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A multiobjective location-allocation model for day-care facilities planning

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Abstract

One of the concerns within public organizations in Mexico is to improve the services provided to citizens, however, budget cuts have caused these institutions to seek solutions that fit their resources. Location – allocation of facilities is one of the most important decision-making problems, however, applications of this type of problem have hardly been studied in the context of the institutions in charge of social security in the Mexican public sector. This paper develops a multiobjective optimization model to address the problem of locating day-care facilities for the beneficiaries of the Mexican Social Security Institute, where the objectives are to minimize the cost of operation and the distance traveled by service users, while maximizing the demand covered to be able to have an adequate planning and make improvements for this service.

Keywords: Multiobjective optimization; Location-allocation problem; strategic planning; day-care facilities

1. Introduction

Effective social security systems guarantee income security and health protection, thereby contributing to the prevention and reduction of poverty and inequality, and the promotion of social inclusion and human dignity (International Labour Organization, 2020).

In Mexico, social security is a national public service whose purpose is to guarantee the fundamental right to health, medical care, the protection of livelihoods and social services for the well-being of citizens.

The IMSS (Instituto Mexicano del Seguro Social – Mexican Social Security Institute) is the government agency responsible for the administration and organization of healthcare system and other social services for salaried workers in the private sector in the country. As of December 2020, the institute had 19,773,732 beneficiaries, which is equivalent to 15.69% of the country's population in the same year, according to the last population census conducted by INEGI (Instituto Nacional de Estadística y Geografía – National Institute of Statistics and Geography).

Within the social services provided, the IMSS offers its beneficiaries day-care centers for children between 43 days and 4 years old. These facilities are classified into two categories: Direct service (IMSS' own facilities and resources) and Indirect service (subrogation service through a contract with third parties). In both cases, the facilities are evaluated and monitored by the institute to ensure compliance with quality and safety standards.

The IMSS also faces several difficulties stemming from the economic, social, demographic, and epidemiological situation of the country over time. Some of these problems are the financial deficit and insufficient infrastructure to meet the demand for services. Table 1 shows the number of outstanding service request for the day-care service for the month of January 2022.

Table 1. Day-care service (January 2022).

Service	Enrolled children	Outstanding request
Direct	10,712	5,141
Indirect	154,021	20,433
Total	**164,733**	**25,574**

Data from the Monthly Statistical Bulletin of Day-care centers January 2022 (IMSS).

The IMSS' institutional development program (PIIMSS) for the period from 2020 to 2024 states that one of its main objectives is to ensure access to day-care centers by drawing up a plan to expand the number of facilities providing this type of service, including the opening of new ones as well as the expansion of the capacity of current ones.

The objective of this work is to propose a multiobjective optimization model (MOO) focused on the problem of locating the day-care centers that will provide service to IMSS' beneficiaries. The aim is to find locations that minimize operating costs and distance travelled by users while maximizing demand coverage. Thus, to provide a tool for strategic decision-making for those in charge for managing the expansion plan of the institute.

This paper is divided as follows: the second section provides a summary of the current literature; the third section describes the proposed methodology and includes an application case; the fourth section we discuss the results of the case study and in the fifth section we present the conclusions, limitations, and future work.

2. State of the art

The problem of finding the ideal location to establish public facilities that provide essential services to a population has been an important issue for urban planning and for government strategies in certain branches (such as health), this due to the geographical characteristics of an area, the continued population growth, the corresponding increase in the demand of certain services, among others. These types of problems are known as location-allocation problems, and they have been approached from different perspectives.

For example, Galvão et al (2002) present a 3-level model for the location of maternal and perinatal health care facilities in the municipality of Rio de Janeiro with the objective of reduce perinatal mortality in the municipality.

Ndiaye & Alfares (2008) formulated a binary integer programming model to determine the optimal number and locations of primary health units for nomadic population groups in the United Arab Emirates and the Sultanate of Oman. The goal is minimizing the total cost of serving all populations groups during different seasonal periods.

