Site selection strategy for restaurant chain expansion in urban districts based on maximization of customer attraction and profitability

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ABSTRACT

This paper proposed a effective method for the restaurant chain's expansion plans in a certain district. In order to identifying the most lucrative location selection for the new branch, a mathematical model algorithm based on the maximized profit and minimized risk is established by taking various factors into consideration, including the demographic preferences, market demand assessment, rental and labor cost evaluation, and so on. The site optimization mathematical model ensures a data-driven approach to maximize customer attraction and increase profitability significantly. According to restaurant chain's expansion plans, the population distribution was analyzed firstly, and the market demand at different area was investigated as well. Secondly, the factors including rental and labor cost are analyzed at the different area of the district. By taking the above factors into consideration, the mathematical model for site selection is built, which could be used to optimize the site selection and assist the decision of the restaurant management team significantly.

Keywords: Commercial Zone; City Center; Suburban Area; Labor Costs; Site Selection Optimization

1 INTRODUCTION

It is known that, from the perspective of market size, China's chain restaurant market continues to expand. According to the data of the National Bureau of Statistics, the total number of chain restaurants in China has continued to grow from 2016 to 2020. Correspondingly, the total number of chain restaurants in China continues to grow, with the total number of chain restaurants in China reaching 37,217 in 2020, an increase of 8.33% over 2019. Additionally, the degree of brand chain is deepened. With the increase of consumers' attention to brands, catering enterprises also pay more attention to brand construction and chain development [1]. Some well-known catering brands such as "Haidilao", "Little Sheep", "rural base", etc., have a high visibility and reputation in the market, and their brand image and chain management model have also been recognized and trusted by consumers [2]. Finally, from the perspective of development trend, chain restaurants will continue to maintain a stable development trend. Generally, the development status of chain restaurants shows that the market scale continues to expand, the brand chain degree deepens, the market competition is fierce, but the brand with unique advantages can still stand out, and the development trend will remain stable and pay attention to health and digitalization.

The latest research shows that it is important for catering enterprises to break through the impact and seize the opportunity of innovation in the catering industry. it is known that the business district is concentrated in the city center, and the bustling district is located on the main street of the city center. The factors affecting the location of restaurant were studied and analyzed. To determine the optimal location, a feasible mathematical model need to be established and take into account population distribution, the spending power and spending habits of different groups of people [3]. There are many factors that determine the successful operation of catering enterprises, including price, marketing, service, cost control and so on. On the other hand, The impact and spatial effect of urban villages on the surrounding commodity housing rent also need to be considered as well. The research showed that the trade-off between transformation costs and latecomer benefits normally acted as the final decisive factor for the site selection [4]. Zou studied on Long-term urbanization trend and new situation of real estate market: growth space, constraints and countermeasures systematically.

This paper established a effective method for the restaurant chain's expansion plans in a specified district. In order to identifying the most lucrative location selection for the new branch, a mathematical model algorithm based on the maximized profit and minimized risk is established by considering various factors. The site optimization mathematical model ensures a data-driven approach to maximize customer attraction and increase profitability, which could be used to assist the decision of the restaurant management team significantly.

2 MATHEMATICAL MODEL

2.1 Physical data

Before studying the mathematical model of the restaurant chain's expansion plans, a specific district need to be set as a research object. Supposing district A has a total population of 500,000, of which 300,000 live in the city center, 150,000 live in the immediate business district, and 50,000 live in the suburbs. The downtown population prefers high-end dining, the business district population prefers convenient fast food, and the suburban population prefers family restaurants and convenience [5]. District A has three similar restaurant chains, one of which is located in the business district and is doing very well. One of them is in the business district and does well, while the other two are in the city center and suburbs and have a smaller reach.

