Model of Determination of Industrial Center Locations for Small and Medium Enterprises Framework for Smart Cities: Case Study

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Abstract
Ponorogo Regency has many small and medium enterprises (SMEs) that produce furniture. Unfortunately, these SMEs are still managed at a home industry scale and lack information to develop. In Industry 4.0, there are many opportunities for districts to go to smart cities. A new paradigm is needed in the management of the SME industry. This is necessary to develop and support SMEs through the development of industrial centers for small and medium enterprises within the framework of smart cities. Therefore, this study was conducted to determine the location of the SME center to support government policies in managing and developing SMEs. To identify the optimal location of the information center, we propose a center of gravity and a huff model to determine the location of the industrial center for SME. Finally, this paper describes the results of the implementation of the SME center in the furniture industry.

Keywords:
Center of Gravity, Model Huff, Smart City, SME Center

1. Introduction
Ponorogo Regency is an area in East Java Province which is administratively divided into 21 Districts, 307 Villages, 1,002 Neighborhoods, 2,274 RWs, and 6,869 RTs, Data from the Department of Industry, Trade, Cooperatives and Small Businesses of Ponorogo Regency shows that in 2015 the number of formal industries was as much as 619 units that absorb 6,452 workers with a production value of Rp 734.38 billion. Meanwhile, there were 19,089 units of non-formal industries with a total workforce of 39,342 with a production value of 177.45 billion rupiahs. Ponorogo Regency also has many Small and Medium Enterprises (SMEs) that produce furniture but are still managed on the Home Industry scale and very little information is obtained to support SME Industry 4.0 in Ponorogo Regency which needs to be developed through an industrial center for small and medium enterprises. To get as many consumers as possible and the minimum flow of raw materials, one that needs to be considered by Small and Medium Industry players in the selection of the optimal location because this will have an impact on the continuity of their business.

Industrial centers are small units of areas that have certain characteristics in which there are production process activities and are areas that are more specific to a commodity of economic activity that has been formed naturally

which is supported by the means for the development of products or services consisting of a group of micro, small and medium enterprise. In the industrial center area, there is a physical functional unit: land, geography, infrastructure, institutional and human resources, which have the potential to develop economic activity under the market influence of a product that has high selling value and competitiveness (Setiawan, 2004). This makes SMEs important to study, from various sides, such as in research Giyanti et al (2020) researching SMEs in the application of halal food standards. Then in the research of Amalia et al (2020) determined the location of suppliers/recycling centers and KOMBAT collection centers in batik SMEs.

Smart cities combine at least one of the following dimensions: smart economy (e.g. innovation, entrepreneurship, productivity), smart mobility (e.g. accessibility, sustainable transportation systems), smart environment (e.g. pollution, sustainable resource management), smart people (eg qualification level, creativity, flexibility), smart life (eg quality of life) and smart governance (eg public and social services, transparent governance). (Giffinger et al 2007)

The problem of selecting a distribution center is a complex issue regarding operational research. There are several factors to consider. In practical problem solving, not only flexibility to use theoretical knowledge, but also to choose according to the actual environment. Any model when applied to practical problems will show some flaws, but this does not mean that it is completely useless. As long as the actual computation process continues to be revised, the calculation results will have high reliability. So, we have to revise the computational process of the Center for Gravity Approach constantly, at the same time, adding some other factors or combining other methods constantly (Zi-xia and Wei, 2010). In determining the location, distance becomes important because the longer the transportation time and the greater the transportation distance, the greater the transportation costs (Saputri et al, 2019).

In his research (Jayakumar, and Krishnaraj 2015), the gravity model is used to find locations to minimize the cost of transporting raw materials from suppliers and finished goods to the markets served. This model also assumes that transportation costs increase with the quantity shipped. Then (Irwanto and Hasibuan 2018) examined the Determination of Distribution Center locations as a solution to improve the efficiency of distribution systems and logistics management. And research (Gutierrez and Mutuc 2017) optimizes the movement of relief goods by minimizing total transportation costs using an operations research approach with the integration of the Center of Gravity method.