Widener & Horner (2011) developed a strategy for distributing aid after hurricanes and other extreme weather events in Florida using geographic information systems and a hierarchical capacitated-median model minimizing inaccessibility to aid.

Shariff et al (2012) addressed the issue of locating healthcare facilities in Malaysia through a Capacitated Maximal Covering Location Model (CMCLP). And Chouksey et al (2022) proposed a mixed-integer linear programming formulation for maternal healthcare facilities in India. Both works focused on maximizing service coverage.

For a more detailed information, Marianov & Serra (2002) compile trends in facility location problems in the public sector.

2.1. Multiobjective optimization

A wide variety of problems in various fields such as engineering, industry or economics involve the simultaneous optimization of several objective functions. These problems are called Multiobective optimization problems (MOO). In many cases the objectives conflict with each other. For example, Hauder et al (2019) developed a model for steel industry resource-constrained project scheduling problem, in which they minimize the overall makespan (the time interval in which all production orders are completely processed) and maximize the selection of the routes which the company prioritizes the highest.

Folezzani et al (2013) optimized the sterilization process of a pouch packing with the main objectives of minimizing the consumption of H_2O_2 and the costs while maximizing the sterilization efficacy on the packaging volume.

2.1.1. Multiobjective approach to facility location

For location-allocation problems the tendency is to focus attention on solving some of the aspects that make up the problem (as presented at the beginning of the current section), for example: achieving equity in accessibility, reducing costs, maximizing coverage, among others.

However, there are researchers that have opted for a multiobjective approach to addressing location-allocation problems. Within this line of research, Mapa & Lima (2014) evaluated the quality of the solutions produced by the TransCAD software, a geographic information system focused on transportation (GIS-T), when comparing it with mixed integer linear programming (MILP) models. The comparison was made by running simulations for three problems in particular: in the first one focused on finding the location for the opening of factories and assignment of clients in the state of São Paulo, Brazil, the second on the location and assignment of distribution for retail customers, and the third the location and allocation of demand for day care centers for children from 0 to 3 years old. Concluding that while the software provides good solutions, programming models are better when considering the capacity of the facilities within the models (covering up to 37% more) and offer different locations to open the facilities.

Zhang, Cao, Lui & Huang (2016) focus their research on locating places to build new health centers (in addition to the 174 that existed at the time) in Hong Kong, considering four objectives: maximize accessibility for the entire population, minimize inequity in accessibility, minimize the number of people without coverage, and minimize the cost of building the facilities. Its model considers the variables of demand, current supply capacity and its possible increase, as well as accessibility, and uses genetic algorithms to obtain the Pareto solutions corresponding to the possible locations.

Khodaparasti et al (2017) presented a multi-period probabilistic location-allocation model for nursing home network planning. And You (2019) explores the potential location of day-care centers for the elderly in the Tokyo metropolitan area, with the particularity of the points available for the locations should be kindergartens, to optimize the use of the latter and due to the scarcity of available space in the studied area. Through spatial evaluation and the use of geographic information systems (GIS), the author proposes two models, one to measure the spatial equity of the centers and the other to evaluate the potential of each one.

With the MOO technique we can consider most of the variables that intervene and that are important when planning about where to locate a facility. Therefore, we consider that the MOO method is adequate to address the problem of locating day-care centers for the IMSS' beneficiaries.

We would also want to point out that little work has been done on the location of public services focused on children in Mexico. We can mention the work of Esquivel (2019) in which he proposes an integer linear programming model to optimize the location, dimension, and assignment of students to public schools in areas affected by natural disasters.

Thus, the contribution of this paper addresses the application of multiobjective linear programming as a tool for planning childcare policies in Mexico.

3. Materials and Methods

As mentioned in section 1, the problem to be addressed is the location and allocation of facilities for the IMSS' childcare system.

We assume that there are two categories of facilities, those of direct service and those of indirect service. Each type has its own costs and constraints in terms of budget and capacity to meet demand.

