Best Location for Animal Feed Manifacturing Company in Izmir Province of Turkey

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Abstract: Incorrect selection of location may cause significant problems for businesses. The main problem is critical business activities such as procurement and marketing are greatly dependent on facility location. For this reason, investors must consider the combination of several criterias by selection of the location.

The number of farm animals, distance to raw materials, infrastructure, labor cost, energy costs and the investment cost criterias are taken into account for selection of the facility location in this study. Location problems are usually known as multi-dimensional problems in particular when sustainable development planning is required, so multi-criteria approaches are appropriate techniques for solving location problems. The main objective of this study is to overcome the problem of facility location selection by goal programming. The proposed method has been applied to a selection problem of facility location that determines optimal feed manifacturing company in Izmir province of Turkey.

Keywords: Selection of location, Multi Criteria Decision Making, Goal Programming.

1. Introduction

Incorrect selection of location may cause significant problems for businesses. The main problem is critical business activities such as procurement and marketing are greatly dependent on facility location. Additionally, operating costs originating from incorrect selection of location aggravate competitiveness. For this reason, investors should focus on selection of location that is a strategic decision in terms of investment analysis and project management.

The role of location in competition is pervasive in the manufacturing sector. It is especially important in sectors where transportation and logistics costs play a large role. More generally, a location decision is one part of overall supply chain design, and location competition could be regarded as a core issue in supply chain competition. (Rhim et al., 2003).

Selection of location has been widely given in the literature. Badri (1999) has proposed the use of the Analytic Hierarchy Process and multi-objective goal-programming methodology as aids in making location-allocation decisions. A decision support system for selecting convenience store location through integration of Fuzzy Analytical Hierarchy Process (FAHP) and artificial neural network has been developed by Kuo et al. (2002). Cheng and Li (2004) have explored quantitative methods including data envelopment analysis model and binary integer linear program models that are appropriate for location selection of project. Vahidnia et al. (2009) have developed a Multi-Criteria Decision Analysis process that combines Geographical Information System (GIS) analysis with the FAHP to determine the optimum site for a new hospital in the Tehran urban area. Analytic Network Process (ANP) has been applied by Aragonés-Beltrána et al. (2010) for selecting the best location for the construction of a municipal solid waste (MSW) plant in the Metropolitan area of Valencia (Spain). Ekmekçioğlu et al. (2010) have proposed a modified fuzzy Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) methodology for the selection of appropriate disposal method and site for MSW. Devi and Yadav (2013) have proposed the elimination and choice translating reality (ELECTRE) method with intuitionistic fuzzy sets for selection of appropriate plant location. Güler et al. (2014) have applied Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) method for selection of food industry business facility location.

Table 1. General structure of goal programming model

Goal	Deviation variable to be minimized (included) in z
$\boldsymbol{a_{ij}x_j \leq b_i}$	d_i^+
$\boldsymbol{a_{ij}x_j \geq b_i}$	d_i^-
$\boldsymbol{a_{ij}x_j = b_i}$	$d_i^- + d_i^+$

2. Goal Programming

Simon (1955) conjectures that in today's complex organisations the decision makers do not try to maximise a well defined utility function. In fact the conflicts of interest and the incompleteness of available information make it almost impossible to build a reliable mathematical representation of the decision makers' preferences. On the contrary, within this kind of decision environment the decision makers try and achieve a set of goals (or targets) as closely as possible (Tamiz et al., 1998). Among the proposed methodologies of multi-criteria decision making (MCDM), goal programming (GP) is used for planning (Boukherroub et al., 2015; Schniederjans et al., 2015; Yahia-Berrouiguet and Tissourassi, 2015), supplier selection (Dağdeviren and Eren, 2001; Erdem and Göçen, 2012; Jadidi et al. 2014), selection of facility location (Fang and Li, 2015), network design (Zhong et al. 2012). The roots of GP lie in a paper by Charnes, Cooper, and Ferguson (1955).

