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An Integrated Model for Locating Inventories Based on Algorithmic Approach

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Abstract

The elaboration of an efficient distribution strategy involves the steps of determining the number of deposits and its location, the strategy of allocating stocks of the products in each of the warehouses and the elaboration of product distribution routes from the depots to the final points of sale. Due to the complexity involved in each of these steps, these decisions have been taken hierarchically and sequential. This approach leads to suboptimal solutions because the problem is divided into sub-problems and the solution of one sub-problem affects the others. This work aims to propose an integrated model for the solution problems of deposit localization and inventory allocation and proposes a heuristic algorithm based on an evolutionary approach to its solution. The proposed model was applied to a real problem involving the logistical redesign of a network of pharmacies, demonstrating its technical feasibility.

Key Words: Logistics, stock locations, centralization of inventories, modelling.

1. Introduction

Companies are increasingly seeking alternatives that allow them to reduce their operating costs, improve performance and consequently, the level of service offered to the customer. Suppliers and distributors of products and services all-around the world recognize the need to structure their distribution strategies in order to improve transportation efficiency and the level of customer service. The process of structuring the logistics network is subdivided into well-defined

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and watertight problems such as: location of facilities, allocation of inventories to warehouses and routing of vehicles. These problems are closely related, but are not treated in an integrated way by the current models, mainly due to the computational difficulty involved. This work proposes an algorithm that simultaneously addresses the problems of location of facilities and centralization or decentralization of inventories and demonstrates the advantages of this approach.

2. Literature Review

This section is intended to present a brief review of the modelling of facility location problems, centralization and decentralization of inventories and joint logistic models. The problems of location of facilities have been studied for a long time in services Fitzsimmons (2013), in the logistic area and Simchi (2015) within the scope of operational research. Defining the location of a facility, such as a factory, or a distribution centre is a task generally delegated to logisticians. In most cases, it is a question of choosing among a finite number of possible alternatives the one that proves to be the most advantageous in meeting the objectives that guide the implementation of the company. In addition to the traditional role of creating barriers to entry of competitors and generating demand, location also affects the strategic dimensions of flexibility, competitive positioning and demand management. According to author, gains with economies of scale in production and reduction in transport costs are objects of attention in the studies of location of industries. In recent years, location studies have also covered logistical channel projects, as a result of the globalization of sources of supply and marketing. Global operations have increased the complexity of decisions related to logistics channels, with the definition of alternatives and their logistical costs. The phenomenon of globalization has substantially increased the importance of the study of location. The flexibility of locating a service facility is still a measure of the degree of service response to change in the economic environment and involves capital-intensive aspects with long-term commitments. It is essential to select sites that can respond to future economic, demographic, cultural and competitive changes. For example, by allocating facilities in several states, it is possible to reduce the total risk arising from financial crises triggered by regional problems. This portfolio for multiple locations can be reinforced by the definition of individual sites with almost inelastic demands.

For Jenkins (1990), the location of industries involves the use of much judgment, art, and intuition. Decision analysts should follow a checklist of factors that can help narrow the breadth of their choices. Some factors are: local zoning laws, community and local government attitude towards facility; cost to develop and shape the terrain; cost of construction; availability; salary; environment and productivity of the local labour force; fees relating to the location and operation of the facility; (theft, fire, flood, etc.); promotional value of the site; insurance rates; availability of financing and congestion of traffic in the vicinity of the place. Some authors denominate macro localization the determination of the region propitious to the installation and micro-localization the specific determination of the area to be acquired. This work deals with macro-localization. There are numerous approaches and applications to the location problem. The problems range from the definition of a single location in the continuous plane, to the definition of multiple locations in a graph, in order to meet certain constraints.