It is also assumed that the operating cost is a linear function that depends on the number of children served by the facility. In addition, the potential locations of the facilities are known.

3.1. Problem formulation

For the formulation of the model, we use the following notation

Sets and indices:

I: set of demand nodes (indexed by *i*)

J: set of potential facility sites (indexed by *j*)

$T = \{1,2\}$: set of facility type. Where 1 is assigned for the category "Direct service" and 2 for "Indirect service" (indexed by *t*).

Parameters:

A_i: demand generated at node *i*.

K_t: capacity of the type *t* facility

p: maximum number of facilities to be opened

c_t: monthly operating cost per child of the type *t* facility

M_t: monthly budget available to cover operating costs of type *t* facilities

d_{ij}: distance from demand node *i* to facility *j*

δ maximum acceptable service distance (coverage radius)

Decision Variables:

$$a_{ij} = \text{number of children of node } i \text{ assigned to facility } j$$

$$x_{ij} = \begin{cases} 1 & \text{if demand node } i \text{ is allocated to facility } j \\ 0 & \text{otherwise} \end{cases}$$

$$y_j^t = \begin{cases} 1 & \text{if a facility of type } t \text{ is located at site } j \\ 0 & \text{otherwise} \end{cases}$$

Considering the above notation, we define the set of facilities that can provide service to the demand node *i*

$$S_i = \{ j \mid d_{ij} \leq \delta \}$$

The mathematical formulation of the proposed multiobjective model can be expressed as follows:

$$Min\ Z_1 = \sum_{t \in T} \sum_{i \in I} \sum_{j \in J} c_t a_{ij} y_j^t \tag{1}$$

$$Max\ Z_2 = \sum_{i \in I} \sum_{j \in J} a_{ij} x_{ij} \tag{2}$$

$$Min\ Z_3 = \sum_{i \in I} \sum_{j \in J} d_{ij} x_{ij} a_{ij} \tag{3}$$

s.t.

$$\sum_{i \in I} \sum_{j \in J} c_t a_{ij} y_j^t \leq M_t, \quad \forall t \in T \tag{4}$$

$$\sum_{t \in T} \sum_{j \in J} y_j^t \leq p \tag{5}$$

$$\sum_{j\in S_i} x_{ij} \geq 1, \forall i \in I \quad (6)$$

$$x_{ij} \leq \sum_{t\in T} y_j^t, \quad \forall i \in I, \forall j \in J \quad (7)$$

$$\sum_{i\in I} a_{ij} \leq \sum_{t\in T} K_t y_j^t, \quad \forall j \in J \quad (8)$$

$$\sum_{t\in T} y_j^t \leq 1, \quad \forall j \in J \quad (9)$$

$$\sum_{j\in J} a_{ij} \leq A_i, \quad \forall i \in I \quad (10)$$

$$\sum_{j\in J} x_{ij} \leq \sum_{t\in T}\sum_{j\in S_i} y_j^t, \quad \forall i \in I \quad (11)$$

$$a_{ij} \geq 0 \quad (12)$$

$$a_{ij} \in \mathbb{Z} \quad (13)$$

$$x_{ij} \in \{0,1\}, \quad \forall i \in I, \forall j \in J \quad (14)$$

$$y_j^t \in \{0,1\}, \quad \forall i \in I, \forall j \in J, \forall t \in T \quad (15)$$

The objective function (1) minimizes the monthly operational cost, (2) maximizes the coverage of the demand (number of children receiving day-care services) and (3) minimize the distance between the demand node and the facility that provides the service.

Constraint (4) is based on the number of children allocated to each facility and what type of facility is chosen to open and ensure that the budget isn't exceed. Constraint (5) limits the number of facilities to be opened.

Constraint (6) ensures that each demand node is assigned to at least one facility. In this model, the facilities that provide service have a certain capacity, so the demand of a node must be distributed among several facilities.

Conditions (7) and (11) imply that the demand cannot be allocated to a facility that hasn't been selected. With constraint (8), capacity restrictions for the facilities are introduced.