The basic steps for structuring goal programming are as follows (Rifai, 1996; (Orumie and Ebong, 2014);

- Goals are discovered and converted to constraints by introducing deviational variables.
- Examine the goals to determine the exact deviational variables needed for them, i.e., whether d_i^-, d_i^+, or both as summarized below in Table 1.

In the second objective goal (row 2 of Table 2.1), it implies that anything below the target value b_i is acceptable, so the over-achievement of the target d_i^+ should be minimized to 0. In row three, the objective goal is that anything below the target value b_i should be driven to zero while the over-achievement of the target d_i^+ should be accepted. The last objective goal implies that anything below or above the target value b_i is unacceptable, so the over-achievement of the

target d_i^+ and under achievement of the goal d_i^- should be minimized to 0.

- Goals are ranked in order of importance and pre-emptive priority factor, pi assigned to each of them.
- In case of ties in priority, assign weights to each of the deviational variables in the priority.

Once the above steps are completed, the problem can be quantified as a GP model.

Schniederjans and Kwak (1982) referred to the most commonly applied type of goal programming as "pre-emptive weighted priority goal programming" and a generalized model for this type of programming is as follows:

Minimize:

$$z = \sum_{i}^{m} w_i p_i (d_i^- + d_i^+) \quad (1)$$

$$\sum_{j}^{n} a_{ij} x_{ij} + d_i^- - d_i^+ = b_i \quad (i = 1, 2, \dots, m) \quad (2)$$

$$x_{ij}, d_i^-, d_i^+ \geq 0, w_i > 0 \quad (3)$$

$$i = 1, 2, \dots, m; \; j = 1, 2, 3, \dots, n) \quad (4)$$

For each of the objectives, a target value or goal would be given (b_i), which is needed to be achieved. Finally, the undesired deviations $d = (d_i^-, d_i^+)$ from the given set of targets (b_i) are minimized by using an achievement function (z). In effect, a deviational variable represents the distance (deviation) between the aspiration level and the actual attainment of the goal. Hence, the deviation variable d is replaced by two variables: $\mathrm{d} = \mathrm{d}_\mathrm{i}^- - \mathrm{d}_\mathrm{i}^+$ where $\mathrm{d}_\mathrm{i}^-, \mathrm{d}_\mathrm{i}^+ \geq 0$. The preceding ensures that the deviational variables never take on negative values. The constraint ensures that one of the deviation variables will always be zero. Finally, the unwanted deviational variables need to be brought together in the form of an achievement function whose purpose is to minimize them and thus ensure that a solution that is "as close as possible" to the set of desired goals is found. This solution is called a compromised (harmonized) solution rather than optimal and that is why it is called a satisficing technique.

3. Application

Six objectives are identified to determine the new facility location during interviews with experts. These objectives are deal with minimizing the positive deviation, locating where most of farm animals and raw materials are in proximity, minimizing the costs of labor, energy and investment, maximizing infrastructure possibilities, and maintaining a policy of desired expansion by opening a location. Then, weights of all criteria have been calculated by using expert views. Accordingly, the weights have been realized as follows: The number of farm animals 30%, distance of raw materials 40%, infrastructure 10%, labor cost 5%, energy cost 5%, and investment cost 10%.

In summary, the GP model is given by the following set of equations:

The objective function, given by equation (12) will attempt to minimize the sum of the deviations present in each of these equations. The goals will be preemptive in nature; as a result, priorities will be attached to each of the goals. In addition to the objectives, there is a need for system constraints to assure that allocation will proceed only if the location is open.

The number of farm animals

$$\sum_{i=1}^{m} t_i Y_i + d_t^- - d_t^+ = T \qquad (5)$$

Distance of raw materials

$$\sum_{i=1}^{m} r_i Y_i + d_r^- - d_r^+ = R \qquad (6)$$

Infrastructure

$$\sum_{i=1}^{m} n_i Y_i + d_n^- - d_n^+ = N \qquad (7)$$

Labor cost

$$\sum_{i=1}^{m} a_i Y_i + d_a^- - d_a^+ = A \qquad (8)$$

Energy cost

$$\sum_{i=1}^{m} e_i Y_i + d_e^- - d_e^+ = E \qquad (9)$$

Investment cost

$$\sum_{i=1}^{m} v_i Y_i + d_v^- - d_v^+ = V \qquad (10)$$

Desired expansion rate

$$\sum_{i=1}^{m} Y_i + d_l^- - d_l^+ = L \qquad (11)$$

$$Min\ Z = P_1 d_t^- + P_2 d_r^+ + P_3 d_n^- + P_4 d_a^- + P_5 d_e^- + P_6 d_v^- \qquad (12)$$

