The Analysis Of Variables Which Influence Rent-Value Of Units On Multi-Level Commercial Building Based On 3d Network Data Structure

(Case Study: units in Istana Bandung Electronic Center - BEC, Bandung City)

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ABSTRACT

The value of business units on multi-level commercial building is influenced by physical and location factors. The physical factor variables could be easy identified from attribute data. However identifying location factor variable is more difficult because it requires geometric calculation based on the model of topological relationship among units on multi-level commercial building (room, vertical conduits and corridor). The objective of this research is build data structure of 3D network, which is weighted by *euclidian-distance* and *time-distance* to identify the location factor variable coefficient using shortest path analysis of djikstra algorithm. Subsequently, the results of variable identification analyzed using multiple regression analysis to derive topological relationship and variable which most influencing rent-value of units.

This research shows the weight of *euclidian-distance* of network has more influence to rent-value rather than the *time-distance* of network. Variables: *floor level* has negatively effect, *amount of access* has positively effect, *distance to entrance* has negatively effect, *distance to escalator* has negatively effect and *distance to elevator* has negatively effect to rent-value of units with 95% confidence level signification.

Keyword: 3D network, shortest path analysis, multiple regression analysis.

1. PRELIMINARY

1.1 Background

The limited supply of land, causes a horizontal commercial building is inefficient to be built, rather than the vertical one (Purbo, 1998). The fact now can be seen by a lots of units business have been emerging in stories building (such as business building through the Sudirman street, Mal Ciputra, Plaza Blok M and many others in Jakarta). In order to represent the complex internal structure of the buildings on geometric and thematic dimensions, there are some limitations in the current 2D data structure. The 3D objects presented as 2D projections in Geographic Information Systems (GIS) may loose some of their properties and spatial relationships to other objects (Billen and Zlatanova, 2003)

Value of sell/rent business unit per meter square on multi-level commercial building is not same for unit which located in floor differ or different location although they have the same material. Vernor and Rabianski (1993) believe that value of business unit on multi-level commercial building influenced by the unit's location factor. To prove that, Yasin Haryanto (2004) did research of identifying location factors variable with queries spatial from wire frame 3D model building units. In fact, the identification of the location variable is not fully based on the 3D model.

The model can be used to identify variable of factor location unit if the model can represents topological relationship between units. To be able to represent complexity of spatial relationship between units on multi-level commercial building, Lee (2001) using 3D network data structure or node-relation structure (NRS). Using principle of *poincare duality*, room unit (3D) and vertical conduits(doorstep, elevator, escalator) becoming node (0D) and corridor polygon (2D) becoming line (1D), each of node unit linked to medial axis line of corridor at each floor and each floor connected by the link of the pair of vertical conduits node. 3D network data structure allows the implementation of network-based analysis such as shortest path analysis to identify variable of location factor.

1.2 Problem Statement

This research starts from these *research questions*:

1. How to build data structure of 3D network, which represents the topological relationships of units on multi-level commercial building.
2. What is the possible variable of location factor that influence the unit's of rent/sell value on multi-level commercial building.
3. How to identify the variable of location factor from formed 3D network data structure.

This research limits the problem at the followings:

1. The election of variable based on possibility of the variable that can be identified in data structure of network obtained from attribute data.

2. Data structure of network is limited to weighted network of *euclidian-distance* and *time-distance*

1.3 Research's purpose and benefit

The research's purposes are:

1. Obtaining most influencing spatial relationship to rent-value units.
2. Obtaining model for predicting rent value unit.

The Research's benefit is:

1. Besides giving technique alternative visualizing room units on multi-level commercial building Data structure of 3D network also gives amenity and speed of identification of factor location.
2. Alternative of assessment method (comparator method) in assessment study especially to assess business units on multi-level commercial building.

1.4 Hypothesis

For the focus of research hence, this research is based on hypothesis:

1. Location factor variables can be identified easily and quickly with data structure of 3D network.
2. Variables:
   a. Wide of unit (physical factor) has positively effect
   b. Amount of access (physical factor) has positively effect
   c. Floor level (location factor) has negatively effect
   d. Distance to closest Entrance (location factor) has negatively effect
   e. Distance to closest Elevator (location factor) has negatively effect
   f. Distance to closest Escalator (location factor) has negatively effect
   g. Distance to closest Stairway (location factor) has negatively effect

   to rent value of unit.
3. *Euclidian-distance* relationship among units has more influence to rent value rather than *time-distance*.

1.5 Methodology

Figure 1 describes the methodology, which is used in this research.

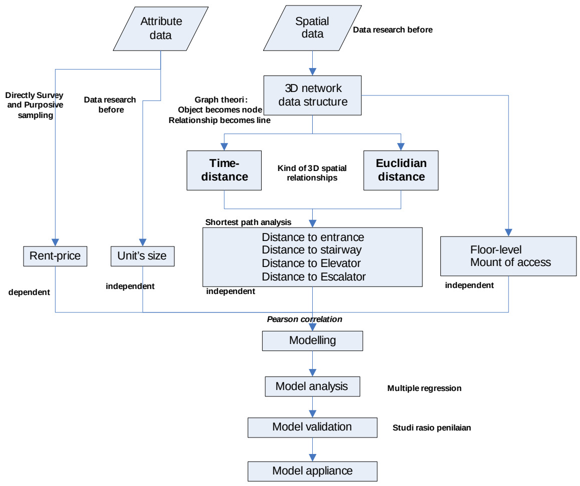
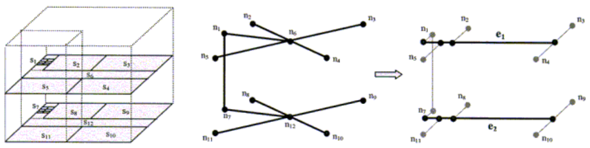