Constraint (9) states that only one type of facility may be opened at each candidate node, i.e., the facility that is opened at certain location may provide direct or indirect service, but not both. Condition (10) indicates the desired coverage level for each demand node

Finally, restrictions (12) to (15) define the non-negativity and the nature of the decision variables (integer ones and binary ones).

3.2. Testing

To test the model described in the previous section, we develop a representative planning scenario to demonstrate the applicability of the programming model to the planning of the IMSS' childcare service.

Figure 1 gives the steps of proposed methodology to apply the model previously described to a case study.

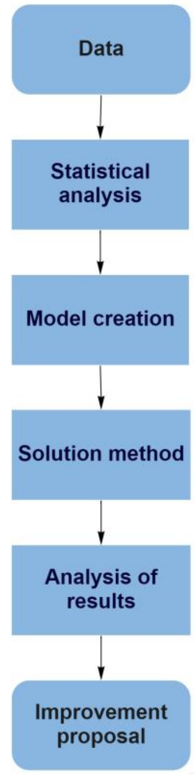

Figure 1. Steps of proposed methodology.

The first two steps of the methodology relate to the collection of data on service demand, geographical (possible locations) and economic (budget available to operate the facilities). This data should be reviewed using basic statistical techniques to ensure its reliability.

Once the reliability and veracity of data is certain, the sets and parameters on which the model is built are established.

Then a solution method is applied to the model. There are many techniques that can be applied to solve the MOO, for example some heuristic methods such as genetic algorithms. Which method to use will depend on the computing capacity and the time available to obtain results.

Finally, the results are analyzed to determine which solution is the most appropriate for the problem.

3.2.1. *Study area*

For the planning scenario we chose the borough Miguel Hidalgo located to the west of Mexico City, Mexico.

The data on the IMSS' records were obtained from the institute's web pages. Due to confidentiality policies, the IMSS provides information on its beneficiaries grouped by first-level health centers (UMF - Family Medicine Units) to which its beneficiaries are assigned. Each one is assigned to the center closest to their place of residence, so these centers can be considered as a centroid for demand.

As of December 2021, the IMSS had two UMF in the borough, in which 5,632 children whose ages range from 0 to 4 years old are beneficiaries. Table 2 shows the beneficiaries by health center.

Table 2. UMF in the borough Miguel Hidalgo (December 2021).

Health center	Enrolled children
UMF 5	3,050
UMF 17	2,582
Total	**5,632**

For the purposes of the study, the following conditions were established:

1. The demand for the day-care service is 20% of the beneficiaries enrolled to each UMF.
2. 7 possible locations for day-care facilities are proposed, of which no more than 5 can be chosen.
3. The coverage radius is 2 km.
4. For facilities that provide Indirect service, the monthly cost for each child is $4,196.26 (Mexican pesos). This is the cost reported by IMSS for the year 2021.
5. For facilities that provide Direct service, the monthly cost for each child is $4,615.89 (Mexican pesos). This cost was obtained by increasing the cost for the indirect service by 10%, as IMSS did not disclose information.
6. The monthly budget to operate is $8,000,000.00 for Direct service facilities and $5,000,000.00 for Indirect service facilities. The figures are in Mexican pesos.
7. We took the Euclidean distance between the UMF and the candidate locations for opening facilities. This measurement was obtained using the software QGIS 3.16.16.

Figure 2 shows the distribution of the UMF and the candidate locations.

3.2.2. *Model creation*

With the data acquired we sets the parameters of the model

Sets and indices:

I = {1,2}: demand nodes

J= {1,2,3,4,5,6,7,8,9,10}: potential facility sites

T = {1,2}: facility type.