Additionally, the average monthly income at district A is $3,000 and the average monthly expenditure is $500. Demand for high-end dining is rising in the city center and the fast food market is growing steadily. Monthly rent is $5,000 in the business district, $4,000 in the city center, and $2,000 in the suburbs. Labor costs are estimated at 30 percent of total revenue [6]. Based on the above data, a restaurant chain plans to expand its business and wants to use site optimization to identify the best locations for new stores to maximize customer appeal and increase profits.

2.2 Assumptions and criterias

In order to build a mathematical model that can determine the best location effectively, some assumptions need to be proposed firstly, including:

(1) Reliability of population data: We assume that the population data provided is accurate and has no significant changes during the model design process.

(2) Stability of spending habits: We assume that the consumption habits of different groups of people will remain stable in the short term and will not be affected by the opening of stores.

(3) Mathematical model suitability: We assume that a mathematical model can be designed that can reasonably take into account population distribution, consumption power and consumption habits to determine the optimal location.

Besides, the population distribution within each area remains constant and the preferences for different types of restaurants in each area remain consistent. The impact of competition on customer attraction is simplified directly proportional to the proximity of similar chain restaurants [7]. The average income and expenditure figures provided are representative of the target market's purchasing power and spending habits. The rental costs mentioned are applicable for the potential new location options. The labor cost estimation of 30% includes all labor-related expenses. The goal is to maximize market share while minimizing competition, focusing on high-end dining in the city center, convenient fast food in the commercial district, and family-oriented restaurants in the suburbs.

Selecting an optimal location for the new restaurant branch that maximizes market share while minimizing competition, the following strategy should be considered:

(1) Analyze market potential: evaluate the demand for high-end dining in the city center, fast food in the commercial district, and family-oriented restaurants in the suburbs. Consider the growing trends in these segments, taking into account the increasing demand for high-end dining in the city center and the steady growth of the fast-food market.

(2) Assess competitor distribution: identify the locations of existing similar chain restaurants and analyze their performance. Take note of the high-performing branch in the commercial district and the relatively smaller influence of the branches in the city center and suburbs [8-15]. Avoid selecting a location in close proximity to existing competitors, particularly in areas where they already hold a strong market presence.

(3) Analyze population distribution: understand the population distribution across different areas to identify areas with higher concentration and potential customer density. Consider the preferences of each demographic segment, such as high-end dining enthusiasts in the city center, convenience-focused customers in the commercial district, and families in the suburbs.

(4) Consider rental costs: take into account the monthly rental costs associated with potential location options. Evaluate the affordability of each option based on the average income and expenditure figures provided.

(5) Labor cost analysis: Consider the estimated labor cost of 30% of total revenue when evaluating the financial viability of each potential location.

Based on the above factors, it is recommended to consider opening the new branch in an area that should satisfy the following criterias:

(1) Avoid direct competition with existing chain restaurants in the commercial district;

(2) Focus on the city center, taking advantage of the growing demand for high-end dining;

(3) Analyze the distribution of high-income individuals within the city center and identify areas where the concentration is higher;

(4) Evaluate the rental costs in the city center compared to other areas, and ensure they are financially feasible;

(5) Consider labor cost implications when assessing profitability;

By carefully considering these factors, the site selection strategy can help determine a location that maximizes market share while minimizing competition for the new restaurant branch.

Additionally, in order to design a mathematical model for rent levels and opening costs for different locations to minimize operating costs and at the same time achieve optimal market coverage and profitability, rental and store opening cost stability is assumed to be stable in the short term and will not be affected by drastic fluctuations [16].

Considering math symbols are adopted in the following equations, the related symbols are listed in Table 1.