Fig. 1. Research's methodology

2. RESEARCH'S STUDY

Jiyeong Lee (2001) introduced data model of node-relation structure (NRS) to represent topological relationship among discrete 3D object on multi-level building. Topology of units in building (room, corridor, elevator, escalator, etc) with NRS can be interpreted by two data model: Model Logical and Geometric (figure 2). Model of Logical is depicting topological relationship between units in building. Model of Geometric is a model that depicts topological and geometric relationship among units for the purpose of calculation of geometric (distances between objects, long of corridor) of unit, so that Network Analysis, like shortest path analysis, can be done.



a. Multi-level building units **b. Logical** **c. Geometric**

Figure 2. Node-relation structure (NRS)

Each room unit is represented by dot geometric (Node) at centroid of the polygon. Vertical conduit units on each floor (stairway, elevator, escalator) also represented by dot (Node). Each corridor is represented by line geometric (Edge) by using algorithm of Straight Medial Axis Transform-SMAT. All node of units linked to line/corridor edge to form the structure of network 2D. Each floor connected by line of pair of vertical conduit unit nodes to form 3D network data structure. Data structure of NRS can be used for the analysis network among units on multi-level building using the modified djikstra algorithm.

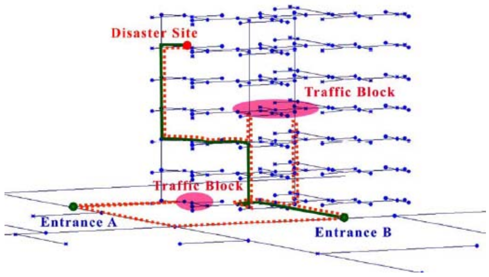


Fig. 3. NRS for GIERS

Jiyeong Lee and Mei-Po Kwan (2004) implemented model of node relation structure (NRS) to examine the potential of using real time 3D GIS for the development and implementation of GIS-BASED intelligent emergency response systems (GIERS) that aim at facilitating quick emergency response to on multi-level structures (such as building of WTC in United States). 3D Network (data structure of NRS) of multi-story building is connected to network outside building, integrated with spatial information systems in and outside building it is expected that it can be analyzed with shortest path analysis so that evacuation paths entirely network in and outside multi-story building can be tested. Their study shows that response delay within multi-level structures can be much longer than delays incurred on the ground transportation system and GIERS have the potential for considerably reducing these delays (figure 3).

Jiyeong Lee and Hamid Yunus (2005) propose a new approach in creating a 3D Cadastre using 3D topological data model based on Node-Relation Structure in order to represent 3D attribute data (thematic properties) integrated with 3D spatial data (geometric and topological data) of spatial objects in 3D GIS. The conceptual topological 3D data model represents the topological relationships such as adjancey and connectivity between 3D geographic entities in graph theory.

M. Meijers S. Zlatanova and Pfeifer (2005) built a semantic model representing 3D structure of interiors to be used for an intelligent computation of evacuation routes. The model consist of two levels (polygon and section), which take into account the possibilities to move through buildings. A semantic classification of polygons with respect to different characteristics is introduced as the first level (i.e. polygon level). Sections are specified at the second level (i.e. section level) based on the polygon classification. Particular polygons and sections are accordingly mapped to nodes and edges of graph, which is used for routes calculations. The model is implemented in geo-DBMS using spatial data types and network possibilities of Oracle Spatial 10g.

Yasin Haryanto (2004) did a research of assessment of business units in building of trade center (case study of JITC Mangga Dua) by measuring variables of spatial anticipated influence unit value that are: unit size, floor level, wide front of unit, wide of corridor, amenity of view of street, distance from tenant anchor, distance from entrance, distance from mall, from wire frame geometric model of 3D building, using spatial query. Result of research shows that floor position, unit size, wide front unit, distance from tenant anchor, wide of corridor, amenity of view of street, distance from entrance and distance from mall have a significant effect to unit value.

3. IMPLEMENTATION

The flow of this research is depicted at figure 4.

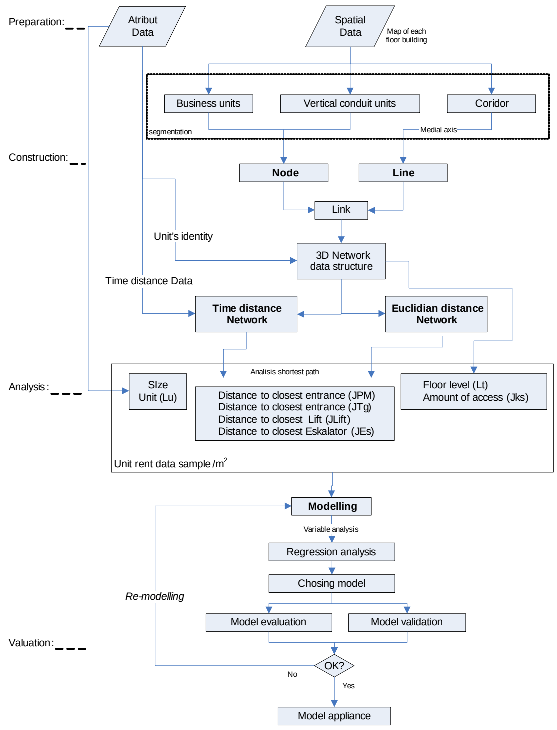


Fig. 4. Research's flowchart

3.1 Research's object

Research's object is units in *Istana Bandung Electronic Center* (BEC) Building, Purnawarman street number 13-15 Bandung City.

Fig. 5. Units in Istana BEC, Bandung

Underground Floor (LU) has 129 special retail shops of hand phone, Ground Floor (LG) has 97 special shop retail of hand phone, Upper Ground (UG) has 100 special shop retail of hand phone, Floor 1 has 77 special shop retail of computer, PDA, digital camera, and appliances home, Floor 2 has 93 special shop retail of computer, PDA, digital camera, Floor 3 as special place of Food Court and play ground, 15 Escalators, 2 passenger elevators and 2 goods elevators, 2 stairways and toilet at each floor.

3.2 Network data structure construction

Construction phase in this research is developed data structure of 3D network from research's object. Construction step or design in this research covers: segmentation, extraction, topology, unity, visualization and weighting.