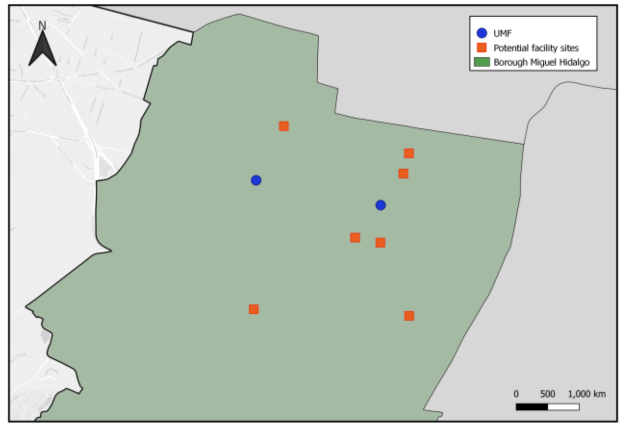

Figure 2. UMF (demand nodes) locations and feasible locations for opening day-care centers within the planning scenario.

Also, $p = 5$ *and* $\delta = 2$ km. The rest of the parameters are shown in Tables 3 and 4.

Table 3. Demand nodes.

Health center	Demand (A_i)
UMF 5	610
UMF 17	516
Total	**1,126**

Table 4. Facilities.

Facility type	Capacity (K_t)	Cost (c_t)	Budget (M_t)
Direct service (1)	10,712	$4,615.89	$8,000,000
Indirect service (2)	154,021	$4,196.26	$5,000,000

3.2.3. *Solution methodology*

The general multiobjective problem formulation is posed as follows:

$$Minimize\ F(x) = [F_1(x), F_2(x), \dots, F_k(x)]^T, x \in \mathbb{R}^n \quad (16)$$

subject to

$$g_i(x) \leq 0, \quad i = 1, \dots, l \quad (17)$$

$$h_i(x) = 0, \quad i = 1, \dots, m \quad (18)$$

Where k is the number of objective functions, l the number of inequality constraints and m the number of equality constraints.

Usually, a single point x that minimizes all objectives simultaneously does not exist because the MOO problems tend to have conflicting objectives, so improving one objective requires degrading another one. Therefore, the concept of Pareto optimality is used for the solutions for a MOO problem. A solution x is Pareto optimal if it is not possible to move from that point and improve at least one objective function without detriment to another objective function.

In this paper we use the Weighted Sum Method to find the points on the Pareto optimal front that determine suitable solutions for our case of study. This method incorporates user preferences for the multiple objectives, these preferences are reflected in a scalar weight vector (w_i) that multiplies objective functions before running the optimization algorithm.

$$Minimize\ U(x) = \sum_{i=1}^{k} w_i F_i(x) \tag{19}$$

where

$$\sum_{i=1}^{k} w_i = 1 \tag{20}$$

If all the weights are positive the minimizing (16) provides a sufficient condition for the solution, the minimum of (16), to be Pareto optimal (Timothy Marler, 2009). By choosing different weights we can find the Pareto optimal solutions.

This method also requires that all objectives be formulated as a minimization problem. Also, we need to scale all objective functions to the same magnitude, i.e., normalize them (Deb, 2010). To normalize the functions the following equation is used

$$F_i^{norm}(x) = \frac{F_i(x) - a}{b - a} \tag{21}$$

Where a is the minimum of the function F_i, and b is the maximum. So, the MOO problem is posed as follows:

$$Mini\ Z(x) = \sum_{i=1}^{k} w_i F_i^{norm}(x) \tag{22}$$

subject to

$$g_i(x) \leq 0, \quad i = 1, \ldots, l \tag{23}$$

$$h_i(x) = 0, \quad i = 1, \ldots, m \tag{24}$$

For our case of study, the model, with the normalization of the objective functions and with a vector of assigned weights, was implemented and solved by LINGO 19.0 on machine Intel (R) Core (TM) i5-6200U with 4 logical processors, Microsoft Windows 10.

We work with LINGO's Global solver, which uses the branch-and-bound technique to search for the global solution of the optimization problem. This algorithm has been used successfully to find exact solutions for a wide array of optimization problems (Morrison et al, 2016).