The centre of gravity problem is characterized by the location of a single facility in the continuous plane. The objective is to find the best location that minimizes transport costs, given the sum of the distances multiplied by the flows to be moved and the costs of movement. One can use metropolitan metric, rectangular or Euclidean. The second form makes the non linear problem (because the distance is quadratic) and was called the Weg's problem of centre of gravity or generalized problem, in honour of Alfred Weber, who first formulated it in 1909.Localization problems using graph theory present innumerable real applications. The problem of partitioning of graphs is a particular case of the covering problem and has several applications in localization problems. Daskin (1981) applied the coverage model in the solution of the problem of the location of medical services, and the location of radars. The problem of coverage in the continuous plane is characterized by being more complex, because there is an infinite number of candidate points. Given a set of points to be served by the facility, the distance that the most distant customer should go through to reach the facility is called the maximum service distance. Points whose distances are equal to or less than the maximum service distance is within the coverage area of ??the facility. The problem that aims to find the minimum number and location of facilities that will serve all points of demand, covering them in the coverage area of ??some facilities, is known as the minimum overlay problem. Caprara (2000) proposes a model in which the coverage area is rectangular. *The* maximum number of facilities to locate and demand values at_i, located at each vertex i, what are the locations of the facilities in order to maximize the demand served Church (1971).

The problem that seeks to determine, among the n possible, the k (k <= n) locations, such that the minimum distance between them is maximum, is called the discrete k-dispersion problem. Application examples are generally related to the location problems of facilities whose proximity is undesirable. Drezner (1985) applied the model to problems of location of garbage deposits and Berman (1996), in problems of location of prisons and military installations. In the k-servant problem, the facility travels a path in a graph, answering each node. It differs from the routing problem because the endpoint is different from the initial one and the solution depends on the decision of the starting point of the route. Slack (1998) defined stock as the accumulation of material resources in a transformation system, which can sometimes be used to describe any stored resource and reported that the imbalance between supply and demand generates four different types of inventory: insulation or safety, cycle, anticipation and channel. According to author, the function of inventory in relation to production management is to supply the production-sales flow in a continuous and uniform way, without interruptions. The stock has the purpose of improving the level of service, encouraging production savings, allowing economies of scale in purchases and transportation, acting as protection against price increases, protecting the company from uncertainties in demand and resupply time and serve as security against contingencies.

There are good reasons both to distribute the stock in several distribution centres close to the consumer and to allocate it in a smaller number of centres, each with a larger geographic coverage area, which makes this decision to be carefully analysed. According to Christopher (2016), with the consolidation of inventories in fewer locations, the total needs of the stores can be reduced substantially, as well as the reduction of fixed deposit maintenance costs. Smykay (1961) notes that the stored security stock at a single centralized point is roughly the ratio of the total security stock of the various locations possible by the square root of the total number of locations. In general, the relationship between centralized and decentralized stock is equal to $\sqrt{m} / \sqrt{n}$, where *m is* the number of locations after consolidation and the number of locations prior to consolidation. According to the author, this law may be applicable both to the calculation of the reduction of the safety stock and to the calculation of maintenance inventories, when the economic lot is used for resupply request. It also recognizes that centralization reduces the level of security stocks in an environment of uncertainty. However, it observes that a greater degree of centralization can increase the distances to the markets and, consequently, it damages the customer service and cause loss of market. According to the author, reductions in the level of service could be minimized through investments aimed at greater agility in the transport system or in the performance of order processing, which may increase costs. The uncertainties faced by the company could also be reduced through contractual agreements with customers and suppliers.

According to author, there are two characteristics of the product that impact the decision to centralize or decentralize inventories. First, the higher the value added, the greater the propensity to centralize inventories in a single facility, in order to reduce the duplicity of costs associated with maintaining stockpiles at various locations. Second, the greater the degree of obsolescence, the greater the propensity to centralize inventories, in order to reduce the risks of non-sale. According to Simchi (2015), as a general rule, products that have high value and low demand should generally be stocked in a central warehouse. Low-cost items that have high demand must be stocked in a decentralized way. According to the same author, the higher the coefficient of variation of the item, the greater the benefit obtained in its centralization. The analyses of Chang (1991) to include the analysis of negatively correlated demands. They verified that these generate still greater reductions of stock by the centralization than those obtained with uncorrelated demands. In addition, they developed the portfolio effect model (PE), defined as "the percentage reduction in security stocks achieved through inventory centralization". The authors have shown that the "square root law" is a special case of the portfolio effect.