3.2.1 Node and Corridor center line extraction

Determination of unit's node could be seen at figure 6. Elevator unit is represented by node at the center (centroid) polygon on the floor. Escalator unit is represented by node at the center of polygon escalator on the floor. Stairway unit is represented by node at the center of its polygon on the floor. Business unit is also represented by node at the center of its polygon on the floor.

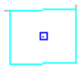
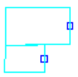
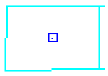
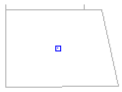
			
a. Elevator	**b. Escalator**	**c. Stairway**	**d. Business unit**

Fig. 6. Extracting *node* unit

Withdrawal of corridor centerline based on the three typical points that are: (see Figure 7)

1. Start/end point is the intersection of bisector angle of elbow tip of polygon.
2. Normal point is the medial axis of correspondence segment.
3. Junction point is center of junction polygon.

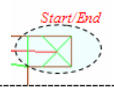
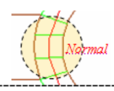
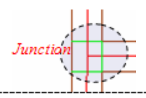
	**Intersection of bisector angle**
	**Medial axis of correspondence segment**
	**Center of junction polygon**

Fig. 7. Corridor centerline extraction

3.2.2 2D network data structure

Each node is linked to corridor centerline, based on closest distance to corridor centerline as described at figure 8. The number of connective lines of unit to corridor is according to the number of amounts access of unit. Amount of access of unit was acquired from direct survey to the object unit.

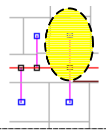
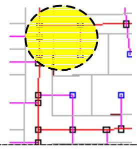
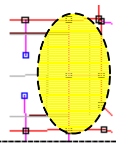
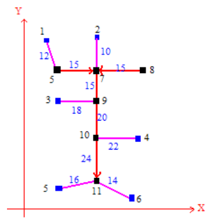
	**1 link/access**
	**2 link/access**
	**3 link/access**

Fig. 8. Link unit node to centerline corridor

Each node has an identifier (Spatial ID), coordinate (X, Y, Z) and unit addresses information. Each connective line has a weight. The Weight relation between nodes is usually known as cost. The cost between nodes do not same of course depended its direction. After finishing all link of nodes to centerline corridor hence data structure of network 2D have been formed (Figure 9). Data structure of network 2D formed step-by-step, floor by floor.

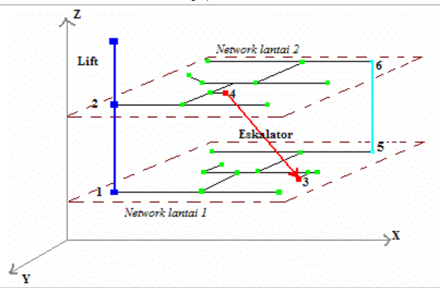


[Nodes]
Id_Node, X, Y, Z, Attribute
1, 0.5, 4.8, 5, elevatorLt1
2, 3, 5, 5,EskalatorLt1
3, 1.5, 3,5,tanggaLt1
4, 3, 2, 5,PintuMasuk
5, 1, 0.7, 5,toilet
....
[Topology]
From,To,Cost_FT, Cost_TF
1, 5, 12, 12
5, 7, 15,-1
7, 8, -1, 15
7, 9, 15, 15
....

Fig. 9. 2D network data structure

3.2.3 3D network data structure

Data structure of network 3 dimension formed by link each pair of vertical conduit (elevator, escalator and stairway) nodes.



Nodes				
Id	X	Y	Z	Attr
1	1	5	1	L1
3	3	3	1	Es1
5	5	1	1	Tg1
2	1	5	2	L2
4	2	3	2	Es2
6	5	1	2	Tg2

Topologi			
From	To	CostFT	CostTF
1	2	5	5
3	4	-1	6
5	6	5	5

Fig. 10. 3D network data structure

3.2.4 *Network* weight and visualization

Every cost at network initially calculated by euclidian-distance so that the formed network called *3D euclidian-network* weight. Based on data speed of visitor walk on corridor, time went through of elevator, stairway, and escalator from floor to floor hence 3D network euclidian-distance converted to *time-distance* weight. Then we have two weights of network that is *euclidian-network and time-network.*

For the visualization purpose of formed network, this research builds an application program using *visual basic 6* developer application. Using function of library *gdi32*, *node* at network drawn with function of *Setpixel* and *line* drawn with function of *Lineto* (see figure 11). Database of network kept and read at ascii file (text).

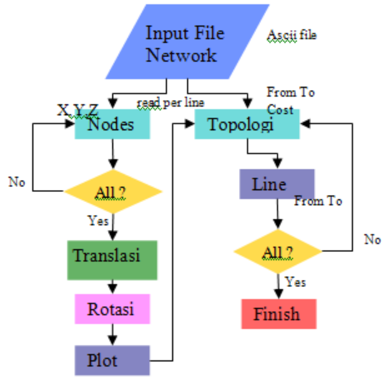


Fig. 11. Network visualization algorithm

3.3 Variable identification

The first phase of analysis in this research is analysis of network to identify location factor variable's coefficient.

3.3.1 Rent data sample

This research identified variables of location factor, which are influencing rent value unit, this research uses 29 rent data units in object study (BEC building) as sample. The data of rent selected because the data is more easily to get than the sell data. Data collection of sample uses principle of purposive sampling, because all of rent data unit has not same probability to get (only for the data which can be accessed) and arranged to represent certain locations in building. All of data sample distribution could be seen at figure 12.

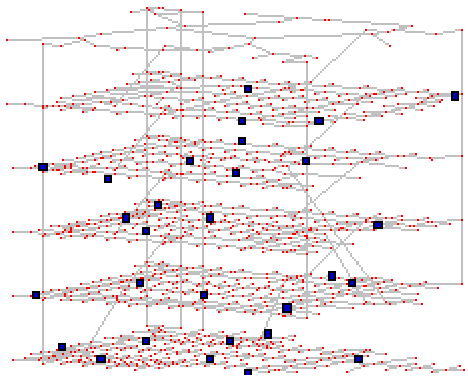


Fig.12. Rent data sample distribution.

