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DATA-DRIVEN ZONING FOR MINIMARKET DEVELOPMENT: ADDRESSING SPATIAL IMBALANCE IN BOGOR REGENCY

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Abstract

The rapid expansion of minimarkets in many Indonesian regions has raised concerns about uneven retail distribution and potential market concentration. In Bogor Regency, strong household consumption, population growth, and residential expansion have encouraged modern retail growth, yet outlet distribution remains uneven across subdistricts. This study analyzes the spatial imbalance of minimarket distribution and develops a data-driven zoning framework to support more balanced retail development. The research applies a quantitative approach using secondary data at the subdistrict level. A multiple linear regression model estimated by Ordinary Least Squares (OLS) is used to estimate the ideal number of minimarkets based on population size, land area, and the number of traditional retail outlets. The estimated values are then compared with existing outlets to classify subdistricts into areas with potential room for expansion, relatively balanced conditions, or a need for closer growth control. The findings show that minimarket distribution varies considerably and is strongly associated with population concentration and settlement patterns. At the regency level, existing outlets remain within the regression-based optimal corridor, but subdistrict-level analysis reveals clear spatial variation. The zoning classification identifies 15 green zones, 17 yellow zones, and 8 red zones. These findings indicate that minimarket planning should be differentiated according to territorial characteristics and regression-based benchmarks to support evidence-based retail zoning in Bogor Regency.

Keywords: minimarket development; spatial imbalance; retail distribution; zoning analysis

INTRODUCTION

The development of modern retail in Indonesia has undergone significant transformation over the past several decades. The emergence of modern retail formats was initially marked by the establishment of the Sarinah department store in 1962, which symbolized the early modernization of consumer shopping patterns in Indonesia (Ashari, 2023; Astina, 2018; Suryadarma et al., 2007) Since the 1990s, the growth of modern retail has accelerated along with urbanization, the expansion of the middle class, and increasing competition among retail companies. These developments gradually expanded the presence of modern retail beyond large cities to smaller urban areas and residential neighborhoods, making retail services more accessible to a wider segment of society.

In this evolving retail landscape, the minimarket format has emerged as one of the most adaptive forms of modern retail in responding to changing consumer demand structures. Minimarkets combine relatively small business scale, flexible location choices, and standardized operational systems, enabling them to expand rapidly across residential areas. Data from AC Nielsen show that during the period 2004–2008, minimarket turnover grew at an average rate of 38.1 percent per year, significantly higher than other modern retail formats (Pandin, 2009). This growth reflects a shift in consumer shopping patterns toward more frequent visits with smaller purchase volumes, consistent with the rhythm of urban lifestyles and the increasing participation of the workforce in economic activities.

Over the past two decades, the development of modern retail in Indonesia has also been characterized by a changing market structure increasingly concentrated in the minimarket format. Data from (Statista, 2024) indicate that minimarkets account for approximately 16 percent of the national fast-moving consumer goods (FMCG) market share, nearly three times higher than supermarkets and hypermarkets, each of which represents around six percent. This dominance indicates that minimarkets have become a backbone in the distribution of daily consumer goods while simultaneously acting as key players in the competitive landscape of modern retail in Indonesia.

Among various modern retail formats, minimarkets have become particularly dominant because of their proximity to residential areas and their ability to provide convenient access to daily necessities. Consumer decisions to shop at minimarkets are influenced not only by price but also by accessibility, product availability, and service convenience (Levy & Weitz, 2012; Teller & Reutterer, 2008). From a spatial perspective, the location of minimarkets plays a critical role in shaping retail demand because stores located closer to residential areas or transportation nodes tend to attract more consumers due to lower travel costs and time savings (Neto et al., 2025). Recent evidence further indicates that retail location patterns are shaped by the interaction of population concentration, road accessibility, residential structure, and local mobility, while different retail formats may exhibit distinct spatial preferences (Fang et al., 2024; Gao et al., 2025).

The phenomenon of minimarket growth has also occurred intensively in Bogor Regency. As one of the main buffer regions of Jakarta, Bogor Regency has experienced rapid population growth, expansion of new residential areas, and significant increases in economic activity. Comparable evidence from the Jakarta metropolitan region shows that peripheral urban expansion has been strongly shaped by residential development and the transformation of formerly rural areas into new urban settlements, creating corresponding demand for commercial facilities and services (Permanasari et al., 2024). These conditions make the region a highly attractive market for minimarket network expansion. Data from the Department of Trade and Industry of Bogor Regency (2025) show that there are 1,359 minimarkets distributed across 40 subdistricts, covering 19 urban villages and 416 rural villages. This figure reflects the high penetration of minimarkets and their important role in the regional retail trade structure.