The problems of location, centralization or decentralization of inventories and routing of vehicles present important interfaces, discussed below. The isolated definition of the location of the deposits can lead to high costs of inventory allocation, since the determination of the number of deposits should, and generally does not, consider the advantages of centralization in terms of reduction of security and reduction stocks of fixed installation costs, against increases in distribution costs and increase in delivery lead times. The number of deposits can have a significant impact on the performance of distribution roadmaps. The greater the number of deposits, the more efficient the distribution routes are generally. On the other hand, the increase in the number of deposits leads to an increase in fixed installation costs. The choice of the location of the deposits, considering only real estate costs and tax exemptions, can generate inadequate distribution scripts. Inventory centralization reduces security stocks, but generally leads to increased distribution costs. This decision generally considers inventory savings and distribution costs, taking into account only the distances between deposits and customers, without considering possible distribution routes. Allocating inventories to existing warehouses can provide inadequate distribution routes, especially in cases of time windows or vehicles with limited capacity. Thus, it is perceived that the problems of localization, inventory centralization and distribution of goods are closely related, but are generally not treated in an integrated way, mainly due to the computational difficulty involved. More recently, some authors have proposed integrating two problems into a single model. The most commonly encountered joint model integrates location-routing problems.

Liu(2014) presents an interesting work which are presented, implemented and analysed heuristic modelling based on taboo search for the joint problem of location of deposits and vehicle routing (LRP), both deterministic and stochastic. Some exact algorithms have been proposed for the LRP in the case of a single deposit and vehicles without capacity limitation Nagy (2007) and with capacity limitation Baldacci (2011). Approaches to the case of multiple deposits and trained vehicles were also proposed in Laporte (1988). We did not find jobs that deal with the problems of location of deposits and allocation of inventories, as does the model proposed here.

3. Materials and Methods

The paper presented here has two main research questions. The first concerns the technical feasibility of jointly modelling the problems of location of facilities and centralization or decentralization of inventories in a logistics network. The second question concerns the gain that can be expected with the application of the proposed model. This work can be classified from the point of view of its nature as an applied research, since "it aims to generate knowledge for practical application and directed to the solution of specific problems". In relation to its objectives, it is exploratory, since it aims, still in a preliminary way, to analyse the technical feasibility and the gains that can be expected with the use of the proposed model. Regarding the approach, the work is characterized as quantitative research. Already the technical procedures used in the work include bibliographic research, mathematical modelling and case study. It is important to point out that the case-study approach does not aim at statistical generalization of results but rather to investigate phenomena and their context in depth Brayman (2015). Thus, the objective of the application of the case study methodology in this work is to verify if the model proposed here is really feasible in a real case, and what results could be obtained with the use of the proposed model.

The work described here is divided into five stages. The first stage includes a literature review on mathematical models for facility location and inventory management and sharing, as well as possible existing joint models. The second stage of the work includes the elaboration of the mathematical model used to locate distribution centres and inventories. The third stage of the work presents the implementation of the mathematical model, elaborated in the second stage. For this, a heuristic application was developed based on genetic algorithms in VBA (Visual Basic for Applications). The third step provides the computational validation of the developed model. The fourth stage of the work comprised the collection of data needed to execute the model in a real case setting. For this, data were collected from the data bases of the logistics network studied. Field data were collected from the concerned locations. Interviews with directors were also conducted to get more insights about the problems. The fifth and final stage of the work deals with the parameterization and execution of the model, the analysis of the results and the elaboration of the conclusions derived from the use of the model.

4. Results and Discussions

4.1 The Proposed Model

This section presents the mathematical modelling involved in the study. The mathematical model is based on discrete location and combination of service alternatives. The objective of the model is the maximization of the function. To achieve this objective, the total fixed costs of installation of the distribution centres and the difference of the costs of the security stocks in the decentralized and centralized cases are subtracted from the total sales. Existing points of sale can operate in two ways: by keeping their own stocks decentralized, or by means of distribution centres, in which the stocks of the sales points served are centralized. The model will seek to create distribution centres that maximize point-of-sale coverage, provided that the savings obtained from the centralization of inventories offset the fixed costs of installing these distribution centres. In order to estimate the cost of the centralized security stock, the equation of Maister (1976) will be used. The main features of the model are:

- Each distribution centre (CD) has limited and distinct capacity.
- Each installed CD (active) has a fixed cost.
- The number of possible CDs is between the minimum number (Nmin) and the maximum number (Nmax).
- Points of sale located within the coverage area of ??a CD, defined by the service distance *S*, may have their stock centralized on one of the CDs that cover it, if there is enough available capacity on this CD.