(Saravi et al. 2017) researched about finding facilities in a competitive environment to maximize market share using the huff model. Then (Su and Youn 2011) examined the prediction of local market retail sales in Jinan city of China using the Huff Model. The probability of customers shopping at locations depends on the size of the store and the travel time factor is calculated using the Huff Model. We found the mall's retail sales prediction has greater value than others. Because larger store sizes mean greater opportunities, encouraging consumers to travel further to competitors' stores after passing closer and smaller stores. and (Jamaludin et al. 2012) predict the location of consumer shopping and explain the market share of hypermarket competition using only hypermarket size and distance variables using the gravity huff model.

Proper implementation of the modified Huff model as was the attempt in this study could facilitate retailers in locational strategy decision making. Measurement and comparison of sales performance should be the basis of evaluating different retail agglomerations. Retailers applying such models should be cautious of suitable estimation of parameters such as store size, accessibility, factors resulting in competition and agglomeration effects, and service area. Correct measurement and application of these factors would have a direct influence on the calculation of store performance and ultimately contribute to deciding location strategy. Also, consideration should be given to a type of product and shopping destination for which location model is being developed. With a change in such factors estimation parameters also might undergo significant changes. Therefore retailers who plan to establish a store either in a shopping street area or a shopping mall should consider the suggested findings (Sigla et al,2018).

2. Methods

2.1 Problem Description

Development of Industrial centers for small and medium enterprises within the framework of smart. To determine the location of Industrial centers to support government policies in developing SMEs based on these conditions, it is necessary to find the optimal location of the Industrial center using the center of gravity and huff models to determine the location of the industrial center.

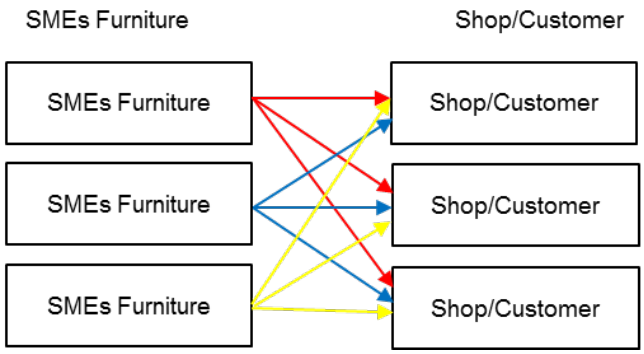

Figure 1. Without Industrial Center

Condition of SMEs in Ponorogo district without an industrial center (Figure 1). SMEs are still managed on a home industry scale so that the supply chain is not effective.

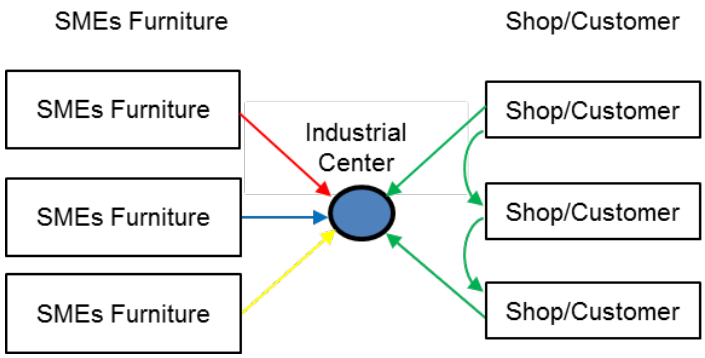

Figure 2. With Industrial Center

By building a SMEs center (figure 2) in Ponorogo district the supply chain becomes effective so that it is easily accessible to serve SMEs to develop their business.

