Combining Analytic Hierarchy Process and Goal Programming for Logistics Distribution Network Design

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***Abstract*—Logistics distribution network design is one of the major decision problems arising in contemporary supply chain management. The decision involves many quantitative and qualitative factors that may be conflicting in nature. This paper applies an integrated multiple criteria decision making approach to design an optimal distribution network. In the approach, the analytic hierarchy process (AHP) is used first to determine the relative importance weightings or priorities of alternative warehouses with respect to both deliverer oriented and customer oriented criteria. Then, the goal programming (GP) model incorporating the constraints of system, resource, and AHP priority is formulated to select the best set of warehouses without exceeding the limited available resources. In this paper, two commercial packages are used: Expert Choice for determining the AHP priorities of the warehouses, and LINDO for solving the GP model.**

I. Introduction

The logistics distribution problem is to allocate a number of points of consumption to a number of points of supply, including suppliers, manufacturers, warehouses, distribution centers, and customers. The connection of these various logistics stakeholders by a mean of transportation facilities is regarded as the logistics distribution network. Its objectives are to deliver the right products/services to the right places at the right time, in the right condition, and at the lowest possible cost. So, any approaches focusing on delivery time minimization [1] or logistics cost reduction [2]–[4] only may not design a good logistics distribution network.

Because the optimization techniques with a single criterion or objective are not suitable for the design of logistics distribution network, multiple criteria decision making (MCDM) techniques have been used in recent years. One of the most prevalent MCDM techniques is the analytic hierarchy process (AHP). Some researchers [5]–[8] applied the combined AHP-mixed integer linear programming (MILP) model approach for the network design, whereas another group of researchers [9]–[14] applied the combined AHP-genetic algorithm (GA) approach to solve the problem. For the combined AHP-MILP approach, the selection of distribution network was simply based on the customer satisfaction priorities instead of minimizing the total logistics cost or maximizing the total profit. Therefore, it is believed that the selected distribution network may not be cost effective. For the combined AHP-GA approach, the evaluation criteria used in the AHP are all quantitative such as total cost, total delivery day, effectiveness of capacity utilization for warehouses, and so on. Some qualitative factors such as flexibility of capacity and condition of service were neglected. These factors are crucial in the integrated logistics system because they affect the customer satisfaction directly. To refine the above approaches, this paper applied the combined AHP-goal programming (GP) model approach for the problem, in which both qualitative and quantitative criteria are considered and handled by AHP and GP, respectively. This model can, definitely, lead to an optimal logistics distribution network and win-win situation because the total cost of the supply side can be minimized and also the satisfaction of the demand side can be enhanced.

II. Literature Review

A number of research projects on the combined AHP-GP approach were found in the last decade. Schniederjans and Garvin [15] applied the combined AHP-GP approach to evaluate and select the best combination of cost drivers. Kwak and Lee [16] tackled the problem of allocating higher education institution's resources to IT-based projects by using the combined approach. Radasch and Kwak [17] applied the combined approach to aid the offset planning. Badri [18] used the combined approach to deal with the location-allocation problem. Guo and He [19] applied the combined approach to evaluate various harvesting measures for improving the grain harvesting and post-harvesting system in China. Kim *et al.* [20] adopted the combined approach to evaluate several nuclear fuel cycle scenarios. Lee and Kwak [21] applied the combined approach to deal with the resource allocation problem in the health-care system. Zhou *et al.* [22] applied the combined approach to tackle the scheduling problem in the supply chain of the petrochemical company. Badri [23] applied the combined approach to design quality control systems in the service-based organizations. Although Kwak and Lee [24] used the combined approach as the case with Kwak and Lee [16], they focused on the resource allocation problem in the health-care system instead of higher education institution. Radcliffe and Schniederjans [25] used the combined approach to evaluate and select the best combination of alternative trust categories. Wang *et al.* [26], [27] used the combined approach to evaluate and select the best supplier. Yurdakul [28] applied the combined approach to evaluate and select the optimal combination of computer-integrated manufacturing technologies. Kwak *et al.* [29] used the combined approach to evaluate and select the best combination of advertising media for a Korean company producing digital appliances. Bertolini and Bevilacqua [30] used the combined approach to find out the optimal maintenance policy for every critical centrifugal pump in an Italian oil refinery.