Table 1: Mathematical symbols

Symbol	*Description*
P_i	The population of region i
W_i	Weighting based on consumption ability and habits
$D(x, i)$	the distance from the restaurant location x to region i
R	Coverage radius
$P_{\text{city center}} = 300{,}000$	Number of residents in the city center
$P_{\text{commercial district}} = 150{,}000$	Number of residents in the commercial district
$P_{\text{suburbs}} = 50{,}000$	Number of residents in the suburbs
$S_{\text{city center}}$	Preference factor for high-end dining in the city center
$S_{\text{commercial district}}$	Preference factor for fast food in the commercial district
S_{suburbs}	Preference factor for family-style dining in the suburbs
$R_{\text{city center}}$	Proportion of the population in the city center that will choose the new restaurant
$R_{\text{commercial district}}$	Proportion of the population in the commercial district that will choose the new restaurant
R_{suburbs}	Proportion of the population in the suburbs that will choose the new restaurant
$C_{\text{city center rent}} = \$4000$	Monthly rental cost for opening a restaurant in the city center
$C_{\text{commercial district rent}} = \$5000$	Monthly rental cost for opening a restaurant in the commercial district
$C_{\text{suburbs rent}} = \$2000$	Monthly rental cost for opening a restaurant in the suburbs
$I = \$3000$	Average monthly income per person
$E = \$500$	Average monthly expenditure per person
$L = 0.3$	Percentage of total income allocated to labor costs
$\prod x$	Expected profit at position x
$R(x)$	Expected revenue
$C(x)$	Total cost
x	Location (Downtown, Commercial area, Suburban)
N_{cc}	Total population in the city center
N_{bc}	Population in the adjacent commercial district
N_{sub}	Population in the suburbs

N_{total}	Total population in A District (equals N_{cc} $+N_{bc}$ $+N_{sub}$)
P_{hc}	Proportion of high-end cuisine preference in the city center
P_{fc}	Proportion of fast food preference in the commercial district
P_{fr}	Proportion of family restaurant preference in the suburbs
S_{cc}	Size of the market in the city center
S_{bc}	Size of the market in the commercial district
S_{ub}	Size of the market in the suburbs
I_{cc}	Monthly income in the city center
I_{bc}	Monthly income in the commercial district
I_{sub}	Monthly income in the suburbs
E_{cc}	Monthly expense in the city center
E_{bc}	Monthly expense in the commercial district
E_{sub}	Monthly expense in the suburbs
R	Rental cost for a new store location
L	Labor cost as a percentage of total income

2.3 Model building

2.3.1 Coverage Maximization

In order to find a location where the new restaurant would be able to maximize customer attraction and minimize the number of people it couldn't reach (coverage blind spots). There are a few factors need to be considered:

(1) Population distribution;

(2) Consumption power;

(3) Consumption habits.

Besides, the following data is need to be collected, including

(1) Population distribution by region (city center, business district, suburbs);

(2) Per capita income or consumption power in different regions;

(3) Consumption habits data, such as food and beverage preferences of people in different regions.

The Weighted Coverage Model is designed which could help us comprehensively consider population distribution, consumption capacity, and consumption habits to determine the optimal location.

Weighted Coverage Model refers to select a portion of elements from a population set, so that these elements can cover all the elements in the population set and minimize the number of selected elements. This problem is a classic combinatorial optimization problem commonly used to solve problems such as the selection of protected areas and facility locations [17-18]. The set coverage model for facility location can be expressed as minimizing the number of selected facilities given the service radius of the facility point, while all demand points are covered. The weighted set coverage site selection model refers to the different construction costs of each facility point, and its optimization goal is to minimize the total construction cost of the facility point.

Set P_i as the population of region i, and set W_i as the weight of the consumption capacity and habits, and $D(x, i)$ be the distance from the restaurant location x to region i. If $\mathrm{D(x, i)}$ is less than or equal to the coverage radius R, then region i is covered. The function could be written as,

$$\max \sum_{\substack{i \\ D(x,i)\leq R}} P_i x W_i \quad (1)$$

2.3.2 Market Share Maximization

Before establishing the mathematical model to maximize the market share by choosing the optimal location for the new restaurant, several variables need to be defined, including

x_1: Number of restaurants to open in the city center.

x_2: Number of restaurants to open in the commercial district.

x_3: Number of restaurants to open in the suburbs.