3.3.2 Variable identified by network analysis

The variables of location factor, which are identified by network analysis is; distance to nearest door, distance to nearest elevator, distance from nearest escalator, distance from nearest stairway, distance from nearest toilet. The applied network analysis is shortest path analysis, which has a function to look for shortest path from a node (start node) to other node (end node) in network. For network euclidian-distance, shortest path analysis function is looking for shortest path between nodes (in meter), while for network time-distance, it is looking for fastest path between nodes (in second).

The coefficient of variable obtained from the length of chosen path (shortest/fastest path). For example, to identify the coefficient of *distance to closest elevator variable* in network, first, all shortest path from sample unit to each elevator (the blue, green and yellow line at figure 13) were counted then the smallest length path (the yellow line at figure 13) was selected as the coefficient of variable.

From many algorithms for the analysis of shortest path, this research chose the djikstra algorithm, because this algorithm besides in this time more popular also the algorithm can overcome enumeration of shortest path at complex network and directions and process relatively quick, compared to other algorithm of shortest path.

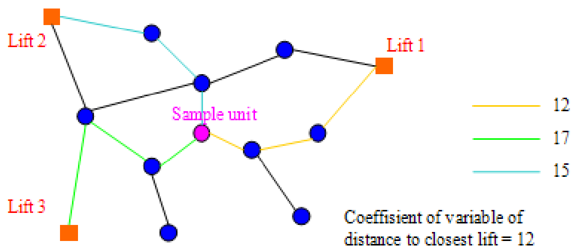


Fig.13. Example network analysis variable

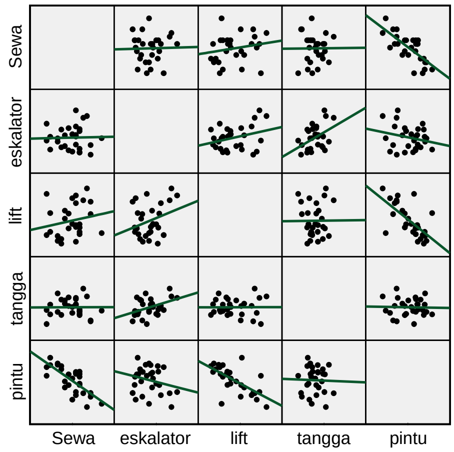


Fig.14 Linear relationships between unit's rent-value with location factor variables which has identified from euclidian-distance network

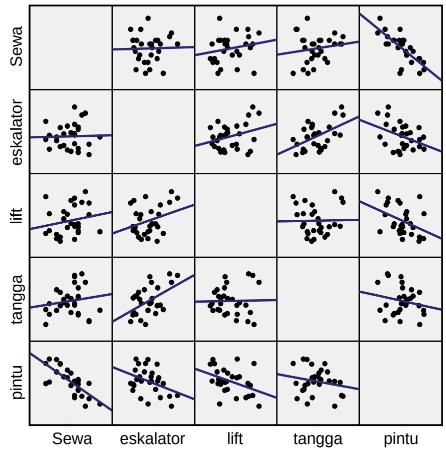


Fig.15 Linear relationships between unit's rent-value with location factor variables which has identified from time-distance network

Figure 14 is the result of identification of location factor variables for the network euclidian-distance and figure 15 is the result of identification of location factor variables for the network time-distance. The results have been tested by manual calculation. There is no different from manual with computing results, but time accumulation required to identify each sample, the manual require time longer far compared to by computing.

3.3.3 Variables without *network analysis*

In this research, not all variables of location factor are identified by shortest path analysis because very easy to be identified from data structure of formed 3D network, that are amount access and floor level variable. Amount access identified from the amount of line which is linked to unit (see figure 7) while floor level given by variable of dummy which is equal to high (z coordinate).

The only physical factor variable used in this research is size unit. This variable was not obtained from shortest path analysis or reckoned from data structure of network 3D formed, but only from attribute data (data of SISMIOP PBB) or data result from direct survey at study object.

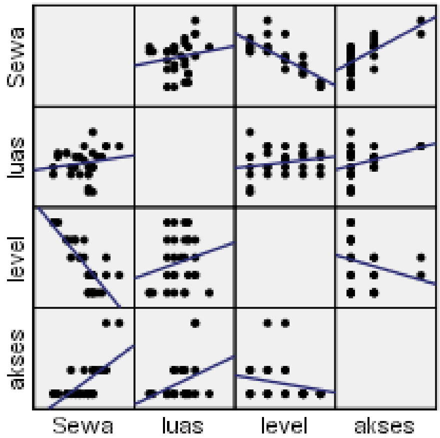


Fig.15 Linear relationships between unit's rent-value with location and physical factor variables which is not identified by network analysis

Variables from network analysis were combined with the variables, which are not come from network analysis as the predictor variables of rent value unit. The data is later analyzed with multiple regression analysis in order to know which variables and topology relation among units that influence rent value.

3.4 Multiple regression analysis

This research chooses computing-method use SPSS version software 13 to analyze variable. This election is based on consideration that besides usage of this software have very common in assessment of property, also to facilitate calculation process and appearance result if compared to manual-method. Test taken was two-side test at 95% confidence level.

Table 1. Variable of regression

Variable	code	Definition
Rent	Rupiah	Market rent price
Level	Nominal (1-5)	Floor level: LUG to Floor-3
Access	number	Amount of access to corridor
Entrance	number	Meter:*euclidian* ;Detik:*time*
Escalator	number	Meter:*euclidian* ;Detik:*time*
Elevator	number	Meter:*euclidian* ;Detik:*time*
Stairway	number	Meter:*euclidian* ;Detik:*time*

3.4.1 Variable correlation

The relationships between variables of regression are analyzed by *pearson* correlation analysis. The correlation coefficient results are such as seen at table 5 and table 6.