4.2 The Mathematical Representation of the Model

Let S be the defined service distance for a point of sale to be covered by a CD, i =

{1, ... *M*} the set of areas to be served, $j = \{1, \dots N\}$ o set of potential locations where CDs can be installed, L_i the profit from the point of sale *i* and c_j the fixed cost of installing the CD at location *j*. Let $y_i = 1$ if the point *i* Î *M* is served by a CD located at *j* Î *N* considering the coverage distance *S*, and $y_{ij} = 0$ otherwise. Also consider that *P* CDs will be allocated, being P >Nmim and $P <$ Nmax. Consider $x_j = 1$ if point j has an active CD and $x_j = 0$ otherwise. Consider $y_i = 1$ if the point of sale *i* is covered by some CD and $y_i = 0$ otherwise. Let *and* $_{i\ be}$ the cost of the security stock at the point of sale *i* and e_j the cost of the centralized security stock on the CD*j*. Be v_i the volume occupied by the safety stock at the point-of-sale *i* and C_j the CD storage capacity *j*. The mathematical representation of the problem is given by:

Max

$$Z=\left(\sum_{i=1}^{M} L_i\right)-\left(\sum_{j=1}^{N} c_j x_j\right)-\left(\sum_{i=1}^{M} e_i-\sum_{j=1}^{N} e_j x_j\right) \qquad (4.1)$$

Subject to:

$$\sum_{j=1}^{N}\left(y_{ij} * x_j\right) - y_i \geq 0 \qquad i=1..M \qquad (4.2)$$

$$\sum_{j=1}^{N} y_{ij} \leq 1 \qquad i=1..M \qquad (4.3)$$

$$\sum_{j=1}^{N} x_j = P \qquad j=1..N \qquad (4.4)$$

$$N_{min} \leq P \leq N_{max} \qquad (4.5)$$

$$e_j = \frac{\sum_{i=1}^{M}\left(e_i y_{ij}\right)}{\sqrt{\sum_{i=1}^{M} y_{ij}}} \qquad j=1..N \qquad (4.6)$$

$$\sum_{i=1}^{M} v_i \left(\frac{\sum_{i=1}^{M}\left(e_i y_{ij}\right)}{e_j}\right) \leq C_j \qquad j=1..N \qquad (4.7)$$

$$x_j \in \{0,1\} \qquad j = 1..N \qquad (4.8)$$

$$y_j \in \{0,1\} \qquad i = 1..M \qquad (4.9)$$

$$y_{ij} \in \{0,1\} \qquad i = 1..M, j = ..N \qquad (4.10)$$

The objective function of the mathematical model (4.1) is given by the sum of the profits of points of sale (PV) minus the annual fixed costs (c_j) of each active CD in the system and the difference between decentralized and centralized stocking costs.

Constraint (4.2) states that if $y_{ij} = 1$, i.e., the point i is covered by the CD j, and where $y_i = 1$ (that is, the point has been met), then there is some $x_j = 1$ (i.e. some CD must be active). Already the restriction (4.3) requires that a point-of-sale should be attended by at most one CD.

The constraint (4.4) determines that there will be P points occupied by active CDs. The constraint (4.5) determines the minimum and maximum number of distribution centres that the system must contain.

The restriction (4.6) determines that the centralized security stock in the CD j is calculated by summing the existing stocks at the points of sale served by the CD divided by the square root of the number of points served by the CD.

Restriction (4.7) states that the stock volume on each CD should not exceed its capacity. The volume of the stock on the CD is less than the sum of the volumes of the decentralized stocks and is estimated by the same proportion of the reduction of the security stocks caused by the centralization.

The constraints (4.8), (4.9) and (4.10) express that the decision variables are binary.

In this work, the adopted solution technique was heuristic and based on genetic algorithms. The algorithm was implemented using the Visual Basic for Applications environment.

4.3 Parameters of the Algorithm

The parameters of the mathematical model to be supplied are: the maximum distance or radius of coverage of each distribution centre, the number of iterations desired, the minimum number and the maximum number of distribution centres. The parameters related specifically to the execution of the genetic algorithm are: the amount of elements that the population must contain and the probability of mutation.