4. Results and Discussion

Before carrying out the optimization we define the weights for the objective functions. For this test we decided that the most important objective would be the maximization of coverage, so the weight w_2 (associated with function (2)) was set at 0.5, the remaining 0.5 was split between the objectives of cost (1) and distance (3). We started with w_1=0.49 and w_3=0.01, and we varied these weights by 0.01 to find the points of the Pareto front. In all cases, the sum of the three weights is equal to 1, in total there were 49 configurations.

Utilizing the afore mentioned parameter settings, we solve de MOO model. The results for each weight configuration are presented in the tables of Appendix A.

As expected, by prioritizing the demand coverage, in each of the solutions found the objective function (2) has a value of 1,126 (1 in the normalized function), which implies that the level of demand that we were aiming to cover is 100% satisfied.

The cost function presents the behavior of a step function whose minimum is in the first configurations because in them a higher weight was assigned. The value of the function increases as its assigned weight decreases (see Figure 3). The average cost is $4,834,606.39 and the maximum cost reached is $5,060,692.76. Both figures are below the allocated budget, which represents savings for the IMSS.

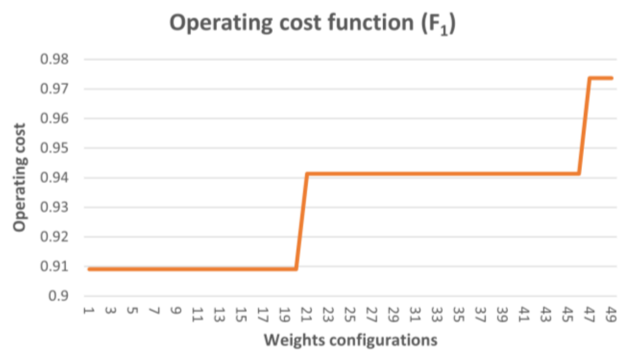

Figure 3. Value of the normalized objective function (1).

Similarly, the distance function has a higher value in the first configurations and decreases as a higher weight is assigned to it (see Figure 4).

The number of day-care facilities that should be opened varies between 4 and 5, with the latter option dominating. Since of the 49 weight configurations, 46 have an arrangement of 5 installations. In addition, the model indicates that most of them are required to provide Indirect service. (See Figure 5). This is because these types of facilities cost less and the demand in the planning scenario can be fully met without exceeding the capacity of these type of facilities. If demand increases, Direct service facilities will begin to appear more frequently in the model solutions (if demand coverage continues to be prioritized over the other objectives).

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the capacity of these type of facilities.

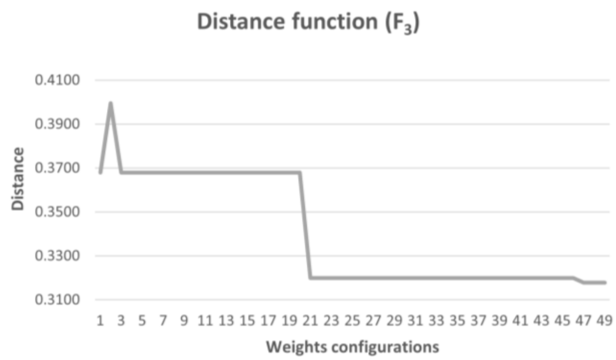

Figure 4. Value of the normalized objective function (3).

If demand increases, Direct service facilities will begin to appear more frequently in the model solutions (if demand coverage continues to be prioritized over the other objectives).

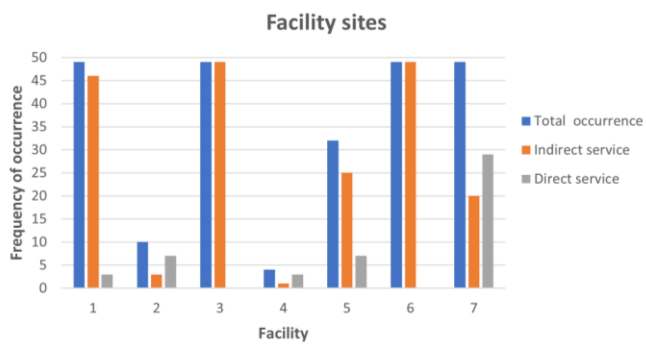

Figure 5. Frequencies of candidate locations in the optimal solutions for all weights configurations.