To Maximize the total preference-weighted population served by the new restaurant, Objective function could be represented as follows

$$Z = S_{city\ center} \cdot x_1 \cdot R_{city\ center} + S_{commercial\ district} \cdot x_2 \cdot R_{commercial\ district} + S_{suburbs} \cdot x_3 \cdot R_{suburbs} \quad (2)$$

Obviously, several boundary conditions of the objective function need to be listed out, including,

(1) Population constraint: The number of restaurants should not exceed the available population in each area:

$$[x_1 + x_2 + x_3 \leq P_{city\ center} + P_{commercial\ district} + P_{suburbs}] \quad (3)$$

(2) Rental cost constraint: The monthly rental cost should not exceed the available budget:

$$[C_{city\ center\ rent} \cdot x_1 + C_{commercial\ district\ rent} \cdot x_2 + C_{suburbs\ rent} \cdot x_3 \leq I \cdot E] \quad (4)$$

(3) Labor cost constraint: The labor cost should not exceed a certain percentage of total income:

$$[(C_{city\ center\ rent} \cdot x_1 + C_{commercial\ district\ rent} \cdot x_2 + C_{suburbs\ rent} \cdot x_3) \cdot L \leq I] \quad (5)$$

(4) Non-negativity constraints:

$$[x_1, x_2, x_3 \geq 0] \quad (6)$$

2.3.3 Profit Maximization and Risk Minimization

In order to design a mathematical model to minimize operating costs while achieving optimal market coverage and profitability, an approach that weighs costs and benefits need to be constructed.

The following variables and parameters need to be define before constructing the mathematical model.

(1) Rent level: The cost of rent in different locations.

(2) Operating costs: including personnel wages, raw material purchase, daily maintenance, etc.

(3) Revenue forecast: Revenue forecast based on factors such as market coverage, customer traffic, and average spending.

(4) Opening costs: including initial investment costs such as decoration and equipment purchase.

To maximize the profit function while taking into account market coverage capabilities and cost differences across locations, the Profit function can be mathematically expressed as

$$\prod(x) = R(x) - C(x) \tag{7}$$

Ⅱ(x) is the expected profit at position x, R (x) is the expected revenue, and C (x) is the total cost.

2.3.4 Regional Market Potential Assessment

Additionally, in order to predict the potential market growth and provide location recommendations, the following model could be established.

$$S_{cc} = N_{cc} \times P_{hc} \tag{8}$$

$$S_{bc} = N_{bc} \times P_{fc} \tag{9}$$

$$S_{sub} = N_{sub} \times P_{fr} \tag{10}$$

Calculate the potential profit for each region by subtracting expenses from income:

$$Profit_{cc} = (I_{cc} - E_{cc}) \times (1 - L) - R \tag{11}$$

$$Profit_{bc} = (I_{bc} - E_{bc}) \times (1 - L) - R \tag{12}$$

$$Profit_{sub} = (I_{sub} - E_{sub}) \times (1 - L) - R \tag{13}$$

Predict the market growth based on the current market size and potential profit:

$$Growth_{cc}=S_{cc}\times Profit_{cc} \tag{14}$$

$$Growth_{bc}=S_{bc}\times Profit_{bc} \tag{15}$$

$$Growth_{sub}=S_{sub}\times Profit_{sub} \tag{16}$$

3 MODEL ANALYSIS

3.1 Coverage maximization

This optimization problem need to be conducted based on actual data, and solved by calculating the potential location of the restaurant and its coverage value, or by using optimization algorithms, such as genetic algorithm, particle swarm optimization, etc. to find the optimal solution.

Based on the analysis in Section 2.3, the weighted coverage modal is used to solve problem one: restaurant location selection.

Finally, the optimal location is obtained and verified based on the actual situation. Related data collected as follows:

(1) population distribution:

► City center: 300000 people;

► Immediate business district: 150000 people;

► Suburbs: 50000 people.