According to the above literature, it is found that the applicability of the combined AHP-GP approach is wide. It can be applied to agriculture [19], business [15], health-care [21], [24], higher education [16], industry [25], logistics [18], [22], [26], [27], manufacturing [28], [30], marketing [17], [29], military [20], and service [23]. However, it has not been used to aid the design of logistics distribution network. This is my primary motivation for writing this paper.

III. MCDM Techniques

MCDM techniques are generally divided into two categories: multiple attribute decision making (MADM) and multiple objective decision making (MODM). MADM techniques aim at selecting the best solution from a population of feasible alternatives which characterized by multiple attributes. One of the commonly used MADM techniques is the AHP, developed by Saaty [31]. MODM techniques are a special extension of linear programming. A model is defined as a linear programming when the single objective function and the constraints involve linear expressions, and the decision variables are continuous. But, in MODM techniques, multiple objective functions are incorporated into the model simultaneously. GP, invented by Charnes and Cooper [32], is an example of the MODM techniques.

IV. Combined AHP-GP Model for the Logistics Distribution Network Design

TABLE I
Notation Used in the Combined AHP-GP Model

i	warehouses (i = 1, 2, …, m)
j	customers (j = 1, 2, …, n)
Q_i	maximum throughput of warehouse i
q_i	minimum throughput of warehouse i
D_j	total product demanded by customer j
fc_i	fixed cost associated with selecting warehouse i
pc_i	penalty cost associated with selecting warehouse i
wp_i	AHP priority of warehouse i
FC	targeted total cost
M	arbitrary large number
x_{ij}	amount of products delivered from warehouse i to customer j
u_i	zero-one variable (1 if the total allocation to warehouse i is less than q_i, 0 otherwise)
v_i	zero-one variable (1 if warehouse i is selected, 0 otherwise)
w_i	zero-one variable (1 if both u_i and v_i are one, 0 otherwise)

Consider a general logistics distribution network which consists of m warehouses denoted as $i = \{1, 2, \ldots, m\}$ and n customers denoted as $j = \{1, 2, \ldots, n\}$. Each warehouse has a maximum throughput (i.e., Q_i), minimum throughput (i.e., q_i), fixed cost (i.e., fc_i), and penalty cost (i.e., pc_i). In cases where the total amount of products assigned to warehouse i (i.e., $\sum_{j=1}^{n} x_{ij}, \forall i$) is less than q_i, this is regarded as impractical allocation because it is not cost-effective to set up a warehouse for processing only a few orders. To avoid low effectiveness of warehouse utilization, pc_i is considered in the model, which is incurred if $0 < \sum_{j=1}^{n} x_{ij} < q_i$. Each customer has a unique order volume (i.e., D_j). The notation used in the combined AHP-GP model is listed in Table I. The problem here is to determine an optimal distribution network, which refers to the allocation of orders to the best warehouses.

A. Prioritization of Warehouses

Traditionally, an optimal distribution network is yielded by allocating customer orders to warehouses so that the total logistics cost is minimized while the warehouse capacity constraint is not violated. As mentioned in Section 1, a solution with the lowest cost does not represent an optimal network in the contemporary supply chain management. Instead, various tangible and intangible criteria need to be considered simultaneously for the design of optimal network. In this paper, five criteria are proposed to evaluate the performance of warehouses. They include total logistics cost, total lead time, reliability of order fulfillment, flexibility of capacity, and condition of service.

Total logistics cost comprises the cost of handling inventories within warehouses, the cost of storing inventories in warehouses, and the cost of delivering products from warehouses to customers. Total lead time comprises the inventory handling time, the inventory storage/loading time, and the delivery time from warehouses to customers. Reliability of order fulfillment consists of the accuracy of quantity fulfillment, the accuracy of the due date fulfillment, and reliability of delivery time. Flexibility of capacity refers to the ability of warehouses to respond to fluctuation in volume of customer orders. Condition of service refers to the condition of products received by customers and the responsiveness of warehouses to customer requests.