Variables and parameters in the Goal Programming Model

Y_i :Zero-one variable (1 if chosen, 0 otherwise)

i :1:Aliaga, 2:Bayındır, 3:Bergama, 4:Beydag, 5:Cigli, 6:Dikili, 7:Foca ,8:Kemalpasa, 9:Kinik; 10:Kiraz, 11:Menderes, 12:Menemen, 13:Odemis, 14:Selcuk, 15:Tire, 16:Torbali

t_i :The number of farm animals in location i

T :Total targeted the number of farm animals = 160

r_i :Distance of raw materials to location i

R :Total targeted distance of raw materials = 0

n_i: Infrastructure of location i

N :Total targeted infrastructure = 160

a_i :Labor cost i

A :Total targeted labor cost = 160

e_i :Energy cost i

E :Total targeted energy cost = 160

v_i :Investment cost i

V :Total targeted investment cost = 160

L :Number of location to open (desired expansion) = 1

d_t^-, d_t^+ :Negative and positive deviations associated with the number of farm animals

d_r^-, d_r^+ :Negative and positive deviations associated with distance of raw materials

d_n^-, d_n^+ :Negative and positive deviations associated with infrastructure

d_a^-, d_a^+ :Negative and positive deviations associated with labor cost

d_e^-, d_e^+ :Negative and positive deviations associated with energy cost

d_v^-, d_v^+ :Negative and positive deviations associated with investment cost

d_l^-, d_l^+ :Negative and positive deviations associated with desired expansion

Table 2. The number of farm animals and distance of raw materials by districts

District	Criteria			
	The number of farm animals (Cattle)	The number of farm animals (Sheep and Goat)	The number of farm animals (Poultry)	Distance of raw materials (Izmir Alsancak Port)
Aliaga (Y_1)	0.30	2.50	1.65	4.09
Bayindir (Y_2)	5.34	1.65	0.88	5.59
Bergama (Y_3)	4.24	10.00	2.91	7.32
Beydag (Y_4)	1.56	0.51	0.01	10.00
Cigli (Y_5)	0.20	0.33	0.00	1.89
Dikili (Y_6)	0.59	4.35	1.04	8.41
Foca (Y_7)	0.83	0.96	4.87	4.75
Kemalpasa (Y_8)	1.39	1.15	10.00	1.99
Kinik (Y_9)	0.76	2.18	2.36	7.61
Kiraz (Y_{10})	5.68	2.30	0.22	9.78
Menderes (Y_{11})	1.78	4.80	1.71	1.77
Menemen (Y_{12})	1.24	4.85	3.44	2.26
Odemis (Y_{13})	10.00	4.48	1.34	8.12
Selcuk (Y_{14})	0.20	0.93	0.19	5.69

Tire (Y_{15})	7.12	3.49	3.90	6.51
Torbali (Y_{16})	1.96	1.86	7.96	3.97

Izmir has thirty districts, fourteen of them are not included in this study. Because, the establishment of factory in these districts is not a rational decision, according to SWOT analysis of Izmir districts (Anonymous, 2015).

Farm animals such as cattle, sheep and goat, and poultry have different level of daily feed intake. In terms of the number of farm animals criteria, they are handled separately. (TÜİK, 2015). The district which has most of farm animals has been scored as 10, and the others has been scored according to it.

Experts have stated that the most of raw materials used in feed factories are imported. So, Izmir Alsancak Port has been determined as the starting point for distance of raw materials to location. Distances between port and districts were measured by using Google Earth. The most far district to the port has been scored as 10, and the others has been scored according to it (Table 2).