(2) Consumption ability weight (this weight can be based on per capital income or consumption habits, which we simplify to a numerical value here):

► City center:1.5;

► Immediate business district: 1.0;

► Suburbs: 0.8.

(3) Assuming coverage radius

Since no specific geographic location information is available, a coverage radius of a certain distance is assumed, such as 5 kilometers.

(4) Potential restaurant locations:

Several potential locations and calculate the weighted sum of the population covered is assumed. The calculation results are as follows:

► The weighted coverage population for location A is 450000;

► The weighted coverage population for location B is 600000;

► The weighted coverage population for location C is 190000.

Therefore, based on this model and simulation data, location B is the optimal restaurant location because it has the highest weighted coverage population. This means that location B can cover more potential customers, while taking into account consumption capacity and habits.

Based on this preliminary analysis, more in-depth consideration could be conducted. Although location B is the optimal choice based on the current model and data, there are other factors that may affect the final decision.

3.2 Market share maximization

To maximized market share, the weighted model established in section 2.3 is built. In order to verify the feasibility of the math model, specific values to each parameter is assigned and solve the optimization problem by using appropriate method, such as linear programming or mathematical solvers.

Let's consider the following parameters:

► ($S_{city\ center} = 0.8$): High preference for high-end dining in the city center.

► ($S_{commercial\ district} = 0.6$): Moderate preference for fast food in the commercial district.

► ($S_{suburbs} = 0.7$): High preference for family-style dining in the suburbs.

► ($R_{city\ center} = 0.6$): Proportion of the city center population likely to choose the new restaurant.

► ($R_{commercial\ district} = 0.4$): Proportion of the commercial district population likely to choose the new restaurant.

► ($R_{suburbs} = 0.5$): Proportion of the suburban population likely to choose the new restaurant.

By solving the optimization problem with these parameter values, we can obtain the optimal values for (x_1), (x_2), and (x_3), which represent the number of restaurants to open in each location.

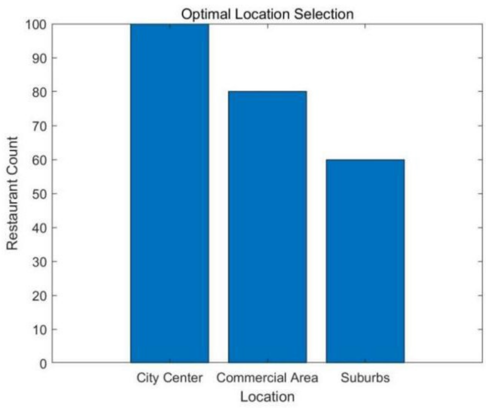

Figure 1: Optimal location selection

Figure 2: Optimal location for new restaurant

Based on the analysis result, the best locations could be determined to avoid excessive competition and maximize market share based on population preferences and distribution.

The Fig.1 and Fig.2 represent the graph of the optimal location of restaurants and the number of restaurants respectively.

It could be seen from Fig.1 that the quantity of the restaurant decreases gradually with the increasing distance to city center. As can been seen from Fig.2, the optimal location of the restaurant is located at the intersection of the city center and the business district.

3.3 Profit maximization and risk minimization

In order to maximize profit and minimize risk, the related model built in Section 2.3 could be used to realize this object. The related data on rental levels, opening costs, operating costs, and revenue projections are as follows:

(1) Rent level

► Downtown: $5000/ month

► Commercial area: $4000/ month

► Suburban: $2000/ month

(2) Opening cost

► Downtown: $200,000

► Commercial area: $150,000

► Suburbs: $100,000

(3) Operating cost (monthly)

► Personnel salary, raw materials, maintenance: $3000/ month

(4) Revenue Forecast (monthly)

► Based on market coverage and average spending: $30,000 downtown, $20,000 downtown, $10,000 suburban

The relationship between different location areas of downtown, business district and town and the benefits obtained is shown in Fig.3, it could be noted that the closer you are to the city center, the more profitable the restaurant will be.