The uneven distribution described above can be understood through central place theory, retail gravitation, and the competitive-substitution perspective in retail markets. Central place theory explains that retail services tend to concentrate in locations where population and purchasing activity are sufficient to meet the minimum market threshold required for outlet viability. Retail gravitation further proposes that the attractiveness of a retail location increases with market size but decreases with distance, travel costs, and other forms of spatial friction

(Christaller, 1966; Huff, 1964). Recent empirical studies confirm that retail distribution is closely associated with population concentration, accessibility, residential structure, and patterns of urban mobility (Fang et al., 2024; Gao et al., 2025). These mechanisms directly support the research problem in Bogor Regency: population size represents potential market demand, land area captures spatial dispersion after population is controlled, and the number of traditional retail outlets represents the local competitive structure.

Population size determines the potential consumer base available to support retail activity. According to central place theory, a larger population increases the likelihood that the minimum demand threshold required for retail operations will be achieved. Recent spatial studies similarly show that retail outlets tend to concentrate in densely populated areas because larger consumer markets generate higher transaction potential and improve outlet viability (Fang et al., 2024; Formánek & Sokol, 2022; Gao et al., 2025).

Land area is expected to influence minimarket distribution through settlement dispersion and spatial friction. After population size is controlled, a larger administrative area generally implies lower population density, greater distances between settlement clusters, and a less concentrated consumer market. Retail gravitation suggests that increasing distance and travel costs reduce the effective attractiveness and market reach of retail locations (Huff, 1964). Empirical studies also indicate that convenience stores and other retail facilities tend to follow concentrated urban functions, accessibility networks, and daily activity centers rather than administrative area alone (Liao et al., 2022; Lu et al., 2023; Neto et al., 2025). Spatial equity research further shows that geographically extensive and dispersed areas may experience weaker retail accessibility despite having substantial aggregate populations (Li et al., 2025).

The relationship between minimarkets and traditional retail outlets can be explained through competition and substitution within local consumer markets. Both formats provide frequently purchased household goods and may compete for overlapping customers, locations, and expenditure. Industrial organization research shows that the entry and expansion of modern retail formats can intensify competitive pressure on incumbent retailers and affect their market performance (Chenarides et al., 2024; Suryadarma et al., 2010). However, evidence from Indonesia also indicates that modern and traditional retail may coexist when they serve different consumer segments, product categories, and shopping purposes (Hikmawati & Nuryakin, 2017; Qanti, 2016). Despite this possible coexistence, the competitive-substitution mechanism implies that, after market size and spatial characteristics are controlled, a stronger traditional retail presence may reduce the market space available for minimarket expansion.

Despite the rapid growth of minimarkets and their importance in the retail economy, empirical studies that systematically evaluate the spatial distribution and market capacity of retail outlets at the regional level remain relatively limited. Recent studies in retail geography highlight that the spatial distribution of retail outlets is strongly influenced by population density, accessibility, and urban economic activity, which together shape the clustering patterns of retail establishments across cities (Demirel et al., 2026; Luo et al., 2025b). However, many studies on retail development still focus primarily on consumer behavior, retail format transformation, and competition among retailers rather than quantitatively assessing the capacity of local markets to accommodate new outlets (Zhang et al., 2025). As a result, the spatial dimension of retail expansion—particularly the question of whether a region has sufficient demand to support additional outlets—remains insufficiently explored. Recent reviews of retail geography also note that although spatial analysis techniques such as GIS, kernel density estimation, and spatial autocorrelation have increasingly been used to study retail clustering patterns, their application for supporting policy-oriented retail zoning and capacity evaluation remains limited (Luo et al., 2025a). Recent data-driven studies have also combined public city-level, competitor, and point-of-interest data with machine-learning and GIS-based techniques to screen potential retail locations and predict site suitability (J. Lu et al., 2024; Zhao et al., 2025). Nevertheless, these approaches primarily emphasize spatial pattern identification and location suitability rather than translating model-estimated benchmarks into a policy-oriented zoning framework at the subdistrict level.

This gap is particularly relevant for regions experiencing rapid retail expansion, such as Bogor Regency. Without a systematic assessment of retail capacity and spatial distribution, the growth of minimarkets may lead to excessive concentration in certain areas while other areas remain underserved. Empirical studies show that retail outlets often exhibit strong spatial clustering and uneven coverage across urban regions, creating disparities in accessibility and service efficiency (Su & Damian, 2024). Therefore, a data-driven evaluation of retail capacity is essential for guiding more balanced retail development and supporting evidence-based spatial planning policies.