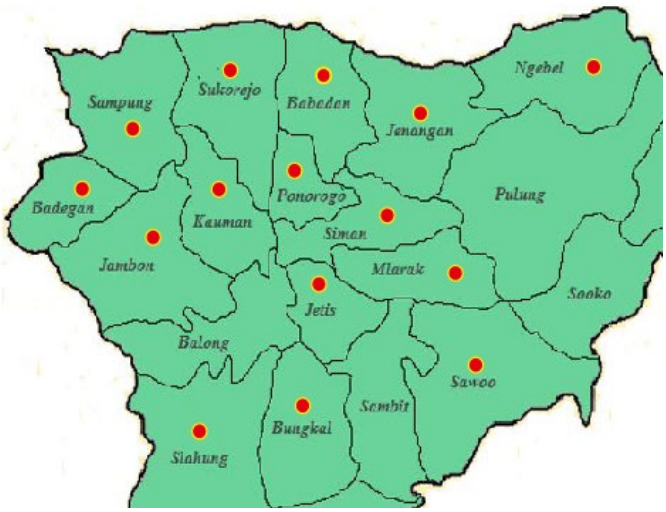

Figure 3. Furniture Industry location.

The condition of SMEs in Ponorogo Regency is still scattered throughout the region (Figure 3). thus it becomes difficult to support government policies in managing and developing SMEs. This paper will discuss determining the location of the SME Industrial Center using the Center of Gravity and the Huff Model.

2.2 Mathematical models

This paper aims to determine the optimal location of the SME industrial center. The relevant symbols are defined as follows:

$$\mathrm{Cx} = \frac{\sum dixWi}{\sum wi} \qquad (1)$$

$$\mathrm{Cy} = \frac{\sum diyWi}{\sum wi} \qquad (2)$$

Where :
Cx = the x coordinate of the center of gravity
Cy = the y coordinate of the center of gravity
dix = the x coordinate of location i
diy = the y coordinate of location i
Wi = volume of goods transferred from or to location i

Based on the above mathematical model, equations (1) and (2) assume that they are directly proportional to both the distance and volume involved. The optimal location is one that minimizes the balanced distance between the industrial center and its customers.

$$Pij = \frac{\frac{S_j}{T_{ij}^{\lambda}}}{\Sigma_j^n \frac{S_j}{T_{ij}^{\lambda}}}$$

P_{ij}: Probability of a consumer at a point i traveling to retail location j
S_j: Size of a retail location
T_{ij}: Travel time (or distance) from the consumer at the point i to travel to location j

Where Pij is the probability of the customer to visit the industrial center. Sj is the size of the Industrial Center at location j, Tij is the time taken by customer i to location j, and λ is the parameter that will be estimated empirically to reflect the effect of travel time on various types of shopping trips.

3. Numerical Example and Result

The data used is in the form of data on the location of SMEs in the Ponorogo Regency area and data on the distance between SMEs from Google Maps, and data on SME production comes from the Department of Trade, Cooperatives and Micro Enterprises of Ponorogo Regency (Table 1). The collected data will be processed using the Center of Gravity method and the Huff Model. The results of data processing are to find the optimal location points that will be used to build SME Industrial Centers

Table 1.Data on SMEs in Ponorogo Regency

Name	Production / Unit	Large/M^2	Coordinate		Time/ Minute
			x	y	
1	2	3	4	5	6
Cahaya terang	70	60.81	-7.85203	111.48831	8
Sumber Makmur	186	549.94	-7.89807	111.32078	35
Jati Trisno	390	211.55	-7.85797	111.61729	26
UD.Sabar subur	180	185.67	-7.84092	111.50513	23
Meubel Suwardi	120	432.48	-7.84092	111.50513	12