Figure 6 shows the location of the 4 candidate locations with the highest frequency of occurrence in the model solutions and the respective allocation of the demand of the UMF.

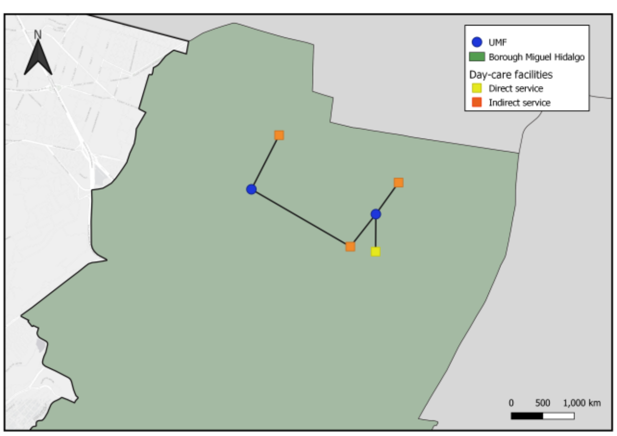

Figure 6. UMF (demand nodes) locations and feasible locations for opening day-care centers within.

With the results obtained we have two proposed solutions to the problem.

1. If, after coverage, we prioritize cost minimization, then the optimal solution would be to open 5 facilities, all will provide indirect service, the monthly operating cost would be $4,724,988.76 (Mexican pesos) and the average travel distance of users would be 0.86 km.
2. If, after coverage, we prioritize the distance between the UMF and the day-care facilities, then 5 facilities should be opened, three will provide direct service and two indirect service. The average distance traveled by users of the service would be 0.75 km and the operating cost would amount to $5,060,692.76 (Mexican pesos) per month.

The results were obtained within a reasonable time, the maximum time recorded was 16.16 seconds. Figure 7 shows the runtime of the solution algorithm with the different weight configurations.

However, it should be noted that this is mainly because the solved problem is small (2 demand nodes and 7 candidate nodes). Usually these types of models (location-allocation) are NP-hard, so it is necessary to use heuristic methods to obtain results in a reasonable time for larger problems.

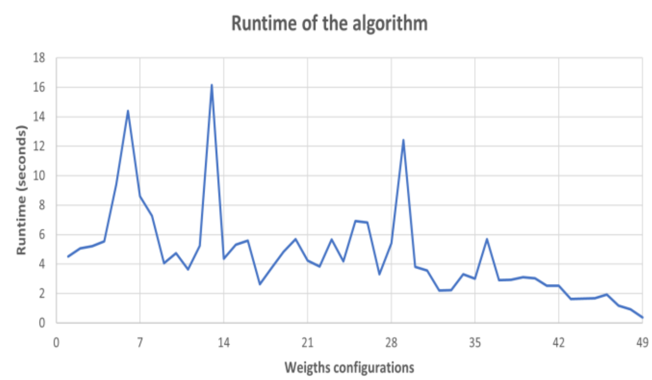

Figure 7. Runtime of the algorithm Branch-and-Bound.

5. Conclusions

Programming models with a multiobjective approach are useful for making decisions about problems that include a variety of goals, which must be treated together.

In this work, we proposed a model for the location and allocation of the IMSS' childcare system. The model was created to fit the guidelines and internal structure of the institute and was tested and verified with a small extract of real data published by same organization on the subject.

The main limitation of this study is the deterministic nature of the model, since it is assumed that the system has a fixed demand and that the beneficiaries will use the service until they are no longer eligible for it (they reach the maximum age to be enrolled in the nursery).

In future works, we plan to apply the model to the

Mexico City area (covering all boroughs). Finally, it is also contemplated to improve the model by incorporating queuing theory and simulation for a better estimation of the demand, use and waiting times of the service; so that the parameters with which the optimization model operates are as close as possible to reality.