4.4 The Solution Algorithm

The algorithm begins with the creation of an initial population of viable solutions. Each individual in the population is represented by a vector and a matrix. The vector represents which of the possible CD locations will be effectively active. Thus, by assigning binary 1 to the position of the vector, a CD is enabled in the system, otherwise the distribution centre is not enabled. In the example given in Table1, locations 1, 4, 29, 34, 38 and 44 receive CD.

Table 1: Vector Solution for CD Localization

	Vector Solution									
Possible CD's	1	4	1	1	1	1	33	3	3	4
CD's Enabled	1	1	0	0	0	1	0	1	1	1

Source: Visual Basic Application, v.6

The second part of the solution representation indicates which PVs will be serviced by each of the active CDs. To elaborate this routine, the distance of service S of the point of sale to the active CDs is considered. If there is more than one candidate CD to match a certain PV, the routine should choose a CD only, verifying that the sum of the volumes of inventories allocated to the CD does not exceed its capacity. In the example in Table 2, the 46 existing points-of-sale (PVs) are allocated to the six active CDs. The value 1 indicates which CD the PV was allocated. Some PVs, such as 41, 42 and 43, have not been allocated to any CDs, either because they are outside the CD area, or because there is not enough capacity on the CD to support them.

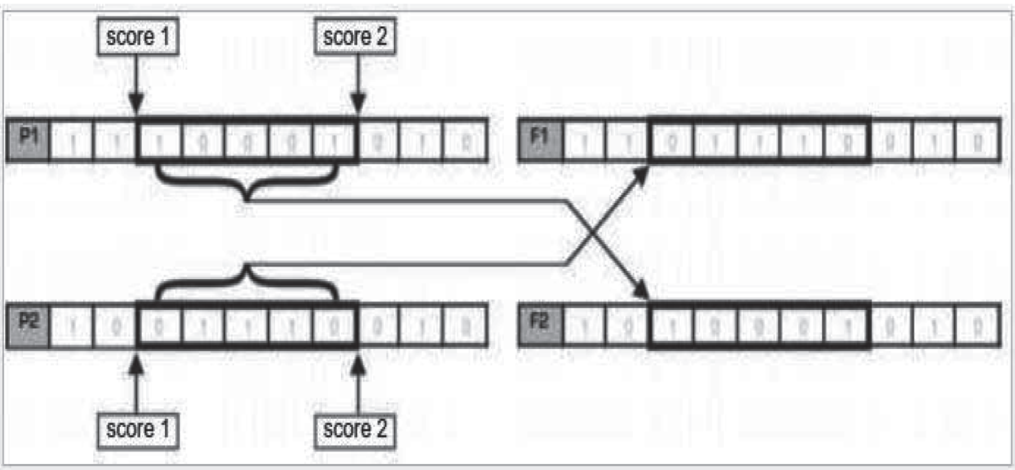
Table 2: Vector Solution for Allocation of Sales Points to CDs

CD's	1	2	3	4	5	6	7	8	9	37	38	39	40	41	42	43	44	45	46
1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4	0	0	0	1	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
44	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0

Source: Visual Basic Application, v.6

From the initial population creation, the genetic algorithm routine selects two individuals from this population, one with the best *fitness* of the population and the other randomly (P1 and P2). Next, the *crossover* is executed, creating two children (F1 and F2). There is still a probability of mutation operation occurring on the created offspring. If any of the children has superior *fitness* to any of the individuals in the population, it is included in the population. The sequence of operations above is performed by a number of generations and the best solution obtained is presented.

The *crossover* operation is done by means of the random selection of two points, in the parent's vectors P1 and P2. A string *string* of the vector P1 is copied to the vector P2, generating the child F2. The same process occurs to generate the child F1. Thus, a string *string* is copied from the vector P2 to the vector P1 generating the child F1. An example of a *crossover* is shown in Figure 1



Source: Prepared by the Author

Figure 1: Creating child vectors F1 and F2 via crossover

Regarding the matrix of allocation of PVs to CDs, the *crossover* is as follows: for each PV, the active CDs of the child are considered and the PVs are allocated to the CD of P1 or P2, by lot.