Karya Asih	216	90.99	-7.92342	111.47051	14
FMP Berkah	352	247.53	-7.87143	111.40761	20
Jati Maksum	180	176.82	-7.81613	111.5843	29
Star Mebel	110	195	-7.86696	111.46765	7
Mekar Jaya	119	144.66	-7.92897	111.51467	19
Sekar Jati	42	205.17	-7.84173	111.35271	33
Mebel Sentosa	203	164.85	-7.92768	111.55423	31
Kayu Jati Sido	288	494.92	-7.86921	111.49431	21
Sari Maju	170	141.87	-8.02358	111.41632	27
Cahaya Tarim	411	415.72	-7.80423	111.42426	30
Proposed Location		22.833			20

to determine the industrial center can use the center of gravity model

Coordinate X $= \dfrac{(-7.85203 \times 70) + (-7.89807 \times 186) + (-7.85797 \times 390) + (-7.94815 \times 180) + (-7.84092 \times 120) + (-7.92342 \times 216) + (-7.87143 \times 352) + (-7.81613 \times 180) + (-7.86696 \times 110) + (-7.92897 \times 119) + (-7.84173 \times 42) + (-7.92768 \times 203) + (-7.86921 \times 288) + (-8.02358 \times 170) + (-7.80423 \times 411)}{70+186+390+180+120+216+352+180+110=119=42+203+288+170+411}$

$= -7.87930$

Coordinate Y $= \dfrac{(111.48831 \times 70) + (111.32078 \times 186) + (111.61729 \times 390) + (111.41021 \times 180) + (111.50513 \times 120) + (111.47051 \times 216) + (111.40761 \times 352) + (111.5843 \times 180) + (111.46765 \times 110) + (111.51467 \times 119) + (111.35271 \times 42) + (111.55423 \times 203) + (111.49431 \times 288) + (111.41632 \times 170) + (111.42426 \times 411)}{70+186+390+180+120+216+352+180+110=119=42+203+288+170+411}$

$= 111.47641$

The industrial center has an important role in the Supply Chain Management system of industry to facilitate the management of logistics needs so that the product distribution process becomes smooth and fast. The purpose of this research is to determine the best location that can be used in determining the location of Industrial Centers. This study uses the Center of Gravity method in calculating the optimal location. From the results of this study, calculations using the Center of Gravity method show that the location of the selected industrial centers is at coordinates X = - 7.87930, coordinates Y = 111.47641, namely Purbosuman, Ponorogo Regency (Figure 4). This location reinforces the recommended coordinate points for determining the location of industrial centers. After the coordinates obtained are then checked using the google maps application, to find out exactly the location of the coordinates of the calculation results. Below is a picture of a suggested industrial center location.

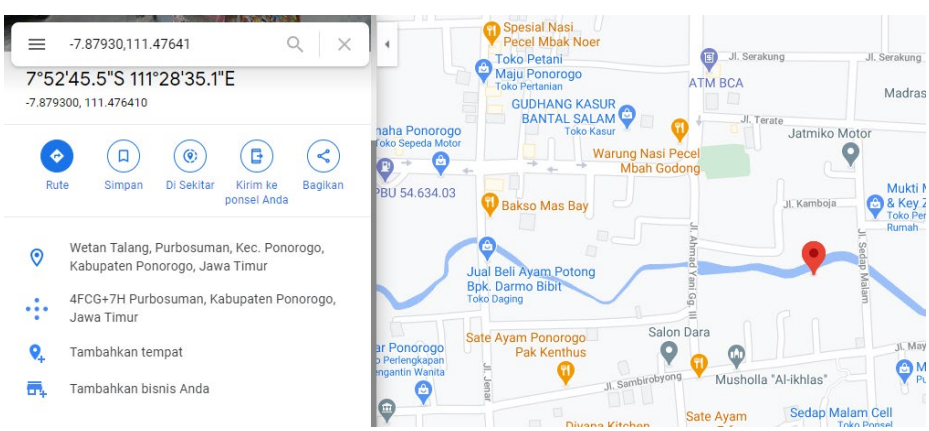

Figure 4. The coordinates of the recommended location for the Industrial Center

Furthermore, to determine the probability of customer visits in each industrial center, an analysis was carried out using the huff model.