Experts scored the criterions which are infrastructure, labor cost, energy cost, and investment cost on a scale between 0 to 10 points. Cost criterion has been scored as 10, if it is lowest in relevant district (Table 3).

Table 3. Experts' Thoughts on infrastructure possibilities, labor cost, energy cost, and investment cost

District	**Criteria**			
	Infrastructure	**Labor Cost**	**Energy Cost**	**Investment Cost**
Aliaga (Y_1)	9	8	10	8
Bayindir (Y_2)	9	9	6	8
Bergama (Y_3)	9	9	3	9
Beydag (Y_4)	3	9	5	9
Cigli (Y_5)	1	5	10	3
Dikili (Y_6)	5	8	3	8
Foca (Y_7)	3	5	3	5
Kemalpasa (Y_8)	9	8	10	3
Kinik (Y_9)	8	10	3	9
Kiraz (Y_{10})	1	10	3	10
Menderes (Y_{11})	1	5	3	6
Menemen (Y_{12})	9	8	5	6
Odemis (Y_{13})	8	9	5	9
Selcuk (Y_{14})	3	5	5	5
Tire (Y_{15})	9	8	5	8
Torbali (Y_{16})	9	8	8	5

$$Min\ Z = 30d_t^+ + 40d_r^+ + 10d_n^- + 5d_a^- + 5d_e^- + 10d_v^- \qquad (12)$$

The number of farm animals in location i (5)

For Cattle:

$$0.30Y_1 + 5.34Y_2 + 4.24Y_3 + 1.56Y_4 + 0.20Y_5 + 0.59Y_6 + 0.83Y_7 + 1.39Y_8 + 0.76Y_9 + 5.68Y_{10} + 1.78Y_{11} + 1.24Y_{12} + 10.00Y_{13} + 0.20Y_{14} + 7.12Y_{15} + 1.96Y_{16} + d_t^- - d_t^+ = 160$$

For Sheep and Goat:

$$2.50Y_1 + 1.65Y_2 + 10.00Y_3 + 0.51Y_4 + 0.33Y_5 + 4.35Y_6 + 0.96Y_7 + 1.15Y_8 + 2.18Y_9 + 2.30Y_{10} + 4.80Y_{11} + 4.85Y_{12} + 4.48Y_{13} + 0.93Y_{14} + 3.49Y_{15} + 1.86Y_{16} + d_t^- - d_t^+ = 160$$

For Poultry:

$$1.65Y_1 + 0.88Y_2 + 2.91Y_3 + 0.01Y_4 + 0.00Y_5 + 1.04Y_6 + 4.87Y_7 + 10.00Y_8 + 2.36Y_9 + 0.22Y_{10} + 1.71Y_{11} + 3.44Y_{12} + 1.34Y_{13} + 0.19Y_{14} + 3.90Y_{15} + 7.96Y_{16} + d_t^- - d_t^+ = 160$$

Distance of raw materials to location i (6)

$$4.09Y_1 + 5.59Y_2 + 7.32Y_3 + 10.00Y_4 + 1.89Y_5 + 8.41Y_6 + 4.75Y_7 + 1.99Y_8 + 7.61Y_9 + 9.78Y_{10} + 1.77Y_{11} + 2.26Y_{12} + 8.12Y_{13} + 5.69Y_{14} + 6.51Y_{15} + 3.97Y_{16} + d_r^- - d_r^+ = 0$$

The possibilities of Infrastructure i (7)

$$9Y_1 + 9Y_2 + 9Y_3 + 3Y_4 + 1Y_5 + 5Y_6 + 3Y_7 + 9Y_8 + 8Y_9 + 1Y_{10} + 1Y_{11} + 9Y_{12} + 8Y_{13} + 3Y_{14} + 9Y_{15} + 9Y_{16} + d_n^- - d_n^+ = 160$$

Labor cost i (8)

$$8Y_1 + 9Y_2 + 9Y_3 + 9Y_4 + 5Y_5 + 8Y_6 + 5Y_7 + 8Y_8 + 10Y_9 + 10Y_{10} + 5Y_{11} + 8Y_{12} + 9Y_{13} + 5Y_{14} + 8Y_{15} + 8Y_{16} + d_a^- - d_a^+ = 160$$