Table 2. Correlation of variables in euclidian-network

	Luas	Level	Akses	Eskalator	Lift	Tangga	Pintu
Sewa	0.17	-0.79	0.63	0.03	0.19	0.01	-0.73
Luas	1.00	0.20	0.35	-0.38	0.01	-0.24	-0.17
Level	0.20	1.00	-0.22	-0.28	-0.08	-0.23	0.42
Akses	0.35	-0.22	1.00	0.03	0.12	-0.26	-0.48
Eskalator	-0.38	-0.28	0.03	1.00	0.31	0.43	-0.23
Lift	0.01	-0.08	0.12	0.31	1.00	0.01	-0.66
Tangga	-0.24	-0.23	-0.26	0.43	0.01	1.00	-0.03
Pintu	-0.17	0.42	-0.48	-0.23	-0.66	-0.03	1.00

Ket: *Nilai korelasi yang signifikan 95%*

Table 3. Correlation of variables in time-network

	Luas	Level	Akses	Eskalator	Lift	Tangga	Pintu
Sewa	0.17	-0.79	0.63	0.03	0.19	0.16	-0.74
Luas	1.00	0.20	0.35	-0.38	0.01	-0.39	-0.04
Level	0.20	1.00	-0.22	-0.28	-0.08	-0.54	0.61
Akses	0.35	-0.22	1.00	0.03	0.12	-0.20	-0.38
Eskalator	-0.38	-0.28	0.03	1.00	0.30	0.51	-0.38
Lift	0.01	-0.08	0.12	0.30	1.00	0.02	-0.40
Tangga	-0.39	-0.54	-0.20	0.51	0.02	1.00	-0.20
Pintu	-0.04	0.61	-0.38	-0.38	-0.40	-0.20	1.00

Ket: *Nilai korelasi yang signifikan 95%*

There is equality of the result of variable correlation analysis at euclidian-network and time-network that is correlation between variable of level with rent, which has strongest correlation than others. However from the result of correlation analysis there are also strong correlations between the independent variables like size-access, level-entrance, etc. This matter probably due to multicolinearity. To know variables that are significantly influence the rent value then the formed model must be analyzed by multiple regression analysis.

3.4.2 Regression modeling

Based on the predictor variables of rent value unit, identified from both network euclidian-distance and time-distance, hence obtained two data of regression. Variable code summary to test can see at table 1. Based on the hypothesis of this research, model of regression to test is linear regression model which the formula is as follows:

$$\textit{Rent value} = b_0 + b_1 Size + b_2 Level + b_3 Access + b_4 Entrance + b_5 Elevator + b_6 Escalator + b_7 Stairway + e$$

Rent variable as dependent variable and variables predictor: Size, Level, Access, Entrance, Elevator, Escalator, Stairway and Toilet as independent variables. *b0* is intercept value as rent value first-approach, assumed is equal to value rent if every predictor variables has zero value and *e* is error variable.

3.4.3 Stepwise Regression analysis

One of the most effective valuation models for mass appraisal is forward-method of multiple regression analysis. In forward-method, variables are entered to analysis until all significant predictors have been included.

The significant variables from enter-method is gradually entered to analysis by forward-method multiple regression. The first variable entered, is that variable most highly correlated with rent variable. A search is then made to determine the remaining variable most highly correlated with the remaining errors. The process continues until all variables have been included or the remaining variables fail to meet some predetermined significance level as measured by their t- or F-values. At each step, the algorithm may either add a new variable or delete a variable that falls below the minimum significance level. The algorithm prevents redundant and insignificant variables from making the model more complex than necessary. Table 4 and 5 shows stepwise result from variables euclidian-network and time-network model multiple regression analysis.

Table 4. Significant variables by stepwise-method (euclid)

Model	R	R2	Adjusted	Std. Error of	Change Statistics				Sig.
			R2	the Estimate	R2 Change	F Change	df1	df2	F Change
1	0,7942	0,6308	0,61708	115879,8333	0,630756	46,12233	1	27	2,7E-07
2	0,92033	0,847	0,83524	76011,26882	0,216254	36,75142	1	26	2,1E-06
3	0,95724	0,9163	0,90627	57331,85183	0,069302	20,70223	1	25	0,00012
4	0,98577	0,9717	0,96704	33999,62312	0,055434	47,08595	1	24	4,3E-07
5	0,99076	0,9816	0,97762	28017,51613	0,009867	12,34274	1	23	0,00187

1 Predictors: (Constant), level
2 Predictors: (Constant), level, akses
3 Predictors: (Constant), level, akses, pintu
4 Predictors: (Constant), level, akses, pintu, eskalator
5 Predictors: (Constant), level, akses, pintu, eskalator, lift
Dependent Variable: Sewa

Table 5. Significant variables by stepwise-method (time)

Model	R	R^2	Adjusted	Std. Error of	Change Statistics				Sig.
			R^2	the Estimate	R^2 Change	F Change	df1	df2	F Change
1	0,7942	0,6308	0,61708	115879,8333	0,630756	46,12233	1	27	2,7E-07
2	0,92033	0,847	0,83524	76011,26882	0,216254	36,75142	1	26	2,1E-06
3	0,93966	0,883	0,86892	67798,59803	0,035955	7,680439	1	25	0,01038
4	0,97332	0,9474	0,93858	46408,42158	0,064392	29,35656	1	24	1,4E-05

1 Predictors: (Constant), level
2 Predictors: (Constant), level, akses
3 Predictors: (Constant), level, akses, eskalator
4 Predictors: (Constant), level, akses, eskalator, pintu
Dependent Variable: Sewa

3.5 Choosing the model

Adjusted_R^2 of euclidian-network regression model is higher than time-network regression model. *Standard error of the estimate* (SEE) of euclidian-network regression model is lower than time-network regression model. Based upon the adjusted_R^2 and SEE criteria hence the euclidian-network regression model predicts rent-value is better than time-network regression model. Thus, the chosen regression model is euclidian-network regression model. The coefficients of the model such as seen at table 6.

