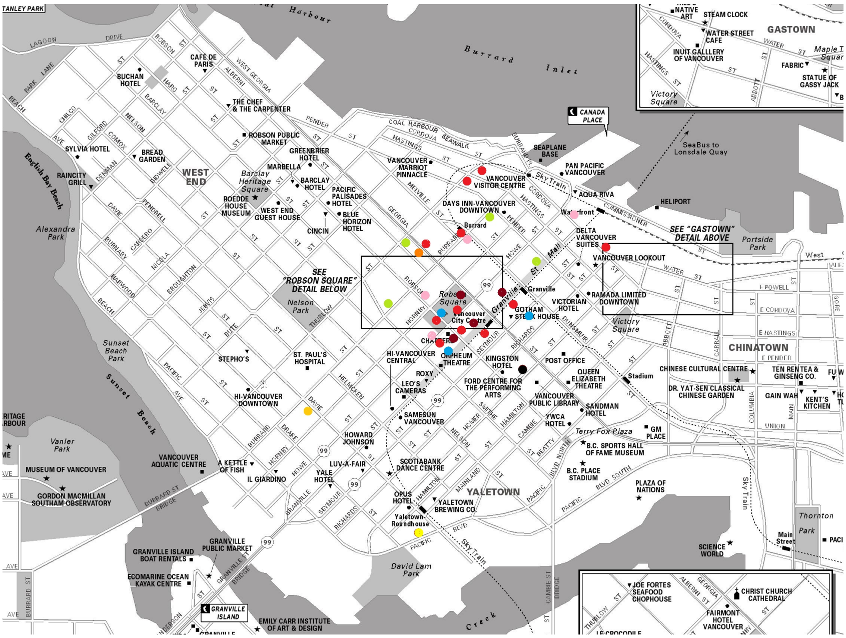


Figure 14: Food trucks locations in August 2012

Note: Figure 14 only shows food trucks that were operating within this paper's consideration area.

According to data obtained, past food trucks were heavily concentrated in the central commercial area where pedestrian density is highest. While it may seem obvious for food truck owners to operate at the central commercial area, it is also clear restaurant owners may be unhappy about the current allocation of food trucks. A majority of these trucks served Canadian/American type food, alarming the many restaurants in that area serving similar food.

The results from our project models suggest that Canadian/American food should stay clear of Robson Square. Both current and optimal locations for Mediterranean/Middle Eastern food trucks have them located around Robson Square. Furthermore, incorporating Japanese food trucks in the same area would allow for more consumer choice.

Overall, the current locations are much more concentrated than optimal placement, discomforting local restaurants. Note that a portion of food trucks not fitting in the area of interest are placed in the South-West beach area. This placement is due to seasonality: the South-Western area is preferred during the summer for the increased potential customers. If data were collected for this area, we predict the optimal placement would include a majority of Canadian/American food trucks there.

7 Conclusion

With the use of our results based on the various models, a comparative analysis is conducted to see the effectiveness of the optimization models. While it is difficult to analysis the results using only coloured points on a map or numbers on an Excel sheet, we have developed an easier visual method to do so. This method, the colour coded density graphs, Figure 15, can be thought of as the amount of influence they have in the area around them. Using the pedestrian average density graph as an example, if a surrounding area contains more streets that have a higher pedestrian average, then the entire area in general will increase in magnitude. The graphs were obtained by adding each 3 by 3 blocks into one new block and then forming surface graphs using Microsoft Excel. These graphs were rotated counter-clockwise by approximately 45 degrees to mirror the excel matrix compared to the actual downtown Vancouver. For the sake of simplicity, directional descriptions will refer to Figure 15 and not the actual map.

An analysis done using the pedestrian density graph concludes that the South and South-East region will be the most beneficial locations for food trucks because they hold the highest potential customer average. The optimal solution naturally has a high correlation to the graph, which results in heavy placements of food trucks within and around this same regeion. It may not be apparent that there are other potential areas fit for placing food trucks, but according to the pedestrian data, it appears that the West area also has a high pedestrian frequency. In short, because of how the objective function was set up, the optimal solution would avoid locations of high restaurant density while taking into account places with high pedestrian density.

The linear food truck density graph, Figure 7, shows that it avoids the mid-West area (where the majority of restaurants are located) while placing a good number of food trucks in the West and mid-East area (where the pedestrian density graph peaks). In the Northern region, it clearly avoids restaurant heavy areas and food trucks reside in the areas between two restaurant peaks on the map.