The mutation of the active CD array occurs with the random draw of a *bit*, changing its value, respecting the restriction of the minimum and maximum number of active CDs. The mutation of the matrix of allocation of PVs to the CDs occurs in an analogous way, that is, a PV is drawn and altered again by drawing for which new CD this PV will be allocated, provided that the coverage distance is respected and capacity of the CD. An individual's *fitness* calculation is based on the total sales of all points minus the fixed installation costs of the active CDs and subtracted from the costs of decentralized and centralized security stocks.

4.5 Application of Algorithm in a Real Problem Setting

The developed model was applied in the logistic study of a network of pharmacies located in a state capital. The network studied is composed of about 90 points of sale. It was then decided to work with the total points responsible for 80% of the network's billing, thus reaching 46 points. Among the 46 selected points of sale, 10 sales outlets were chosen to be also location of CDs. These points were chosen because they have a strategic location, easy access and a physical area available for drug storage. The points of sale that were candidates for PV and CD were those of number 1, 4, 14, 16, 18, 29, 33, 34, 38 and 44. The data collected for the execution of the project were:

- The estimated gross profit of each of the pharmacies that make up the model in the period from January 1, 2017 to January 31, 2018. The sum was estimated at Rupees /- 6,231,185.00. The value was calculated by multiplying the quantities of items traded in the year 2017-18 of each marketed product line (generic, ethical, similar and perfumery) at each point of sale, by the profitability percentages of these lines. The sum of the profit from points 1 to 46 results in the annual profit.

- The estimated annual fixed costs of each of the 10 candidate points of sales to act as a distribution centre within its area of ??coverage.

- The geographic coordinates in UTM (Universal Transverse Mercator) of each point of sale and CD candidate considered in the model, using a GPS.

- The costs of current security stocks. The security stock level was estimated as a percentage of the average stock. The decentralized security stock value of all points was calculated at Rupees /- 1,414,632, 75.

In the execution of the model the following parameters were used:

- The maximum radius of coverage of each distribution centre was 5 km.

- The number of iterations in each execution was 150.

- The minimum number of CDs is 1, and the maximum number of CDs is 10.
- The probability of mutation was 3%.
- The population size equals 8 individuals.

4.6 Results Obtained

The *software* was run ten times sequentially. The best result was obtained in the seventh attempt, in the iteration of number 72. The execution lasted about 5.657 seconds on a Pentium 4, with 256K of RAM. Among the 10 candidate points to act as a distribution centre, the *software* enabled points 4, 14, 16, 29, 38 and 44. With the 6 distribution centres enabled, there is a coverage of 42 points-of-sale, with only 4 unsatisfied sales points. The Figure 4 shows the position of the active distribution centres and points-of-sale. The same result can be seen in Table 3.

Table 3: Active CDs and PVs Served

Active CD's	PV's by CD	Coverage of Sales Points														
4	15	4	2	5	7	10	11	12	22	24	25	26	36	37	39	41
14	3	14	20	21												
16	6	16	19	23	28	32	40									
29	4	29	9	33	42											
38	6	38	1	8	13	15	45									
44	8	44	6	18	27	30	31	35	46							