The first step of AHP for evaluating the performance of warehouses is to develop a hierarchy of the problem. After that, two criteria are compared at a time with respect to the goal. Once the pairwise comparisons have been made for the five criteria, each alternative warehouse is compared against each other alternative with respect to the corresponding criterion at a time. This type of pairwise comparisons is called top-down. On the other hand, the bottom-up pairwise comparison, in which judgments are made about the alternatives before making judgments about the criteria, is also valid. After completion of all pairwise comparisons, Expert Choice (version 11) is used to synthesize the relative priority of each criterion (from Table II), and each alternative (from Table III). The judgments are acceptable because the consistency ratios are all below the maximum 0.10 level. The overall priority ranking of warehouses can then be computed. Warehouse 1 has the best overall performance because it scores the highest weighting ($wp_1 = 0.411$), followed by warehouse 3 ($wp_3 = 0.239$), warehouse 2 ($wp_2 = 0.185$), and warehouse 4 ($wp_4 = 0.165$).

TABLE II

PRIORITIES OF CRITERIA WITH RESPECT TO GOAL

	C1	C2	C3	C4	C5	Priorities
C1	1	1/3	1/3	3	1/2	0.120
C2	3	1	1	4	2	0.317
C3	3	1	1	4	2	0.317
C4	1/3	1/4	1/4	1	1/3	0.063
C5	2	1/2	1/2	3	1	0.183
					Total	1.000
λ_{max} = 5.094; *CI* = 0.024; *RI* = 1.120; *CR* = 0.021						

C1 = Total logistics cost, C2 = Total lead time, C3 = Reliability of order fulfillment, C4 = Flexibility of capacity, C5 = Condition of service

TABLE III

PRIORITIES OF ALTERNATIVES WITH RESPECT TO CRITERIA

	W1	W2	W3	W4	Priorities
(*C1*)					
W1	1	1/2	1/2	1/3	0.122
W2	2	1	1	1/2	0.227
W3	2	1	1	1/2	0.227
W4	3	2	2	1	0.424
				Total	1.000
λ_{max} = 4.010; *CI* = 0.003; *RI* = 0.900; *CR* = 0.004					
(*C2*)					
W1	1	3	3	5	0.518
W2	1/3	1	1	4	0.214
W3	1/3	1	1	3	0.196
W4	1/5	1/4	1/3	1	0.072
				Total	1.000
λ_{max} = 4.076; *CI* = 0.025; *RI* = 0.900; *CR* = 0.028					
(*C3*)					
W1	1	3	2	4	0.467
W2	1/3	1	1/2	2	0.160
W3	1/2	2	1	3	0.277
W4	1/4	1/2	1/3	1	0.095
				Total	1.000
λ_{max} = 4.031; *CI* = 0.010; *RI* = 0.900; *CR* = 0.011					
(*C4*)					
W1	1	1/3	1/2	1/5	0.086
W2	3	1	3	1/2	0.299
W3	2	1/3	1	1/3	0.140
W4	5	2	3	1	0.474
				Total	1.000
λ_{max} = 4.065; *CI* =0.022; *RI* = 0.900; *CR* = 0.024					
(*C5*)					
W1	1	4	2	3	0.470
W2	1/4	1	1/3	1	0.114
W3	1/2	3	1	2	0.280
W4	1/3	1	1/2	1	0.136
				Total	1.000
λ_{max} = 4.031; *CI* =0.010; *RI* = 0.900; *CR* = 0.010					

W1 = Warehouse 1, W2 = Warehouse 2, W3 = Warehouse 3, W4 = Warehouse 4

B. Resource Data and Decision Variables

The necessary resource data, including data on coefficients and right-hand side value, are presented in Tables IV and V. In the model, there are four types of decision variables:

x_{ij} = amount of products delivered from warehouse i to customer j (m = 4; n = 7)

$$u_i = \begin{cases} 1 & \text{if total allocation to warehouse } i \text{ is less than } q_i \\ 0 & \text{otherwise} \end{cases}$$

$$v_i = \begin{cases} 1 & \text{if warehouse } i \text{ is selected} \\ 0 & \text{otherwise} \end{cases}$$

$$w_i = \begin{cases} 1 & \text{if both } u_i \text{ and } v_i \text{ equal to one} \\ 0 & \text{otherwise} \end{cases}$$

C. Constraints

In the combined model, there are three types of constraints: system, goal, and AHP priority constraints. System constraints are ordinary linear programming constraints, in which there is no deviation variable. This type of constraints cannot be violated, and thus they are called hard constraints. Goal constraints are soft constraints, in which there are deviation variables. AHP priority constraints are akin to goal constraints. In this type of constraints, there are deviation variables of which the priority levels are dependent on the overall AHP priority ranking. The combined model has 13 system constraints, 13 goal constraints, and four AHP priority constraints.

