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Location Determination of New Branch for Laboratory Clinic X

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Abstract— **Laboratory Clinic X is a Laboratory Clinic that is developing rapidly and participating in the competition among other health service providers. In a highly competitive environment, the selection of a new branch location that has high competitiveness is a top priority. It is important to obtain a location that provides maximum benefits and high competitiveness in accordance with company objectives. Five alternative districts are determined by identifying target market, including population density, potential age population, and wealth level population. Each of the criteria weights is determined using the pair-wise comparison method. The weight is multiplied by the rank held each district, furthermore the five alternative districts are determined; Wonokromo, Semampir, Sawahan, Simokerto, and Tambaksari. The selection criteria and sub criteria are identified based on Porter's Diamond Model. One of the significant sub criteria is the investment feasibility of each district using NPV, IRR, and payback period. The investment feasibility calculations indicate that Wonokromo District the largest weight; NPV IDR 60.646.579.867, 29% IRR, 5 years and 4 months of payback period. Furthermore, P-Median Method is used to find sub optimal from each location. The ANP assessment was conducted using expert judgments. Furthermore, weighted gained by each district shows Wonokromo District get first priority, with a weight of 0.2038, Tambaksari District the second priority with a weight of 0.0942, Simokerto District get 0.0782 of weight, District Semampir get 0.0726 of weight, and Sawahan District 0.0502. As the district with the highest weight, District Wonokromo is chosen as the best location.**

Keywords: **Laboratory Clinic Location Selection, Porter's Diamond Model, P-Median Method, Investment Feasibility, ANP.**

1. Introduction

The increasing of public awareness about health causes the increasing of the need for clinical laboratories. The existence of more clinical laboratories will increase competition so the Laboratory Clinic X should choose the right location in order to survive and even flourish.

To determine the location of new branches, there is a need to analyze the characteristics of the population in each district, the competitive advantage they had, existing demand in the district, access to supplier, the availability of infrastructure network, competition etc.

2. Theoretical Framework

This research is using these approaches and theories: Target Market, Porter's Diamond Model, Analytic Network Process (ANP) Method, P-Median Method, and the feasibility of investment using the calculation of Net Present Value (NPV).

2.1. Target Market

First stages of the research is identifying the market target for Laboratory Clinic X to obtain five district alternatives. This is not done by [1] in his research, where alternative locations are selected based on one criterion, which is the population density. This study not only using population density but also involving potential age and number of population with upper-middle income.

After identified, the priority weight is calculated for each criteria using pairwise comparison based on assessment which is done by Laboratory Clinic X's management. Furthermore, a weighted value is calculated by multiplying the weight rating value of each district, so we can gain five alternatives with have the highest weighted value.

2.2. Porter's Diamond Model

Identification of competitiveness criteria based on Porter's Diamond Model for evaluating five alternative locations. The criteria identification based on the Porter's Diamond Model is done by [1] and [2] and in this research, respondents are expert of land use, transportation, infrastructure, and and regulations. Those respondents are city planning consultant, government, and academic experts.

Porter's Diamond Model consists of six elements [3], which are:

1. Factor conditions, i.e., factors of production, such as labor resources, capital, etc.
2. Demand conditions, i.e., the nature of consumer demand in the area.
3. Firm strategy, structure, and rivalries.
4. Related and supporting industries: The presence or absence in a nation of supplier industries and related industries that are globally competitive.
5. Government policy and political environment.

6. Chance such as changing market demand, disasters, and technological developments.

Sub-criteria are gained based on existing criteria of Porter's Diamond Model, compared to several references and previous researchs, and adjustments to the observed objects by the laboratory clinic.

2.3. P-Median Method

The calculation to obtain the optimal number of sub district in each district is done using the P-Median Method (Myopic Algorithm approach).

2.4. Investment Feasibility

Furthermore, as an input in assessing the economic factor, the feasibility of investment is done for the five alternatives locations using the calculation of Net Present Value (NPV), Internal Rate of Return (IRR) and payback period.

2.5. Analytic Network Process (ANP)

ANP which was developed by Thomas L. Saaty, provides a procedure to assess and measure the ratio scale of priorities for the influence distribution between the factors and groups of factors in the decision [4].