Table 6. Coefficients model

Model	Unstandardized Coefficients		Standardized	t	Sig.	Collinearity Statistics	
Jarak-tempuh	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1571675	49756.452		31.587	2E-20		
level	-78171.7033	4407.7482	-0.59972854	-17.74	7E-15	0.699116728	1.430376302
akses	64702.8978	7637.3887	0.285909944	8.4719	2E-08	0.701928188	1.42464716
pintu	-5142.64301	520.11865	-0.49324209	-9.887	9E-10	0.321248542	3.112854593
eskalator	-3409.14676	481.32604	-0.21961696	-7.083	3E-07	0.831523335	1.202612071
lift	-2046.44271	582.4972	-0.14998425	-3.513	0.0019	0.438645547	2.279745017

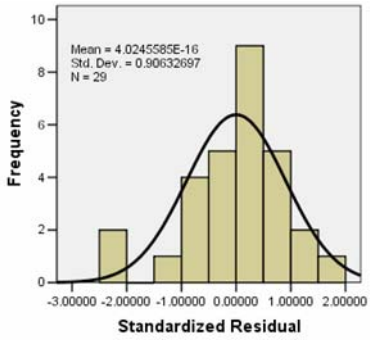
Dependent Variable: Sewa

3.6 Regression assumptions test

The validity and interpretation of model is depending on the extent to which certain assumptions are met. The most important in the context of mass appraisal are normally distributed errors, constant variance of the errors, uncorrelated independent variables.

1. Normally distributed errors test

Non-normal error terms can affect t- and F- values and thus the reliability of individual regression coefficients. Non-normal error terms can result from poorly edited data or improper model specification. Normal distribution errors of selected model can be seen as figure 17. There is no abnormally skewed normal curve of selected model and not like dome-shaped, hence regression selected model has normally distributed errors.



	Kolmogorov-Smirnov		
	Statistic	df	Sig.
Standardized Residual	0.150955	29	0.0896

Fig. 17 normally distributed errors

2. Uncorrelated independent variables test

Multiple regression analysis assumes that the independent variables are uncorrelated. Violation of this assumption known as *multicolinearity*. It is crucial however to distinguish two types of multicolinearity: perfect and imperfect. Perfect multicolinearity exists if VIF ≥ 10 while imperfect multicolinearity exists if VIF < 10. From selected model coefficient (table 6), known that there is no VIF value greater than 10. It indicates that there is only imperfect multicolinearity exists.

3. Test of constant variance of the error

Constant variance of the error term implies that the residuals are uncorrelated with the dependent variable, rent price. Violation of this assumption known as heteroscedasticity. This situation causes concern because the regression model will be unduly influenced by the high-value properties and thus be less reliable when applied to low value properties. Table-7 shows heteroscedasticity test result of selected model.

Table 7. Heteroscedasticity test

		Abs_RES
Sewa	Pearson Correlation	-0,330413
	Sig. (2-tailed)	0,08001347
	N	29

Pearson's significance > 0.05, so it can be concluded that there is no significant heteroscedasticity of empirical model.

3.7 Evaluation and validation of model

The model of rent assessment, which has been chosen and tested before, is used to assess other units (the result could be seen at appendix A). The appraisals should be based on or tested against, available rents (data validation in table 15) to ensure that the appraisals reflect the market. A ratio study of the rent-data validation with the appraisals will be indicating whether the appraisals reflect the market.

Table 15. Data Validation

no.	unit	rent_market	prediction	delta	ratio
1	LUG/E-07	1.000.000	1.139.092	-139.092	1,139
2	LUG/H-01	1.100.000	1.227.006	-127.006	1,115
3	LG/C-18	950.000	966.369	-16.369	1,017
4	LG/F-19	1.000.000	1.116.457	-116.457	1,116
5	UG/E-18	1.000.000	901.845	98.155	0,902
6	L1/C-19	800.000	815.209	-15.209	1,019
7	L2/B-06	700.000	676.114	23.886	0,966

The results of ratio study, as follows.

Price Related Differential =0,995

Coefficient of Dispersion =0,051

Value of COD agrees with IAAO required tolerance range (< 15% for the commercial property). Value of PRD agrees with IAAO required tolerance range (> 0.98 and < 1.03)

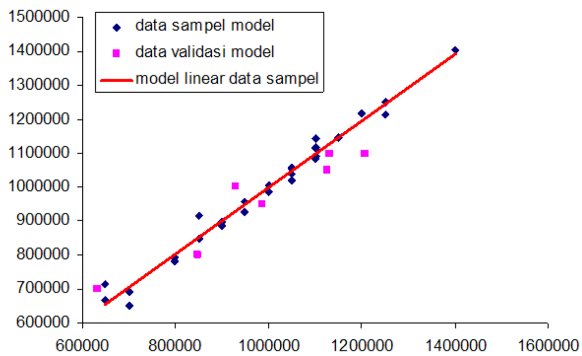


Fig. 18. Model validation

4. RESULT ANALYSIS

4.1 Geometric aspects which are affect the error of variable's coefficient

Inaccurate geometric calculation is probably caused by inaccurate of geometric network. Geometric will influence variable coefficient result identified at network. Geometric network accuracy will depend on these matters below.

4.1.1 Aspect of unit's nodes determination

Figure-19 describes the variation assumptions of node-determination to representing unit.

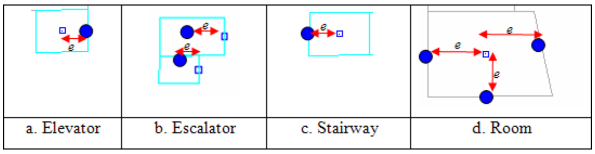


Fig 19. Variation of node-determination

The research assumes that elevator is represented by node at the center of elevator's polygon on the floor because it is more practical, especially by automation (programming). Another assumption is to put node at the center of elevator's door on the floor. However, this alternative needed door information in addition to every unit so this is less practical. The error of variable's coefficient of *distance-to-elevator* is affected by this assumption.