1) System constraints

Number of warehouses selected must be equal to or less than number of warehouses available (i.e., $\sum_{i=1}^{m} v_i \le m$)

$$v_1 + v_2 + v_3 + v_4 \le 4 \quad (1)$$

Determine which warehouse(s) has/have allocation of products that less than minimum warehouse throughput (i.e., $\sum_{j=1}^{n} x_{ij} + Mu_i \ge q_i, \forall i$)

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} + 100000u_1 \ge 7500 \quad (2)$$

$$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} + x_{27} + 100000u_2 \ge 6500 \quad (3)$$

$$x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + x_{36} + x_{37} + 100000u_3 \ge 5500 \quad (4)$$

$$x_{41} + x_{42} + x_{43} + x_{44} + x_{45} + x_{46} + x_{47} + 100000u_4 \ge 4500 \quad (5)$$

Determine which warehouse(s) will be selected (i.e., $\sum_{j=1}^{n} x_{ij} - Mv_i \le 0, \forall i$)

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} - 100000v_1 \le 0 \quad (6)$$

$$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} + x_{27} - 100000v_2 \le 0 \quad (7)$$

$$x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + x_{36} + x_{37} - 100000v_3 \le 0 \quad (8)$$

$$x_{41} + x_{42} + x_{43} + x_{44} + x_{45} + x_{46} + x_{47} - 100000v_4 \le 0 \quad (9)$$

Determine which warehouse(s) will incur penalty cost (i.e., $w_i - u_i - v_i = -1, \forall i$)

$$w_1 - u_1 - v_1 = -1 \quad (10)$$

$$w_2 - u_2 - v_2 = -1 \quad (11)$$

$$w_3 - u_3 - v_3 = -1 \quad (12)$$

$$w_4 - u_4 - v_4 = -1 \quad (13)$$

2) Resource constraints

Priority 1 (P_1): (a) Allocate products to warehouses while the amount must not exceed the maximum warehouse throughput (i.e., $\sum_{j=1}^{n} x_{ij} - d_i^+ + d_i^- = Q_i, \forall i$)

$$x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}-d_1^{+}+d_1^{-}=30000 \quad (14)$$

$$x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27}-d_2^{+}+d_2^{-}=26000 \quad (15)$$

$$x_{31}+x_{32}+x_{33}+x_{34}+x_{35}+x_{36}+x_{37}-d_3^{+}+d_3^{-}=22000 \quad (16)$$

$$x_{41}+x_{42}+x_{43}+x_{44}+x_{45}+x_{46}+x_{47}-d_4^{+}+d_4^{-}=18000 \quad (17)$$

(b) Allocate products to warehouses while the amount must equal to that demanded by the customers (i.e., $\sum_{i=1}^{m} x_{ij}-d_{j+m}^{+}+d_{j+m}^{-}=D_j, \forall j$)

$$x_{11}+x_{21}+x_{31}+x_{41}-d_5^{+}+d_5^{-}=12000 \quad (18)$$

$$x_{12}+x_{22}+x_{32}+x_{42}-d_6^{+}+d_6^{-}=9000 \quad (19)$$

$$x_{13}+x_{23}+x_{33}+x_{43}-d_7^{+}+d_7^{-}=10000 \quad (20)$$

$$x_{14}+x_{24}+x_{34}+x_{44}-d_8^{+}+d_8^{-}=8000 \quad (21)$$

$$x_{15}+x_{25}+x_{35}+x_{45}-d_9^{+}+d_9^{-}=6000 \quad (22)$$

$$x_{16}+x_{26}+x_{36}+x_{46}-d_{10}^{+}+d_{10}^{-}=11000 \quad (23)$$

$$x_{17}+x_{27}+x_{37}+x_{47}-d_{11}^{+}+d_{11}^{-}=7000 \quad (24)$$

Priority 2 (P_2): The total fixed cost associated with warehouse selection must not exceed the targeted amount (i.e., $\sum_{i=1}^{m} fc_i v_i - d_{m+n+1}^{+}+d_{m+n+1}^{-}=FC$)