Within the criteria and sub criteria that have been identified based on Porter's Diamond Model, the relationships between criteria and sub-criteria is identified. This process is an advantage of Analytic Network Process (ANP), which is in accommodating the interdependencies between the criteria and sub-criterion. [5]

In determining the location of Laboratory Clinic X's new branch, there are various interactions and dependencies between the criterion, sub criterion, and alternatives, so, the ANP method is applied. Assessment is done using pair-wise comparison among criterion, among sub-criteria, and between the sub-criteria and the alternatives by some experts, such as city planning experts from academic field, city planning consultant, and the management of Laboratory Clinic X. The values gained from the experts are calculated using the average geometry formula then entered into the matrix of combined opinion that will be input for ANP method. Locations with highest priority weight is selected as the new Clinical Laboratory X's branch location.

2.6. Sensitivity Analysis

In this research, sensitivity analysis is evaluated toward one of the parameters in investment feasibility, that is demand.

3. Data Collection and Implementation

Three criteria for the selection of a new Laboratory Clinic X's branch location based on Market Target, are population density, potential age (25-59 years), and number of population with middle-upper income. Five districts with highest weighted value will be the alternative district.

$$y_n = a \times PD_n + b \times PA_n + c \times PI_n \qquad (1)$$

Explanation:

y_n = Weighted value for the n^{th} district
a = Weight of population density criteria
b = Weight of potential age range criteria
c = Weight of population number with middle-upper income
PD_n = Population Density Rate in the n^{th} district
PA_n = Potential Age Population Rate in the n^{th} district
PI_n = Number of population with middle-upper income rate in the n^{th} district

The values of a, b, and c are the weight of each criteria gained from research done by some experts using pair-wise comparison, as shown by Fig. 1.

Based on pair-wise comparison's result, the weight value of population density criteria is 0.163, the weight value of potential age criteria is 0.297, and the weight value of population number with middle-upper income is 0.54. The value of PD_n, PA_n, and PI_n that shows a district rating based on population density, potential age, and population number with middle-upper income is calculated using the following formula:

$$PD_n = (PD_n/\text{Total } PD) \times 100 \qquad (2)$$

Explanation:

n = The n^{th} district
PD = Population density
PD_n = Population Density Rating in the n^{th} district

The district's rating value based on population density is shown by Table 1.

Table 1. District's Rating Value Based on Population Density

No.	District	Density	Value
1	Sawahan	32216.0	8.57
2	Tambaksari	24821.9	8.56
3	Semampir	22053.3	7.41
4	Wonokromo	22045.5	7.17
	.....	.....	.....
28	Bulak	10531.3	1.35
	TOTAL	**2,605,957**	**100**

R(PDsawahan) = (32216/2605957) × 100
= 8.57

The same calculation are applied to obtain a rating value is done to the potential age and population number

with middle-upper income criterion. After the rating value for each district based on each criteria is known, the calculation of weighted values are done, as shown by Table 2.