Energy cost i (9)

$$10Y_1 + 6Y_2 + 3Y_3 + 5Y_4 + 10Y_5 + 3Y_6 + 3Y_7 + 10Y_8 + 3Y_9 + 3Y_{10} + 3Y_{11} + 5Y_{12} + 5Y_{13} + 5Y_{14} + 5Y_{15} + 8Y_{16} + d_e^- - d_e^+ = 160$$

Investment cost i (10)

$$8Y_1 + 8Y_2 + 9Y_3 + 9Y_4 + 3Y_5 + 8Y_6 + 5Y_7 + 3Y_8 + 9Y_9 + 10Y_{10} + 6Y_{11} + 6Y_{12} + 9Y_{13} + 5Y_{14} + 8Y_{15} + 5Y_{16} + d_v^- - d_v^+ = 160$$

Number of location to open (11)

$$Y_1 + Y_2 + Y_3 + Y_4 + Y_5 + Y_6 + Y_7 + Y_8 + Y_9 + Y_{10} + Y_{11} + Y_{12} + Y_{13} + Y_{14} + Y_{15} + Y_{16} = 1$$

All variables must be non-negative.

$$d_t^-, d_t^+, d_r^-, d_r^+, 10d_n^-, d_n^+, d_a^-, d_a^+, d_e^-, d_e^+, d_v^-, d_v^+ \geq 0$$

Zero-one variable (1 if chosen, 0 otherwise)

$$Y_i = \{0,1\}$$

The Solution to the Model

For cattle feed manufacturing company

$d_t^- = 150$	$d_a^- = 151$	$Y_{13}(Odemis) = 1$
$d_r^+ = 8.12$	$d_e^- = 155$	
$d_n^- = 152$	$d_v^- = 151$	

For sheep and goat feed manufacturing company

$d_t^- = 155$	$d_a^- = 152$	$Y_{12}(Menemen) = 1$
$d_r^+ = 2.26$	$d_e^- = 155$	
$d_n^- = 151$	$d_v^- = 154$	

Poultry feed manufacturing company

$d_t^- = 150$	$d_a^- = 152$	$Y_8(Kemalpasa) = 1$
$d_r^+ = 1.99$	$d_e^- = 150$	
$d_n^- = 151$	$d_v^- = 157$	

4. Conclusion

Three types of market structures related to cattle, sheep and goat, and poultry feed are taken into account for selection of the facility location in this study. According to the results of this study, best location for cattle feed factory is Odemis district; best location for sheep and goat feed factory is Menemen district, and best location for poultry feed factory is Kemalpasa district. But, a factory that will manufacture only poultry feed should be established in Aliaga district . Almost half of the members producing animal feed of Aegean Region Chamber of Industry continue their activities in Kemalpasa district. This indicates that investors had sound decision making on the selection of location for poultry feed manifacturing company. But, a company that will manufacture all of these feed should consider other alternative districts in Izmir Province.

References

Anonymous, 2015. İzmir İlçeleri GZFT Analizi. http://www.investinizmir.com/ upload/Sayfa/209/files/Izmir_Ilceleri_GZFT_Analizi.pdf, Erişim Tarihi: 21/01/2016.

Aragonés-Beltrán, P., Pastor-Ferrando, J.P., García-García, F., Pascual-Agulló, A., 2010. An Analytic Network Process approach for siting a municipal solid waste plant in the Metropolitan Area of Valencia (Spain). Journal of Environmental Management, 91(5): 1071-1086.

Badri, M.A., 1999. Combining the analytic hierarchy process and goal programming for global facility location-allocation problem. International Journal of Production Economics, 62(3): 237–248.

Boukherroub, T., Ruiz, A., Guinet, A., Fondrevelle, J., 2015. An integrated approach for sustainable supply chain planning. Computers and Operations Research, 54: 180–194.