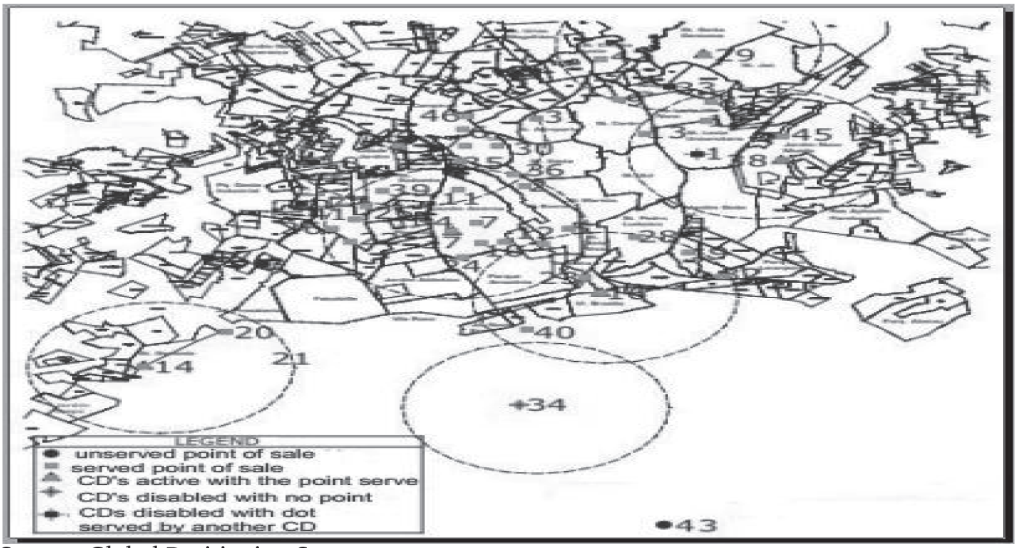
Source: Visual Basic Application, v.6

Table 4: Total Cost of the Proposed System Security Stock

Total Amount of AFDGO	Cost in Rupees
Centralized stocks	473,867,47
Missed point stocks	120,742,45
Total	594,609,92

Source: Stock Reports of Selected Pharmacies

Points 3, 17, 34 and 43, which are out-of-sales outlets for distribution centres, had the value of their security stocks added to the total cost of centralized security inventory, sale that will continue to sell with own stock, as before. The result of the sum of the security stocks of these points of sale was Rupees120,742, 45. Figure 2 shows the geographical distribution of the CDs. With the results obtained after centralizing the security stocks and adding the security stocks of the points of sale that were not covered by the proposed distribution system, we obtained the total security inventory cost of the proposed system. This value was Rupees /- 594.609, 93, according to Table 4.



Source: Global Positioning System

Figure 2: Geographic Configuration Obtained Through the Execution of the Software

The Table 5 shows the final result of the model. In the current decentralized strategy, the gross profit of the 46 points-of-sale was Rupees 6,231,185.00 and the cost of decentralized security stocks totalled Rupees 1,414, 632.75, which results in a net result of Rupees 4,816,552, 25.

Table 5: Comparative Analysis of the Costs of the Two Strategies

Components	Current Distribution Strategy (2017-2018)	Proposed Distribution Strategy
Annual profit	6,231,185	6,231,185
Safety stock	1,414,632.75	594,609,93
Fixed cost of CD's	0.00	470,300.00
Result	4,816,552.25	5,166,275.07

Source: Analysis Results Using the Cost Data

In the strategy of creating CDs and centralizing inventories, the sum of the security stocks of the centralized and uncovered points equals Rupees 594,609.93, that is, a savings in security inventory of Rupees 820,022,82 against an investment of Rupees 470,300,00 in installation of CDs, resulting in a savings of Rupees 349,722, 82 if the strategy of stock centralization proposed by the software is adopted.

5. Conclusion

The elaboration of an efficient distribution strategy involves the steps of determining the number of deposits and their location and the strategy of allocating stocks of the products in each of the deposits. Due to the complexity involved in each of these steps, these decisions have been taken in a hierarchical and sequential manner, which has led to the achievement of sub-optimal solutions to the problem as a whole. This work proposes and implements a joint model for the solution of the problems of location of deposits and allocation of inventories, joining the concepts of modelling of problems of maximum coverage with the equation of Master to estimate the reduction of security stocks due to the centralization of themselves. Due to the combinatorial complexity involved in the problem, the implementation occurred through a heuristic approach, based on genetic algorithms. Future studies should be carried out in order to evaluate the degree of discrepancy between the solution quality of the heuristic model proposed here and the optimal solution to the problem.

Regarding the parameterization of the model, it is important to point out that, according to the literature, in some cases the estimation of the reduction of the safety stocks obtained by the square root law can be very optimistic. Thus, the development of a methodology for estimating the reduction of centralized safety stocks more precisely is recommended. The same observation is valid for the estimation of the fixed costs of CDs. The proposed heuristic model was applied in the study of a network of pharmacies. Considering the centralized and decentralized security inventory costs and the fixed location costs. It is studied the implantation of the proposed model in stages, that is, the implantation of the centralization of inventories, initially creating a CD with an intermediate number of PVs served (probably CD 16 or CD 38) in order to refine the parameterization of model. With this pilot CD, it will be possible to evaluate the real proportion of reduction of safety stocks, the actual costs of CD implantation and possible impacts on customer service, which may reduce the billing.

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