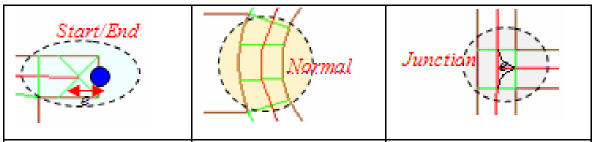
Escalator is represented by node at the arriving or departure point of escalator on the floor. Another alternative is to put down node at center escalator polygon on the floor. This alternative is most practical alternative because it is easy to be done by automation, but this alternative is not true because at the fact of object, below/under escalator often there are business unit also. Determination of node at this research is the single way, which earns to be applied at study object.

The research assumes that stairway is represented by node at the center of stairway's polygon on the floor because it is more practical to be applied, especially by automation (programming). Another alternative is to put node at the center of stairway's door on the floor. However, this alternative needs door information in addition to every unit so that it is less practical. The error of variable's coefficient of *distance-to-stairway* is affected by this assumption.

The research assumes that room is represented by node at the center of room's polygon on the floor because it is more practical to be applied, especially by automation (programming). Another alternative is to put node at the center of room's door on the floor. However, this alternative also needs door information in addition to every room so that is less practical but also create the ambiguity node that represents the room. The error of variable's coefficient, which is identified by network analysis, is affected by this assumption.

4.1.2 Aspect of corridor's centerline – determination

Figure-20 describes the variation of possible polygon's centerline of corridor.



a. start/end point	b. normal points	c. junction point

Fig. 20. Variation centerline representative points

This research determines the start/end points of the centerline at the intersection of bisector angle of polygon's tips. Another alternative is put node at the middle of segment of polygon's tip. Both of these approaches are practical because these can be done by automation. However this research choose the approach of intersection of bisector angle of polygon's tip because it is equal to movement of offset that happened if polygon in shrinking to become line. This assumption only has potency as mistake source of calculation geometric at unit's node, which has position behind of the start/end point of polygon's centerline.

The research determines normal-points of centerline corridor at the middle of two lines of correspondence segment. Normal point is in general illustrated as middle axis of maximal disk, which is exactly, touched two correspondence segments of polygon (medial of transform axis). There is no other alternative to place normal points. There is no error of coefficient variable caused by this assumption.

The research determines junction point of polygon's centerline to be straight to the center of polygon's junction. Another alternative is pursuant to middle point, which is touching at least two segments of polygon's junction. As a result, at the area of junction points formed curve-like line. This research chooses first approach, which more practical compared to second approach. The error of variable's coefficient identified from network is influenced by this assumption.

4.1.3 Aspect of line-projection of unit's node to corridor's centerline

In this research, connective line of node to corridor is based on the projection of unit's node to corridor's centerline (dot projection to line) and if it has the distance of < 0.5m from the existing nodes of corridor's centerline hence unit node interfaced to proximate the exist node. The error of variable's coefficient, which is identified by network analysis, is affected by this assumption.

4.1.4 Aspect of dummy-height between floors

This research assumes that the height of floor is equal for each floor in the building. It could be assumed as dummy-value, which is equal to 5 meters. This assumption will result incorrect geometric calculation on 3D network data structure as in reality the height of floor is different for each floor. However if in reality, the height between floors is same, even not 5 meters, will be not influence the coefficient of variable, because every variable will have the same correction.

The error of height assumption will be not affect time-network because of the height relation of units are derived directly from the observation of the study object.

4.1.5 Aspect of network-weight

The weight of network could be the source of error of variable identification both of euclidian-network and time-network weight. The weight of euclidian-network as source of error of variable identification depends on the accuracy of spatial data of the object while, the weight of time-network depends on the accuracy and consistency of time data from object.

4.2 The variables which are influencing rent-value

Based upon multiple regression analysis, the correlation and the statistic test of variable's predictor of rent value have different result to euclidian-network and time-network. How the variables have an affect to rent-value, which model of network is representing rent-value relationship, which model of regression is representing the model of rent-valuation on multi-level commercial building will be resuming below.

4.2.1 Variable's correlation

In analyzing correlations of the dependent variable, remember that the correlation coefficient is a dimensionless figure or percentage, indicating only whether two variables are linearly related.

Results of correlation analysis both of euclidian-network and time-network regression model has an important similarity that is variables predictor, which has strong linear relationship to rent-value, are variable of floor-level and entrance (distance to entrance). However, there is also strong correlation between variables of predictor of both euclidian-network and time-network that is variable of entrance with elevator. This matter is indicating that the relationship has multicolinearity. By stepwise-method regression analysis, two variables which are highly correlated could be excluded if fault to meet a specified significance level.

4.2.2 Variable's sign and signification

Research's result shows that variable coefficients sign and signification both of time-distance and euclidian-distance network are not fully same. There are variables that have same sign and significance from the model that are *level, access*(*akses*)*, entrance (pintu*) *and escalator(eskalator)*. That variable is called the primary variable. There is variable which significance with euclidian-distance model that is *elevator*(*lift*). This variable is called the secondary variable.

Table 9. Variable which influence rent-value unit

No.	Variabel	*Jaringan Jarak tempuh*		*Jaringan waktu tempuh*	
		Arah tanda	*Sig.*	*Arah tanda*	*Sig.*
1	Luas	?	Tidak	?	Tidak
2	Level	Negatif(-)	Ya	Negatif(-)	Ya
3	Akses	Positif (+)	Ya	Positif (+)	Ya
4	Pintu	Negatif(-)	Ya	Negatif(-)	Ya
5	Eskalator	Negatif(-)	Ya	Negatif(-)	Ya
6	Lift	Negatif(-)	Ya	?	Tidak
7	Tangga	?	Tidak	?	Tidak

According to Spreiregen (1965), view-distance has an effect negatively to value. It means that an increase view-distance will decrease the price. Elevator is one of the facilities that will be used by visitors when they want to travel in the building, so that the unit around it will be having closer view-distance. Therefore, the negative sign direction on euclidian-network can be more accepted than time-network.

Variable of *size (luas)* and *stairway (tangga)* are not significance to influence rent-value unit. Perhaps the data sample are not sufficient to be analyzed to get the significance of those variables or those variables are really not significance to influence rent-value unit.