Charnes A., Cooper, W.W., Ferguson, R., 1955. Optimal Estimation of Executive Compensation by Linear Programming. Management Science, 1: 138-151.

Cheng, E.W.L., Li, H., 2004. Exploring quantitative methods for project location selection. Building and Environment, 39(12): 1467-1476.

Dağdeviren, M., Eren, T., 2001. Tedarikçi Firma Seçiminde Analitik Hiyerarşi Prosesi ve 0-1 Hedef Programlama Yöntemlerinin Kullanılması. Gazi Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi, 16(2): 41-52.

Devi, K., Yadav, S.P., 2013. A multicriteria intuitionistic fuzzy group decision making for plant location selection with ELECTRE method. The International Journal of Advanced Manufacturing Technology, 66(9): 1219-1229.

Ekmekçioğlu, M., Kaya, T., Kahraman, C., 2010. Fuzzy multicriteria disposal method and site selection for municipal solid waste. Waste Management, 30(8-9): 1729–1736.

Erdem, A.S., Göçen, E., 2012. Development of a decision support system for supplier evaluation and order allocation. Expert Systems with Applications, 39(5): 4927-4937.

Fang, L., Li, H., 2015. Multi-criteria decision analysis for efficient location-allocation problem combining DEA and Goal Programming. RAIRO-Operations Research, 49(4): 753-772.

Güler, D., Adanacıoğlu, H., Saner, G., Azak, Ş., 2014. Food Industry Business Location Selection by Using Promethee Method: A Case of Dry Tomato Business. 1st Project Management Conference with International Participation, Istanbul Technical University, Management Faculty, Macka- Istanbul. September 19-20.

Jadidi, O., Zolfaghari, S., Cavalieri, S., 2014. A New Normalized Goal Programming Model for multi-objective problems: A Case of supplier selection and order allocation. International Journal of Production Economics, 148: 158-165.f

Kuo, R.J., Chi, S.C., Kao, S.S., 2002. A decision support system for selecting convenience store location through integration of Fuzzy AHP and Artificial Neural Network. Computers in Industry, 47(2): 199-214.

Orumie, U.C., Ebong, D., 2014. A glorious literature on Linear Goal Programming Algorithms. American Journal of Operations Research, 4: 59-71.

Rhim, H., Ho, T.H., Karmarkar, U.S., 2003. Competitive location, production, and market selection. European Journal of Operational Research, 149(1): 211-228.

Rifai, A.K., 1996. A note on the structure of the Goal-Programming model: Assessment and Evaluation. International Journal of Operations and Production Management, 16: 40-49.

Schniederjans, M.J., Kwak, N.K., 1982. An Alternative Method for Solving Goal Programming Problems: A Reply. The Journal of the Operational Research Society, 33: 859-860.

Schniederjans, M.J., Schniederjans, D., Cao, Q., 2015. Value analysis planning with Goal Programming. Annals of Operations Research, DOI 10.1007/s10479-015-1882-9. pp 1-16.

Simon, H.A., 1955. Models of Man. Wiley, New York.

Tamiz, M., Jones, D., Romero, C., 1998. Goal programming for decision making: An overview of the current state-of-the-art. European Journal of Operational Research, 111(3): 569-581.

Turkish Statistical Institute, 2015. Animal Husbandry Statistics, http://www.turkstat.gov.tr/, 21/01/2016.

Vahidnia, M.H., Alesheikh, A.A., Alimohammadi, A., 2009. Hospital site selection using fuzzy AHP and its derivatives. Journal of Environmental Management, 90(10): 3048–3056.

Yahia-Berrouiguet, A., Tissourassi, K., 2015. Application of Goal Programming model for allocating time and cost in project management: A case study from the Company of Construction SEROR. Yugoslav Journal of Operations Research, 25(2): 283-289.

Zhong, C.-B., Wei, X.-P., Nie, M.-L., Jiang, D.-Y., 2012. Multi-objective optimization model of distribution network design considering DNCVaR-benefit-customer satisfaction. Xitong Gongcheng Lilun yu Shijian/System Engineering Theory and Practice, 32(10): 2154-2162.