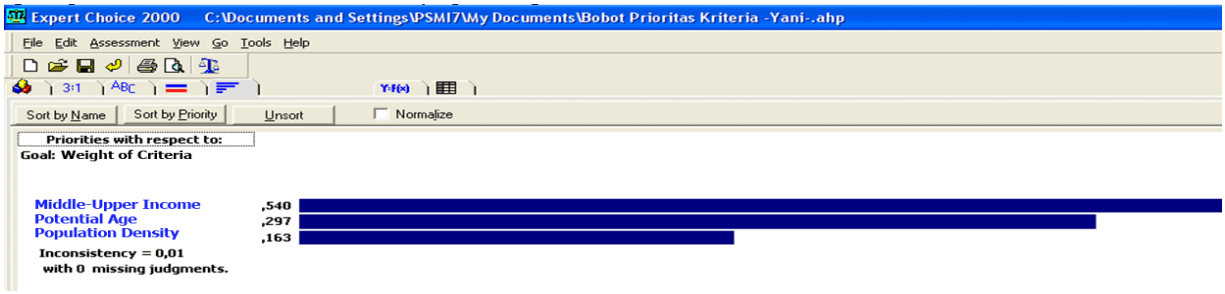

Fig. 1. Pairwise Comparison of Selection Criterion

Table 2. District's Weighted Value

No	District	PD_n	Weight of PD	PA_n	Weight of PA	PI_n	Weight of PI	Weighted value (y_n)	
1	Sawahan	8.57	0.163	9	0.297	4.34	0.54	8.954	3
2	Tambaksari	8.56	0.163	8.48	0.297	4.04	0.54	8.498	5
3	Semampir	7.41	0.163	7.25	0.297	7.15	0.54	11.051	2
4	Wonokromo	4.8	0.163	7.47	0.297	11.09	0.54	15.014	1
5	Krembangan	4.58	0.163	4.87	0.297	5.57	0.54	8.344	
6	Tegalsari	4.48	0.163	4.75	0.297	4.98	0.54	7.68	4
7	Kenjeran	4.45	0.163	4.1	0.297	3.32	0.54	5.809	
8	Bubutan	4.09	0.163	4.52	0.297	2.99	0.54	5.6	
9	Simokerto	3.81	0.163	4.06	0.297	6.25	0.54	8.661	
10	Sukolilo	3.74	0.163	3.83	0.297	5.79	0.54	8.088	
11	Sukomanunggal	3.62	0.163	3.68	0.297	4.38	0.54	6.625	
12	Tandes	3.6	0.163	3.68	0.297	1.74	0.54	3.961	
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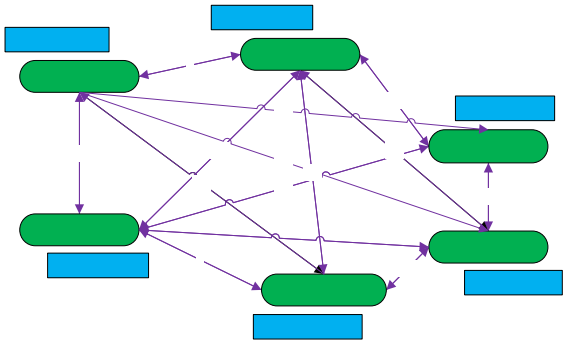

Fig. 2. Sub District Network at Wonokromo District

Based on the weighted value, five alternative districts are determined, they are: Wonokromo District, Semampir District, Sawahan District, Simokerto District, and Tambaksari District, as shown by Fig. 2. Distance between sub districts in Wonokromo District is shown by Table 3.

Districts have a very large area and it will complicate the assessment of specific criterion. To overcome that difficulty, the optimal sub district is determined for each district using P-Median method, with Myopic Algorithm approach.

$$\min \sum_i \sum_j d_i d_{ij} \qquad (3)$$

h_i = Demand at node i

d_{ij} = Distance between demand point at node i with node j, which is the built candidate (d_{ij} is zero if $i = j$).

For example:

Wonokromo Sub District

= (0 × 40426) + (2 × 24931) + (3.4 × 12762) + (3.1 × 50548) + (2.6 × 19583) + (2.6 × 33411)

= 387520

The calculation is applied to all existing sub district in the Wonokromo district until the demand-weighted distance for each sub district is obtained, as shown by Table 4. Minimum demand-weighted distance is the optimal sub district.

Table 3. Distance Between Sub Districts in Wonokromo District

No.	Sub District	Wonokromo	Jagir	Ngagel	NgagelRejo	Darmo	Sawunggaling	Population Number
1	Wonokromo	0	2	3.4	3.1	2.6	2.6	40,426
2	Jagir	2	0	4.2	3.7	4.9	4.9	24,931
3	Ngagel	3.4	4.2	0	0.8	2.2	4.1	12,762
4	NgagelRejo	3.1	3.7	0.8	0	2.1	4	50,548
5	Darmo	2.6	4.9	2.2	2.1	0	3	19,583
6	Sawunggaling	2.6	4.9	4.1	4	3	0	33,411

Table 4. Wonokromo District's Total Demand-Weighted Distance

WONOKROMO DISTRICT (Node *j*)							
No	Node *i*	Wonokromo	Jagir	Ngagel	NgagelRejo	Darmo	Sawunggaling
1	Wonokromo	0	80852	137448	125321	105108	105108
2	Jagir	80852	0	104710	92245	122162	122162
3	Ngagel	84765	104710	0	10210	28076	52324
4	NgagelRejo	39562	47219	10210	0	106151	202192
5	Darmo	131425	247685	111206	106151	0	58749
6	Sawunggaling	50916	95957	80290	78332	58749	0
Total		387520	576424	443864	412258	420246	540535