The non-linear food truck density graph is quite similar to the linear graph. However, one notable difference is that it is spread out much more evenly. This is especially apparent in the South-East area, where more food trucks are placed. This is directly due to the negative influence food trucks of the same type would have on each other.

The food truck density graph for the linear model, when incorporated with an additional 15 new trucks, shows that the best area to expand and locate more food trucks is the Northern area; this remains true as the amount of food trucks continue to increase. The nonlinear model showing food truck density also shows a very similar density graph. If there were more data given for other location, more interesting and diverse results would be expected.

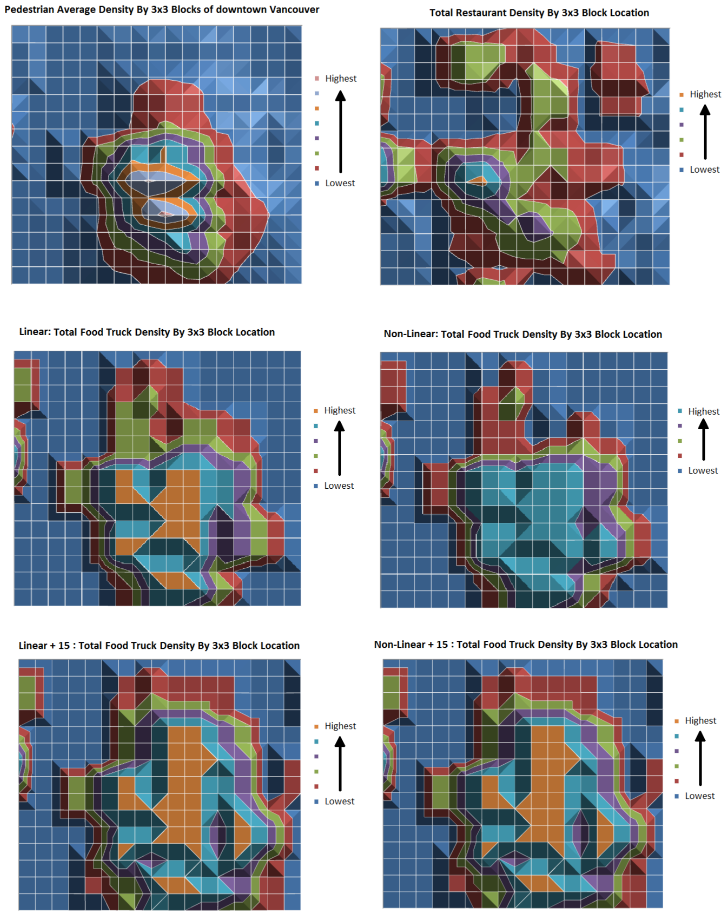


Figure 15: Coloured density maps

Using the map derived from the results, Figure 7-14, section 7 shows a more circular formation around the most pedestrian dense areas (around Robson Square), where current locations cluster the food trucks in the area directly. The circular formation is due to the construction of an objective value and how there is a negative influence with food trucks serving similar foods; the degree of negative influence depends on the proximity these food trucks are to each other. However, this method of food truck allocation may be effective. Placing food trucks in areas close by, but not on the streets with an abundance of local restaurants may conflict with local restaurants. This placement minimizes competition between restaurants and food trucks while both vendors have equal access to potential customers passing by. New optimal solutions suggested by this paper also give pedestrians and citizens more diversity in terms of food choices around downtown Vancouver. Although further research and information will definitely strengthen the effectiveness of the results and make it more conclusive, these various modelling methods provide an interesting alternative in tackling the food truck problem.

Also, food trucks serving Japanese, Mediterranean/Middle Eastern, South East Asian Food, Indian, Korean, and Chinese are recommended to apply for a license. These type of vendors are less likely to create a negative impact to local restaurants, as they add diversity to certain pedestrian dense areas of downtown. Because these cuisine are rare in the proposed areas, it is expected that introducing to these new types of food trucks will have little to no impact on existing food trucks. The remaining food truck types can be considered not preferable for the City to license as there will be an abundance already. Many cities, including Vancouver, are finding more effective ways to decide the best places for food trucks to operate without hurting local businesses; this paper suggests not only the various quantitative methods of tackling this problem, but also gives qualitative insight on factors that influence these location choices.