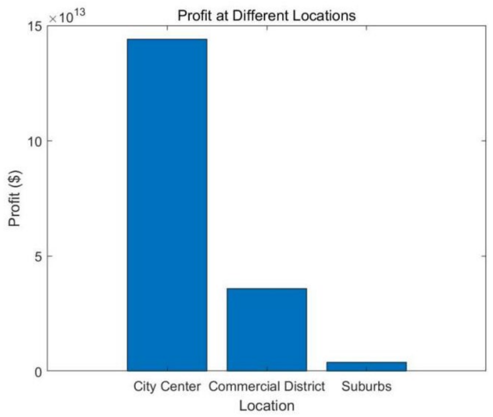

Figure 3: The relationship between different regions and profitability

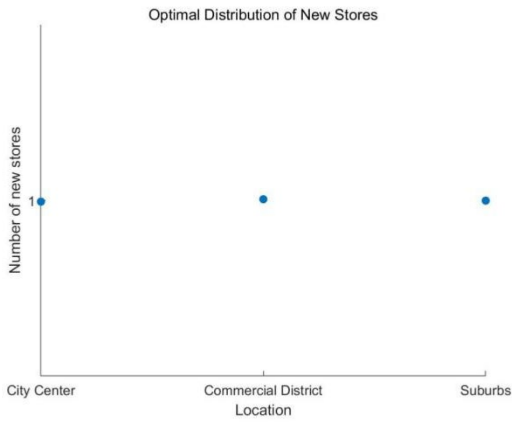

Figure 4: Optimal distribution of new stores

Fig.4 represents optimal layout and quantity of new stores by the way of scatter plot. It is expected that the difference between the number of new stores in the city centre and the number of new stores in the commercial and suburban areas will be reduced, so that the number of new stores in the three regions will be balanced.

By using optimization methods (such as linear programming, nonlinear programming, etc.) to solve the profit maximization problem. Our goal is to maximize profit, where profit is defined as total revenue minus total costs.

► Total cost: Total cost = rental cost + opening cost + operating cost.

► Expected revenue: Estimated based on market coverage and expected sales.

► Profit function: Profit = expected revenue - total cost.

For each location, the expected profit could be calculated by using:

$$\prod(x) = R(x) - (\text{Rent}(x) + \text{Opening costs}(x) + \text{Operating costs}(x)) \tag{17}$$

Where, x is the location (Downtown, Commercial area, Suburban).

► Downtown: Profit =$30,000-($5,000+$200,000+$3,000).

► Business district: Profit =$20,000 - ($4,000 +$150,000+$3,000).

► Suburban: Profit =$10, 000- ($2, 000 + $100, 000 + $3, 000).

3.4 Regional market potential assessment

Regional market potential assessment model established in Section 2.3 is used to solve the problem four.

The related parameters and values are shown in Table 2. By using these values, we can calculate the market sizes, potential profits, and market growth for each region. Finally, comparing the growth rates to determine the best location for a new store.

Table 2: Model test value

Parameters	Value
N_{cc}	300,000
N_{bc}	150,000
N_{sub}	50,000
P_{hc}	0.6
P_{fc}	0.7
P_{fr}	0.8
I_{cc}	3000
I_{bc}	3000
I_{sub}	3000
E_{cc}	500
E_{bc}	500
E_{sub}	500
R	2000
L	0.3

The forecast curve of market gain and population growth is shown in Fig.5 to Fig.7.

Fig.5 shows the linear relationship between market growth forecast and population growth over time. The city center as a whole has more people than the business district and the suburbs. The suburbs have the smallest and slowest population growth over time, followed by the business district, and the fastest growth is in the city center.

Fig.6 shows he relationship between potential market size, restaurant type and market growth potential. As can be seen from Fig.6, family restaurants in the city center are the most popular, while fast food in the suburbs is more popular.