$$3000v_1+2500v_2+2000v_3+1500v_4-d_{12}^{+}+d_{12}^{-}=7000 \quad (25)$$

Priority 3 (P_3): Allocation of products to warehouses incurring penalty cost is not allowed (i.e., $\sum_{i=1}^{m} pc_i w_i - d_{m+n+2}^{+}+d_{m+n+2}^{-}=0$)

$$750w_1+625w_2+500w_3+375w_4-d_{13}^{+}+d_{13}^{-}=0 \quad (26)$$

3) AHP priority constraints

Priority 4 (P_4): Select warehouse 1 ($wp_1=0.411$)

$$v_1-d_{14}^{+}+d_{14}^{-}=1 \quad (27)$$

Priority 5 (P_5): Select warehouse 3 ($wp_3=0.239$)

$$v_3-d_{15}^{+}+d_{15}^{-}=1 \quad (28)$$

Priority 6 (P_6): Select warehouse 2 ($wp_2=0.185$)

$$v_2-d_{16}^{+}+d_{16}^{-}=1 \quad (29)$$

Priority 7 (P_7): Select warehouse 4 ($wp_4=0.165$)

$$v_4-d_{17}^{+}+d_{17}^{-}=1 \quad (30)$$

4) Objective function

The objective function is to minimize the total deviations from the goals.

Minimize z =

$$P_1\left[\sum_{k=1}^{4} d_k^{+}+\sum_{k=5}^{11}\left(d_k^{+}+d_k^{-}\right)\right]+P_2\left(d_{12}^{+}\right)+P_3\left(d_{13}^{+}\right)$$
$$+P_4\left(d_{14}^{+}+d_{14}^{-}\right)+P_5\left(d_{15}^{+}+d_{15}^{-}\right)+P_6\left(d_{16}^{+}+d_{16}^{-}\right)+P_7\left(d_{17}^{+}+d_{17}^{-}\right)$$

V. Result Analysis

The combined model was solved using LINDO (version 6.1). When priority level 6 was found to be unachievable, the optimization process was terminated. The optimal solutions are summarized in Table V. The solution satisfying the first three priority levels (i.e., P_1 to P_3) is feasible because the allocation does not exceed the maximum throughput of warehouses, does satisfy the volume requirement of customers, does not exceed the fixed cost budget, and does not incur any penalty cost. However, it is not an optimal solution because the best warehouse (i.e., warehouse 1) was not selected. Besides, the summation of AHP priorities of the selected warehouses is 0.589 only. An optimal allocation means that the total cost is minimized and also the customer satisfaction is maximized. Shorter lead time, higher accuracy in order fulfillment, higher flexibility, and better condition of service can achieve higher customer satisfaction. To achieve this goal, warehouses with higher AHP priorities should be selected. The solution satisfying the fourth priority level (i.e., P_4) is better than the previous one. Although the total fixed cost is higher, £7000 vs. £6000, the summation of AHP priorities of the selected warehouses is increased ($\sum wp_i = 0.761$, here *i* represents warehouses 1, 2, and 4). When the fifth priority level (i.e., P_5) was achieved, the solution was further improved in two aspects. First, the total AHP priorities are higher, 0.815 vs. 0.761. Second, the total fixed cost is reduced, £6500 vs. £7000. This is an optimal solution because the next priority level (i.e., P_6) could not be achieved. The values of decision variables v_i show that three warehouses were selected including warehouse 1 (v_1 = 1), warehouse 3 (v_3 = 1), and warehouse 4 (v_4 = 1). The total fixed cost spent for setting up these three warehouses is £6500 with a slack of £500. Besides, the total penalty cost incurred is zero. Priority level 6 could not be achieved because of constraint set (30). If warehouse 2 instead of warehouse 4 was selected, the total fixed cost spent (£7500) exceeds the targeted amount (£7000).