7.1 Preferred Model

Through analysis of each of the models using density graphs and doing comparisons with the current locations, the non-linear model is suggested for general purposes. The reason why the non-linear model was chosen was because it increases food diversity by preventing food trucks of the same type from clustering together in a specific area. Although this effect is seemly not drastic based off of the results, it is expected to have a better effect when considering a larger area, or when more food trucks are introduced to the problem. A disadvantage of using this model, however, is that the objective function is generally smaller compared to the linear version, which suggests that food truck owners may prefer the linear locations as it, on average, has more pedestrians (hence more potential customers). While these models try to maximize potential customers for food trucks, the main situation at hand is to prevent food trucks from hurting restaurant businesses. The linear model is often times not favourable because it tends to cluster together food trucks serving similar food, which hurts not only local restaurant businesses, but also other food trucks.

In short, it is important to consider not only the risk of food trucks affecting restaurant businesses, but also the proximity of food trucks to each other, as both negatively impact both parties. However, exceptions where a large influx of people will occupy a certain location for a long period of time (seasonal situations, special recreational events, cultural events) may suggest circumstances where the linear model would be more practical. In scenarios where the number of potential customers is very large, it may be advantageous to have foods trucks serving the same type of food in a specific location.

When deciding which model to utilize, it is important to consider the location's demographic. In this case study where the area of interest is downtown Vancouver, the nonlinear version seems to be more effective overall.

7.2 Difficulties Encountered

A problem encountered during the study was translating the streets in the designated area to an Excel spreadsheet. Roads in downtown Vancouver are not constructed into a perfect grid; diagonal roads and minor roads have been a problem for that Excel spreadsheets are in perfect grids. As a result, imaginary roads have been added to solve this issue. A more accurate solution can be obtained in a further study where the model would be implemented in a program which can solve the street issue.

Another problem that was encountered during the study was translating all the pedestrian data and restaurant data into Excel spreadsheets. Although possible, inputting data onto the spreadsheets for downtown Vancouver was a long and tedious process. If the model was generalized to all locations around the world, data input for a larger area would be extremely difficult. As a result, finding or producing a software capable of handing repetitive work, such as translating data onto Excel spreadsheets, would save a lot of time and labour.

7.3 Difficulties Restricting Models And Further Research Plans

While investigating the nature of these models, tests were ran using the linear and nonlinear versions without two constraints: first one was having only one food truck at each location, while the other was leaving no more than five food trucks within a 2.5 minute walking radius from each other. As expected, the results lead to food trucks of different types to be located too close to each other. This is especially prevalent in dense areas such as Robson Square. While these constraints are important in the models, they bound the feasible solution tightly and lead to quite restrictive results. It may then be preferable to relax the problem by lifting these two constraints by replacing the original objective function with a penalty function. Using this method, the two constraints are now integrated into the objective value, and the optimal locations for this model may actually break the previous lifted constraints. In doing so, however, will lead to a negative impact upon the new objective (penalty) function. By doing so, it may lead to more natural and practical results.

In addition, there are instances where food trucks, regardless of the type of food they sell, can actually increase the average sale of both parties when placed in close proximity of each other. Further research is suggested to be done following this path, which may lead to a more effective model.

While there were many issues that surfaced when creating a model to tackle this problem, such as the lack of accessible information and other research papers on this topic, we were able to avoid them by stating reasonable assumptions. Three factors were identified as vital sources of information that shaped the entire project. As time progressed, two main models were created, with one being more favourable than the other. This paper considers a model that is general enough to be applicable to other cities by doing research on demographics and adjusting the influence factors as needed. Through analysis of various results via graphical and quantitative analysis, it is clear that the model successfully does what is intended to: to find optimal locations to maximize profit for food truck owners while preventing restaurant businesses to suffer from food trucks. Further research could eliminate the need for certain assumptions and restrictions and make it possible to implement the model into a food truck location designating program.

8 Appendix

8.1 Interviews

1. Triple O (a food court restaurant under Bentall center mall) [Mr. Liu]
   (a) believes food trucks and food carts are too different from local restaurants
   (b) considers food trucks not a competitor to his business
2. JapaDog (Japanese hot dog food on the West side of Burrard St.) [Yoshi]
   (a) doesn't know if the current location is good or bad, the location was assigned by the government
   (b) from his observation, there are not many regular customers, the majority of them just found it convenient
3. HotDog (Hot dog food on the East side of Burrard St.) [anonymous]
   (a) feels there are no effect from other food trucks, even though JapaDog is located right around the corner
   (b) is willing to have other food trucks nearby selling different food
4. Red burrito (Robson St. & Seymour St.) [Adriana]
   (a) feels business will be better if there are no food trucks around
   (b) conerns about health and food safety problems for food trucks, such as clean water