The bar chart shows, as shown in Fig.7, that the location of restaurants in different regions has different profits. Restaurants in the city centre are the most profitable, followed by business districts, and the suburbs are the least profitable.

To enhance the model's effectiveness, it is recommended to regularly update and validate the parameters based on real-time data and feedback from customers. Additionally, incorporating additional factors like demographics and accessibility can further improve the accuracy and reliability of the location selection process.

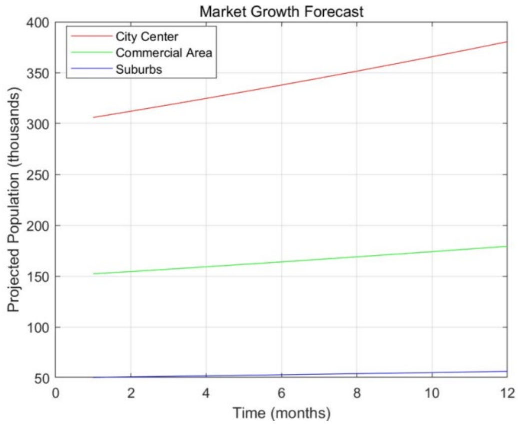

Figure 5: Market growth forecast

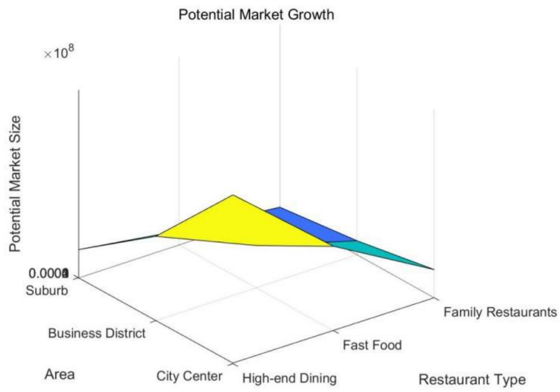

Figure 6: Potential market growth

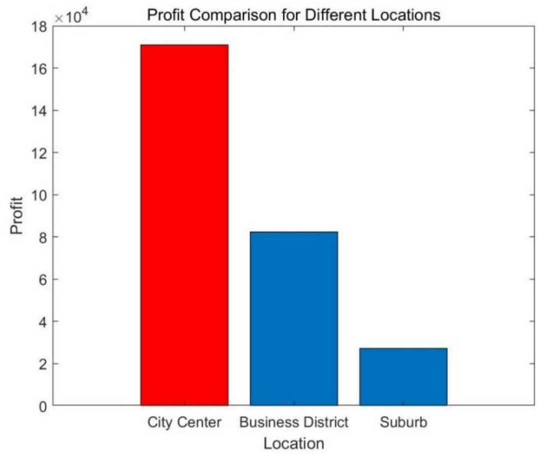

Figure: 7: Profit comparison for different locations

4 CONCLUSION

This report provided a effective way for the restaurant chain's expansion plans in A district. By considering various factors such as population distribution, market demand, rental costs, and labor expenses, the report provides valuable insights on identifying the most lucrative location for the new branch. The brand-new algorithm with data-driven approach is established to optimize the site selection based on the maximization of customer attraction and profitability. There are several conclusions could be obtained as follows:

(1) The demographic preferences for different types of dining establishments should be investigated by analyzing the population distribution among the city center, commercial zone, and suburbs, and so on;

(2) The Market demand assessment study shows that a rising demand for high-end dining is exited in the city center and sustained growth in the fast-food market;

(3) Rental and Labor Cost Evaluation shows that rental costs are highest in the commercial zone, followed by the city center and suburbs, and labor costs occupies approximately 30% of total revenue in the restaurant industry;

(4) The data driven mathematical model could be used to optimize the site selection significantly based on maximized profit and minimized risk, which could enhance the validity of the decision of the management team effectively.

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