From the calculation above, it is known that the Wonokromo Sub District is the optimal sub district from Wonokromo District with a minimum average distance to all demand points.

$$\text{Average distance} = \frac{\text{Total demand weighted distance}}{\text{Total Demand}} \quad (4)$$

Average distance = 387520 / (181661) = 2.13 km

Calculation of demand-weighted distance and average distance to all demand points are done for five districts in order to obtain the sub district with an optimal average distance, as shown by Table 5.

Table 5. Demand-Weighted Distance and Average Distance

Median Number	Location (Sub District)	Demand-Weighted Distance	Average Distance
1	Wonokromo	387520	2.13 km
1	Wonokusumo	359558	1.85 km
1	Kupang Krajan	309913	1.39 km
1	Simokerto	276254	1.22 km
1	Ploso	90634	0.89 km

After identifying the optimal sub district from each district, criteria and sub criteria for selecting the locations Laboratory Clinic X are identified using Porter's Diamond method. Sub criteria are identified based on previous research and adjustments are made by some experts, as shown in Table 6.

From twenty-eight identified sub-criteria, there are two sub-criteria which are not valid, which are:

1. Soil physical conditions (SC5)
   This sub criterion is considered not significant in the selection of the Laboratory Clinic X's new branch location. So, sub-criteria SC5 is removed and not included in the next process.
2. Significant changes in production costs due to events such as fuel, steel, and iron prices rising, and the energy crisis (SC26) This sub-criterion is invalid because the sub-criterion is considered not giving different assessments in each alternative district.

Economic factor is one of the sub criteria in Porter's Diamond Model. So, the economic factor is calculated by calculating Net Present Value (NPV), Internal Rate of Return (IRR) and payback period. The NPV calculation for Wonokromo District is shown by Table 7.

Based on the calculation Table 7, the Wonokromo District's NPV is Rp.60.445.764.441,00, its IRR is 28.9%, and its payback period is in five years and four months. Furthermore, the same calculation is applied, in order to calculate feasibility of investment for the other alternatives as shown by Table 8.

Based on the calculation of NPV, IRR, and payback period above, it is known that the districts which are not feasible in terms of investment are Sawahan District and Tambaksari District. This result will be used as one of the sub-criteria assessment in ANP questionnaire, as

Table 6. Criteria and Sub Criteria for Selecting Laboratory Clinic X's Location

Level 1: Ultimate Goal	Level 2: Criteria	Level 3: Sub-Criteria	Level 4: Alternatives
Getting a new branch location for Laboratory Clinic X based on its competitiveness.	Condition Factor (C_1)	Availability of infrastructure (SC_1)	**Wonokromo District (Ae_1)**
		Availability of Public transportation (SC_2)	
		Closeness with hospital (SC_3)	
		Congestion level (SC_4)	
		Soil physical conditions (SC_5)	
		Free of Floods (SC_6)	
		Free of polution (SC_7)	
		Proximity to police stations and fire extinguisher (SC_8)	
		Availability of sewerage drainage (SC_9)	
		Permit ease (SC_{10})	
	Demand Condition (C_2)	Existance medical school (SC_{11})	
		Population characteristics (SC_{12})	
		Community acceptance (SC_{13})	
		Marketing Scope (SC_{14})	
		Economics Factor (SC_{15})	**Semampir District (Ae_2)**
	Company's strategy structure and competitiveness (C_3)	The absence of clinical laboratory (SC_{16})	
		Existance of CSR (SC_{17})	
		Local Appropriation for laboratory (SC_{18})	
	Supporting and related industries (C_4)	The existence of health services, such as hospitals, health centers, and physicians (SC_{19})	**Sawahan District (Ae_3)**
		Proximity to suppliers of the clinical laboratory (SC_{20})	
		Proximity to a pharmacy and related industries (SC_{21})	
	Government (C_5)	Legal restrictions (SC_{22})	**Simokerto District (Ae_4)**
		Government policy (SC23)	
		Political environment (SC24)	
	Opportunity/ Change (C6)	Level of community acceptance (SC25)	
		production costs (SC26)	**Tambaksari District (Ae_5)**
		Crime rate (SC27)	
		Changes in market demand (SC28)	