The comparison between AHP priority ranking and the optimal solution of the combined model is summarized in Table VI. The two best performed warehouses were selected. This is a very satisfactory result because the selection can avoid excess usage of the resources and also can increase the competitiveness of the deliverer. Because of the limited fixed cost budget, the third best performed warehouse (i.e., warehouse 2) could not be selected as mentioned earlier. If an excess of £500 is acceptable, warehouse 2 can be selected, too. The total AHP priorities are even higher ($\sum wp_i = 0.835$, here *i* represents warehouses 1, 2, and 3).

VI. Conclusions

There are mainly two inadequacies in the traditional approaches for logistics distribution network design. First, they focused on the points of supply only. The objective was either to minimize the total logistics cost or total delivery time. However, the viewpoints of customers were neglected. Second, they considered the quantitative factors only. Some customer oriented factors in terms of qualitative were not studied.

To overcome the drawbacks, this paper developed an integrated multiple criteria decision making approach to design an optimal distribution network. First, the AHP was used to determine the relative importance weightings of alternative warehouses with respect to five criteria: total logistics cost, total lead time, reliability of order fulfillment, flexibility of capacity, and condition of service. The relative importance weightings or the AHP priorities represent the ability of the warehouses in minimizing the operational cost of the deliverer and maximizing the satisfaction level of the customers. Second, the GP model incorporating the AHP priority, system, and goal constraints was formulated to select the best set of warehouses. The major advantages of this integrated approach are that both qualitative and quantitative factors are considered simultaneously and also both viewpoints of deliverer and customers are focused. Therefore, it is believed that this approach must be more practical and applicable than the stand-alone AHP or GP techniques in making complex decision problems.

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TABLE IV
RESOURCE DATA FOR THE COMBINED MODEL

Warehouse, i	Customer, j 1	2	3	4	5	6	7	Maximum throughput of warehouse i, Q_i	Minimum throughput of warehouse i, q_i	Fixed cost (£), fc_i	Penalty cost (£), pc_i
1	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}	30000	7500	3000	750
2	x_{21}	x_{22}	x_{23}	x_{24}	x_{25}	x_{26}	x_{27}	26000	6500	2500	625
3	x_{31}	x_{32}	x_{33}	x_{34}	x_{35}	x_{36}	x_{37}	22000	5500	2000	500
4	x_{41}	x_{42}	x_{43}	x_{44}	x_{45}	x_{46}	x_{47}	18000	4500	1500	375
Amount demanded by customer j, D_j	12000	9000	10000	8000	6000	11000	7000				

Targeted total fixed cost, FC = £7000; Arbitrary large number, M = 100000.

TABLE V
OPTIMAL SOLUTIONS OF THE COMBINED MODEL

Goal priority	Goal achievement	Solutions: i	j 1	2	3	4	5	6	7	v_i	fc_i	wp_i
P_1, P_2, P_3	Achieved	1	–	–	–	–	–	–	–	0	N/A	N/A
		2	9000	–	–	–	6000	11000	–	1	2500	0.185
		3	–	–	10000	8000	–	–	4000	1	2000	0.239
		4	3000	9000	–	–	–	–	3000	1	1500	0.165
										Total	6000	0.589
P_4	Achieved	1	–	–	–	8000	6000	11000	5000	1	3000	0.411
		2	–	9000	10000	–	–	–	–	1	2500	0.185
		3	–	–	–	–	–	–	–	0	N/A	N/A
		4	12000	–	–	–	–	–	2000	1	1500	0.165
										Total	7000	0.761
P_5	Achieved	1	–	9000	10000	8000	–	–	–	1	3000	0.411
		2	–	–	–	–	–	–	–	0	N/A	N/A
		3	–	–	–	–	6000	5000	7000	1	2000	0.239
		4	12000	–	–	–	–	6000	–	1	1500	0.165
										Total	6500	0.815
P_6, P_7	Not achieved											

TABLE VI
COMPARISON BETWEEN AHP PRIORITY RANKING AND OPTIMAL SOLUTION

Warehouses	wp_i	AHP ranking	v_i	Combined model
1	0.411	1st	1	Selected
2	0.185	3rd	0	Not selected
3	0.239	2nd	1	Selected
4	0.165	4th	1	Selected