8.2 Files

Files used in this project are made available online. The links are available below:

1. Linear Model Excel File

   https://www.dropbox.com/s/arz68f95ibgiwv2/Food Truck Optimization Results - Linear.xlsx

2. Non-Linear Model Excel File

   https://www.dropbox.com/s/z15fg0fu917d4wt/Food Truck Optimization Results - NonLinear.xlsx

3. Linear Model With Additional Trucks Excel File

   https://www.dropbox.com/s/eq8ycxc68k21d02/Food Truck Optimization Results - Linear Addition.xlsx

4. Linear Model With Additional Trucks Without Korean Excel File

   https://www.dropbox.com/s/yuxrvq9r5jvhbux/Food Truck Optimization Results - Linear Addition Minus Korean.xlsx

5. Non-Linear Model With Additional Trucks Excel File

   https://www.dropbox.com/s/mxxszr3jfccr9bh/Food Truck Optimization Results - NonLinear Addition.xlsx

6. Non-Linear Model With Additional Trucks Without Korean Excel File

   https://www.dropbox.com/s/nd9a43zms2v8pdi/Food Truck Optimization Results - NonLinear Addition Minus Korean.xlsx

7. List of All 55 Food Trucks That Were Active in August 2012

   https://www.dropbox.com/s/m0s3aq6nk0jip5y/Food Truck Categorized August

8. List of All 446 Restaurants For Downtown Vancouver Used in the Model

   https://www.dropbox.com/s/7beetv05mh1zj4u/Final downtown Restaurants - with types.xls

9. 2008 Pedestrian Data for Vancouver

   https://www.dropbox.com/s/29of24sxwvvovap/2008 Ped Study - Appendix A.pdf

References

[1] CBC (Nov. 1, 2012). *Vancouver's Food Carts Getting Too Close, Say Restauranteurs*. Retrieved from http://www.huffingtonpost.ca/2012/11/01/vancouver-food-trucks-restaurants_n_2060331.html.

[2] City of Vancouver (Aug. 2012). Retrieved from http://vancouver.ca/your-government/open-data-catalogue.aspx.

[3] City of Vancouver (2012). *Vending Information Guide for Stationary Food and Non Food Permit Locations.* Retrieved from http://vancouver.ca/files/cov/street-vending-information-package.pdf.

[4] City of Vancouver (2013). *Public Vancouver Map*. Retrieved from http://vanmapp.vancouver.ca/pubvanmap_net/default.aspx.

[5] Delaware Health and Social Services (Nov. 2012). *Plan Review and Approval for Mobile Food Units*.

[6] Flash Hearth. Retrieved from http://www.flashearth.com.

[7] Food Queen Media (2013). Retrieved from http://thefoodqueen.com.

[8] Good Child, M. (1984). *ILACS: A Location-Allocation Model for Retail Site Selection*. Journal of Retailing, 60(1).

[9] Google Maps (2013). Retrieved from https://maps.google.ca.

[10] Hermosillo, J. (Mar. 2012). *LONCHERAS: A Look at the Stationary Food Trucks of Los Angeles*.

[11] Mui, M (Jan. 8, 2013). *City Council Looks into Impact of Vancouver Food Carts*. Retrieved from http://vancouver.24hrs.ca/2013/01/08/city-council-looks-into-impact-of-vancouver-food-carts.

[12] Korstorm, G. (Oct. 2012). *Proliferation of food carts irks city restaurateurs*. Retrieved from http://www.biv.com/article/20121030/BIV0109/121029929/proliferation-of-food-carts-irks-city-restaurateurs.

[13] Reupbbq (Nov. 2, 2012). *BC Restaurants Call Out Food Carts*. Retrieved from http://reupbbq.com/2012/11/02/bc-restaurants-call-out-food-carts.

[14] Smith. A. (2013). Email Communication.

[15] Street Food App. (2013). Retrieved from http://streetfoodapp.com/vancouver/history.

[16] The McMaster University Sustainable Communities Research Group. *Neighbourhood Structure*. Retrieved from http://www.eng.mcmaster.ca/civil/sustain/designparam/dparameters1.htm

[17] Vancity Buzz (Jun. 2012). Retrieved from http://www.vancitybuzz.com/image.php?src= http://www.vancitybuzz.com/wp-content/uploads/2012/06/photo-15-1024x768.jpg&w=650&a=t.

[18] Walker, J. (2013). http://www.humantransit.org/2011/04/basics-walking-distance-to-transit.htm.