Table 7. Wonokromo District's Net Cash Flow

Year	Cash Flow			Net Cash Flow
	Operation Activity	Investment Activity	Funding Activity	
0	-	(17,906,422,635)		(17,906,422,635)
1	878,989,984	705,741,340	(1,074,385,358)	510,345,966
2	1,320,823,374	2,026,564,714	(1,074,385,358)	2,273,002,730
3	1,818,752,037	2,482,447,349	(1,074,385,358)	3,226,814,028
4	2,338,767,082	3,031,202,717	(1,074,385,358)	4,295,584,440
5	2,904,147,827	3,564,897,256	(1,074,385,358)	5,394,659,725
6	3,526,321,045	4,155,892,723	(1,074,385,358)	6,607,828,410
7	4,197,228,417	4,845,850,210	(1,074,385,358)	7,968,693,268
8	4,929,336,601	5,612,892,436	(1,074,385,358)	9,467,843,679
9	5,729,054,053	6,374,095,107	(1,074,385,358)	11,028,763,802
10	6,603,452,862	7,287,008,697	(1,074,385,358)	12,816,076,201
11	7,560,815,540	8,122,504,099	-	15,683,319,639
12	8,508,556,548	9,191,474,483	-	17,700,031,031
13	9,556,896,444	10,192,999,421	-	19,749,895,865
14	10,716,319,386	11,399,237,320	-	22,115,556,706
15	11,998,392,795	12,629,697,239	-	24,628,090,034
16	13,415,878,826	14,010,874,731	-	27,426,753,557
17	14,982,857,278	15,608,871,339	-	30,591,728,617
18	16,714,861,128	17,397,779,063	-	34,112,640,191
19	18,629,025,985	19,249,207,400	-	37,878,233,385
20	20,744,254,884	21,427,172,819	-	42,171,427,703

IRR	0.289983335
NPV	60.445.764.441
Payback Period	5 years and 4 months

shown by Table 9, with the following assessment:

<0: Very not good
1-29: Not good
30-59: Good
60-79: Very good
80-100: Absolutely good

Table 8. Investment Feasibility of Each District

Feasibility of	Semampir	Sawahan	Simokerto	Tambaksari
NPV (thousand	20.347.080	11.043.224	10.695.000	14.158.684
IRR	18%	7%	15%	6%
Payback Period	9 years	14 years	10 years 6 months	15 years 10 months
Decision	Feasible	Not Feasibl	Feasible	Not Feasible

Table 9. Assessment Categories in Feasibility of Investment

District	NPV	Rating	Assessment Category
Wonokromo	60.646.579.867	91.2	Absolutely good
Semampir	20.347.080.593	30.6	Good
Sawahan	-11.043.224.549	-16.6	Very not good
Simokerto	10.695.000.476	16.1	Not good
Tambaksari	-14.158.684.019	-21.3	Very not good
Total	66,486,752,368		

Assessment categories obtained from the feasibility of investment calculation will be used to assess the sub-criteria in economic factors as one of the attributes in the ANP.

Valid sub criteria are used as questionnaire inputs in the model and in the weight priority determination using Analytical Network Process (ANP) method. ANP method is used to determine the weight of each alternative to select a location with best competitiveness and potential. Before the weighting determination of criteria, sub-criteria, and alternatives are done, the relationship among the criteria, among sub-criteria, and between the sub-criteria and alternatives are identified. After identified, validation is done by conducting brainstorming with some experts in order to get valid relationships. An ANP model using the Super Decision software is shown below. In this model, interdependencies among the criteria in the 'criteria cluster', the relationship among sub-criteria in the 'sub-criteria cluster', and the relationships between each node in the sub-criteria cluster with each node in the alternative cluster are determined. The relationship among criteria will show the importance of a criteria compared with the other criteria, similarly with the relationship among sub-criteria. A sub-criteria node connected with nodes of other sub-criteria node based on its the basis of their relationship with a sub-criteria node.