$$P_1 = \frac{(70)/(8)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/((7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 1{,}40\%$

$$P2 = \frac{(186)/(35)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/((7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 0{,}66\%$

$$P3 = \frac{(390)/(26)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 0{,}46\%$

$$P4 = \frac{(180)/(23)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 0{,}53\%$

$$P5 = \frac{(120)/(12)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 4{,}41\%$

$$P6 = \frac{(216)/(14)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 0{,}68\%$

$$P7 = \frac{(352)/(20)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 0{,}91\%$

$$P8 = \frac{(180)/(29)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 0{,}31\%$

$$P9 = \frac{(110)/(7)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 5{,}84\%$

$$P10 = \frac{(119)/(19)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 0{,}59\%$

$$P11 = \frac{(42)/(33)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 0{,}28\%$

$$P12 = \frac{(203)/(31)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 0{,}25\%$

$$P13 = \frac{(288)/(21)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 1{,}65\%$

$$P14 = \frac{(170)/(27)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 0{,}29\%$

$$P15 = \frac{(411)/(30)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 0{,}68\%$

$$P16 = \frac{(22.833)/(20)^2}{(70)/(8)^2 + (186)/(35)^2 + (390)/(26)^2 + (180)/(23)^2 + (120)/(12)^2 + (216)/(14)^2 + (352)/(20)^2 + (180)/(29)^2 + (110)/(7)^2 + (119)/(19)^2 + (42)/(33)^2 + (203)/(31)^2 + (288)/(21)^2 + (170)/(27)^2 + (411)/(30)^2 + (22.833)/(20)^2}$$

$= 81{,}09\%$

Table 2 Probability using huff model

Name	Probability
1	2
Cahaya terang	1.40%
Sumber Makmur	0.66%
Jati Trisno Mebel	0.46%
UD.Sabar subur	0.52%
Meubel UD Suwardi Indah Jaya	4.41%
Karya Asih	0.68%
FMP Berkah Furniture Kauman	0.91%
UD Jati Pak Maksum	0.31%
Star Mebel	5.84%
Mekar Jaya Abadi Furniture	0.59%
Sekar Jati	0.28%
Mebel Sentosa Jaya	0.25%
Mebel Kayu Jati Sido Mapan	1.65%
Sari Maju Mulyo	0.29%
Cahaya Tarim	0.68%
Proposed location	81.09%

By knowing the probability of visits in each SMEs (Table 2), it is possible to determine the optimal location of industrial centers that can be used to collect various goods from different regions before distributing the required places. The benefits of having an industrial center include ensuring the availability of goods, increasing price stability of goods, being able to absorb new workers, and being a means for the government to regulate, control and distribute the supply chain.

4. Conclusion

From the results of the calculation analysis using the center of the gravity model, the x and y coordinates are obtained which are located in the Tonatan Village, Ponorogo Regency. From the analysis using the huff model to calculate the probability of a consumer's visit to the industrial center, the probability level between industrial centers is obtained. owned by the industrial center of the proposed location, namely in Krajan, Kauman Ponorogo Regency with a visiting probability of 81.09% and the lowest chance of visiting is owned by Santosa Jaya furniture with a probability of visiting 0.25% of the analysis results it is estimated that if an industrial center is established in that location facilitate access to transportation, improve customer service, refill finished goods faster, reduce transportation costs due to fewer routes, better monitor and manage raw material stocks.

Approach with the center of gravity method is used to select a location that can minimize distance or cost to existing facilities. For example, it is used to select industrial center locations to supply goods to several furniture industries in a certain area. This approach selects one of the coordinates of the center point. Center of Gravity Techniques Is a mathematical technique used to find the best location for a single distribution point serving multiple furniture industries. This method takes into account the distance to the location of the furniture industry, the number of goods shipped.

The huff model used to determine the optimal location of industrial center facilities is strategic decision making for the supply chain, which determines the probability of visits currently, the competition between the

furniture industry is getting tougher. One of the models that can be used for competition is the Huff model. In this model, the attractiveness of customers to facilities depends on the distance to all facilities and the quality of all facilities. In other words, consumers usually do not choose the closest location, they prefer to choose probabilistically among the many furniture industries.

for further research, it can be added to the investment costs for the establishment of an industrial center in the Ponorogo district.

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Biography

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