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Appendix A. The results for each weight configuration

We show the Pareto-optimal solution obtained with the different weights configurations for the scenario proposed in section 3.2

Solution	Weights configurations			Objective function (normalized)			
	w_1	w_2	w_3	Global (F)	Cost (F_1)	Coverage (F_2)	Distance (F_3)
1	0.49	0.5	0.01	-0.051	0.909	1	0.368
2	0.48	0.5	0.02	-0.056	0.909	1	0.400
3	0.47	0.5	0.03	-0.062	0.909	1	0.368
4	0.46	0.5	0.04	-0.067	0.909	1	0.368
5	0.45	0.5	0.05	-0.073	0.909	1	0.368
6	0.44	0.5	0.06	-0.078	0.909	1	0.368
7	0.43	0.5	0.07	-0.083	0.909	1	0.368
8	0.42	0.5	0.08	-0.089	0.909	1	0.368
9	0.41	0.5	0.09	-0.094	0.909	1	0.368
10	0.4	0.5	0.1	-0.100	0.909	1	0.368
11	0.39	0.5	0.11	-0.105	0.909	1	0.368
12	0.38	0.5	0.12	-0.110	0.909	1	0.368
13	0.37	0.5	0.13	-0.116	0.909	1	0.368
14	0.36	0.5	0.14	-0.121	0.909	1	0.368
15	0.35	0.5	0.15	-0.127	0.909	1	0.368
16	0.34	0.5	0.16	-0.132	0.909	1	0.368
17	0.33	0.5	0.17	-0.137	0.909	1	0.368
18	0.32	0.5	0.18	-0.143	0.909	1	0.368
19	0.31	0.5	0.19	-0.148	0.909	1	0.368
20	0.3	0.5	0.2	-0.154	0.909	1	0.368
21	0.29	0.5	0.21	-0.160	0.941	1	0.320
22	0.28	0.5	0.22	-0.166	0.941	1	0.320
23	0.27	0.5	0.23	-0.172	0.941	1	0.320
24	0.26	0.5	0.24	-0.178	0.941	1	0.320
25	0.25	0.5	0.25	-0.185	0.941	1	0.320
26	0.24	0.5	0.26	-0.191	0.941	1	0.320
27	0.23	0.5	0.27	-0.197	0.941	1	0.320
28	0.22	0.5	0.28	-0.203	0.941	1	0.320
29	0.21	0.5	0.29	-0.210	0.941	1	0.320
30	0.2	0.5	0.3	-0.216	0.941	1	0.320
31	0.19	0.5	0.31	-0.222	0.941	1	0.320
32	0.18	0.5	0.32	-0.228	0.941	1	0.320
33	0.17	0.5	0.33	-0.234	0.941	1	0.320
34	0.16	0.5	0.34	-0.241	0.941	1	0.320
35	0.15	0.5	0.35	-0.247	0.941	1	0.320
36	0.14	0.5	0.36	-0.253	0.941	1	0.320
37	0.13	0.5	0.37	-0.259	0.941	1	0.320
38	0.12	0.5	0.38	-0.265	0.941	1	0.320
39	0.11	0.5	0.39	-0.272	0.941	1	0.320
40	0.1	0.5	0.4	-0.278	0.941	1	0.320
41	0.09	0.5	0.41	-0.284	0.941	1	0.320
42	0.08	0.5	0.42	-0.290	0.941	1	0.320
43	0.07	0.5	0.43	-0.297	0.941	1	0.320
44	0.06	0.5	0.44	-0.303	0.941	1	0.320
45	0.05	0.5	0.45	-0.309	0.941	1	0.320
46	0.04	0.5	0.46	-0.315	0.941	1	0.320
47	0.03	0.5	0.47	-0.321	0.974	1	0.318
48	0.02	0.5	0.48	-0.328	0.974	1	0.318
49	0.01	0.5	0.49	-0.335	0.974	1	0.318

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