Questionnaire based on expert judgment compares the location selection criteria, sub-criteria, and between the sub-criteria and alternative locations. Experts needed in this assessment of optimal location is Surabaya city planning expert and experts working in the health services field, especially laboratory clinic. Experts who have the expertise in Surabaya city planning are consists of the Surabaya city planning consultant and Surabaya city planning experts from the academic field. Meanwhile, experts from the laboratory clinic health services field is the branch manager and marketing team of Laboratory Clinic X.

The results of sub-criteria priority weights using ANP method is shown by Table 10. Priority weights' alternatives is shown by Table 11.

Table 10. Sub Criteria Priority Weights

No	Sub criteria	Weight	Limiting
1.	Infrastructure	0.154	0.0769
2.	Public Transportation	0.089	0.0446
3.	Closeness to Hospital	0.031	0.015
4.	Traffic Density	0.029	0.014
5.	Flood Free	0.0004	0.00018
6.	Pollution	0.023	0.0012
7.	Closeness to police &	0.001	0.00049
8.	Waste Drainage	0.018	0.0091
9.	Existing Land	0.148	0.0738
10.	Related Institution	0.024	0.117
11.	Accordance to Public's	0.031	0.0156
12.	Public Acceptance	0.022	0.011
13.	Marketing Scope	0.084	0.042
14.	Feasibility of Investment	0.274	0.137
15	Unavailability of Other	0.025	0.0127
16.	Social Responsibility	0.01	0.0051
17.	Policy Maker Preference	0.009	0.0043
18.	Helath Services	0.007	0.0036
19.	Closenees with supplier	0.017	0.0087
20	Closeness with pharmacy	0.0138	0.0069
21.	Legal restriction	0.0001	0.00005
22.	Government Policy	0.0016	0.0008
23.	Political Environment	0.0008	0.0004
24.	Public's social condition	0.0048	0.0024
25.	Crime Level	0.0018	0.0009
26.	Market Demand Changes	0.0021	0.001

Table 11. Priority Weights' Alternatives

Alternative	Normalized by Cluster	Limiting
Wonokromo District	0.40841	0.203813
Semampir District	0.14558	0.072649
Sawahan District	0.10066	0.050231
Simokerto District	0.15668	0.078192
Tambaksari District	0.18867	0.094155

4. Conclusion

Based on calculations using the ANP method, among the six criteria in Porter's Diamond Model, which are consists of the condition factor, demand factor, competitive strategies, support and related institutions, government, and changes, the criterion that has the most impact in the selection of the laboratory clinic is the demand criterion, with a priority weight of 0.202.

Competitiveness sub criterion, which is considered in the selection of the Laboratory Clinic X's new branches location, is consists of twenty-six sub-criteria, where the five most influential sub-criteria based on the weighting using ANP method are the feasibility of investment (NPV, IRR, and payback period) with a weight of 0.14, availability of network infrastructure with a weight of 0.077, existing land use with a weight of 0.074, public transportation with a weight of 0.045, and scope with a weight of 0.042.

Calculation of weighted values based on the target market, the priority weights, which are calculated by pairwise comparison, and rating values result five alternative districts, which are Wonokromo, Semampir, Sawahan, Simokerto, and Tambaksari District.

Optimal sub districts for each district based on P-Median method, are Wonokromo Sub District in Wonokromo District, Wonokusumo Sub District in Semampir District, Kupang Krajan Sub District in Sawahan District, Simokerto Sub District in Simokerto District, and Ploso Sub District in Tambaksari District.

The selected location based on priority weights obtained using ANP method is Wonokromo District with a weight of 0.204, then Semampir District with a weight of 0.073, next Sawahan District with a weight of 0.051, Simokerto District with a weight of 0.0782, and Tambaksari District with a weight of 0.094.

Wonokromo District as the selected location (with highest priority weight) also has the highest feasibility of investment value with Net Present Value (NPV) of Rp. 60,646,579,867.00, IRR of 29%, and payback period of five years four months. Based on the sensitivity analysis, a 51% decline in the demand of Laboratory Clinic X in Wonokromo District is the maximum reduction that can be accepted without changing the feasible decision.

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