4.3 Empirical model and validation

Based on regression analysis result, the research obtained empirical model that is:

rent-value = 1571675-78172***Level***+64703***Access*** – 5143***Entrance***-3409***Escalator*** – 2046***Elevator***

Variable: distance to entrance, distance to escalator and distance to elevator is identified from euclidian- distance relationships

From the empirical model, which formed can be interpreted as follows:
(1) Intercept value is equal to +1.571.675; it means that the proximity of rent-value at study object is equal to Rp **1.571.675/m^2**.
(2) The coefficient of variable of *floor-level* is equal to **-78172**; it means that an increase of 1 *floor-level* will decrease rent-value by Rp **78.172.**
(3) The coefficient of variable of *mount-access* is equal to +**64073**; it means that an increase of 1 *access* will increase rent-value by Rp **64.073.**
(4) The coefficient of variable of *escalator* is equal to -**3409**; it means that an increase of 1 meter *distance-to-escalator* will decrease rent-value by Rp **3409.**
(5) The coefficient of variable of *entrance* is equal to **-2.046**; it means that an increase of 1 meter *distance-to-entrance* will decrease rent-value by Rp **2.046.**

The coefficient of determination (R^2) equals the percentage of variance in rents price explained by the regression model. Empirical model has adjusted_R^2=0.978; it means that rents-market-value is 97.8% can be explained by the variables included in empirical model. In addition, 2.2% will be explained by other variables.

The ratio study of the rent-data validation agrees with the IAAO ratio standards. It indicates that appraisal's rents value reflects rent's market value.

5. CONCLUSION AND SUGGESTION

5.1 Conclusion

1. Based on the results of identification of location factor variables, 3D network data structure has a potential to contribute in significant as a tool of rent-market-value assessment.
2. Based on the result of regression analysis of euclidian-network and time-network model, the primary variables which influence rent-value is:
    a. Mount of access: the coefficient has positively sign, which means an increase of access will be increase rent price.
    b. Floor-level: the coefficient has negatively sign, which means an increase of floor-level will be decrease rent price.
    c. Distance-to-escalator: the coefficient has negatively sign, which means an increase of the distance to escalator will be decrease rent-price.
    d. Distance-to-entrance: the coefficient has negatively sign, which means an increase of the distance to the entrance will be decrease rent-price.
3. The secondary variable is distance to elevator. Variable which has not influence significantly are size and stairway variables.
4. Based on the results of regression analysis of euclidian-network and time-network model, the spatial relationship among units that most influencing rent-value units, is Euclidian-distance.
5. Based on the results of ratio study of data validation, the appraisal's rents-value reflect rents market value.

5.2 Suggestion

The research has suggestions as follow:
1. It is important to intense this kind research, with same kind research's object and same kind research's method but with a large number samples to be more representing population.
2. The research only used one year observation, for the best result, it is important to extending time-period of sample rents unit observation particularly when markets are stable. Even when prices are changing, the technique can be effective if rent prices are adjusted for time.

3. To minimizing the error of the coefficient of location factor variables on network, it is important to analyze geometric network potential error number for each variable identification coefficient.
4. It is important to study other variables, which are probably influence rent value units on multi-level commercial building.

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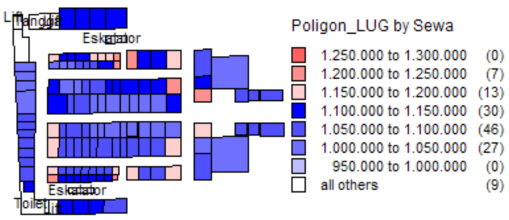
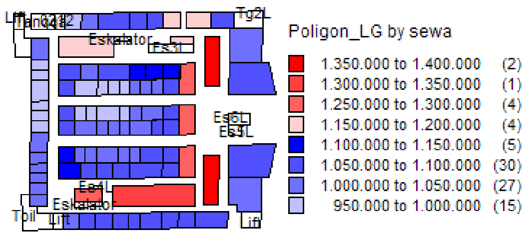
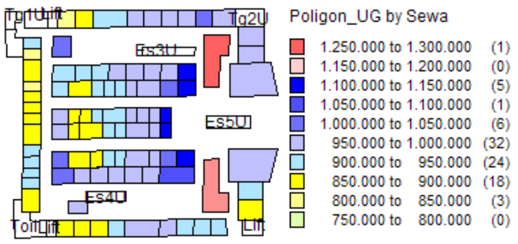
APPENDIX A. Rent-value appraisals of units by empirical model



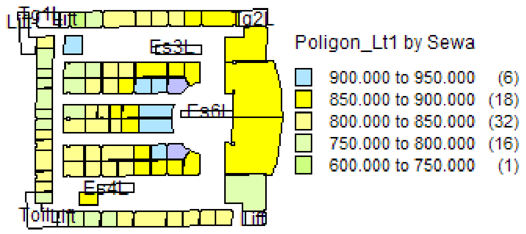
Rent price at underground-floor (LUG)



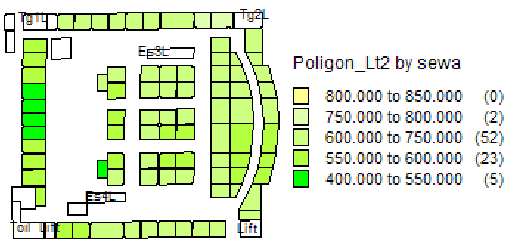
Rent price at ground-floor (LG)



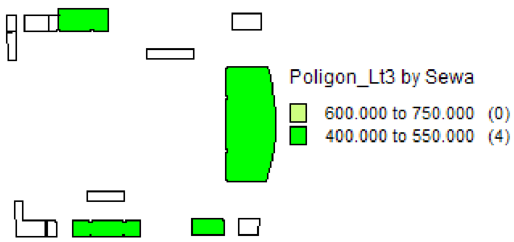
Rent price at upper- floor (UG)



Rent price at 1st-floor (Lt1)



Rent price at 2nd-floor (Lt2)



Rent price at 3rd-floor (Lt3)