Unlike previous studies that mainly examine the spatial distribution or clustering patterns of retail outlets, this study focuses on estimating the capacity of local markets to accommodate minimarket development. Previous research in retail geography has shown that retail outlets tend to form spatial clusters influenced by population density, accessibility, and economic activity, which shape the spatial structure of retail services across urban areas (Lee, 2024). However, these studies generally emphasize spatial patterns, population-flow prediction, agglomeration processes, and commercial site selection rather than quantitatively estimating the market capacity for additional retail outlets (Zou et al., 2024). By applying an econometric approach to subdistrict-level data, this research provides a quantitative estimation of the ideal number of minimarkets based on regional characteristics. The study therefore extends the existing literature by linking retail spatial analysis with econometric estimation and translating the resulting benchmarks into a policy-oriented zoning classification. This approach complements recent GIS- and prediction-based studies that primarily identify spatial patterns, estimate location suitability, or support individual store-location decisions (Demirel et al., 2026; J. Lu et al., 2024; Zhao et al., 2025).

In addition to its academic contribution, this study also provides practical insights for regional retail governance. Spatial analysis of retail systems has increasingly been recognized as an important tool for improving urban planning and ensuring equitable access to commercial services (Luo et al., 2025b). Building on this perspective, the estimation results in this study are translated into a zoning-based classification that identifies areas where minimarket development can be encouraged, moderated, or restricted. Such an approach can support local governments in designing more balanced and evidence-based policies for regulating minimarket expansion while maintaining fair competition and improving access to retail services.

The principal scientific contribution of this study lies not in the use of regression alone, but in translating model-estimated benchmarks into a policy-oriented zoning framework. Previous studies have primarily examined retail clustering, spatial determinants, trade areas, or site suitability (Demirel et al., 2026; Lu et al., 2024; Zhao et al., 2025). The proposed framework extends this literature by converting econometric estimates into three diagnostic planning categories that identify subdistricts with potential room for expansion, relatively balanced conditions, or a need for closer growth evaluation. This integration of econometric estimation and zoning classification provides an applicable instrument for evidence-based retail governance in regional settings where detailed market and mobility data remain limited.

Therefore, this study aims to analyze the spatial imbalance of minimarket distribution in Bogor Regency and to develop a data-driven zoning framework that can support more balanced retail development. Using subdistrict-level data and a multiple linear regression approach, the study estimates the ideal number of minimarkets based on regional characteristics and compares these estimates with the existing distribution of outlets. The findings are expected to provide empirical insights that can support more evidence-based planning for minimarket development in Bogor Regency.

METHODS

Research Design and Data

This study constitutes applied quantitative research based on secondary data at the subdistrict level. Following Creswell & Creswell (2022), a quantitative approach is appropriate when a study relies on numerical data, variable measurement, and statistical analysis to examine patterns or relationships among variables. In this study, the quantitative approach is used to examine the spatial distribution of minimarkets and to estimate the ideal number of outlets across all 40 subdistricts in Bogor Regency. The data were obtained from the Department of Trade and Industry of Bogor Regency, Statistics Indonesia, regional statistical publications, official government documents, and relevant literature. The variables include the existing number of minimarkets by brand, population size, land area, and the number of traditional retail outlets. These variables are used to represent local market potential, spatial characteristics, and the structure of retail competition, providing an empirical basis for evaluating spatial imbalance and formulating zoning-based policy recommendations for minimarket development.

Data processing and analysis are conducted using Tableau Desktop 2025.2, Stata 18, and Microsoft Excel 2021. The analytical procedure begins with descriptive analysis to examine the existing condition and spatial distribution of minimarkets across subdistricts. This is followed by regression analysis to estimate the ideal number of minimarkets based on regional characteristics. The estimated results are then compared with the observed number of minimarkets to identify subdistricts with potential room for expansion, relatively balanced conditions, or possible concentration of outlets. The outputs include summary tables, graphical visualizations, spatial maps, and zoning classifications that can support evidence-based minimarket planning in Bogor Regency.

Research Framework and Hypotheses

Based on the theoretical mechanisms discussed in the introduction, Figure 1 presents the empirical framework used to analyze minimarket distribution. Population size, land area, and the number of traditional retail outlets are specified as explanatory variables for the observed number of minimarkets. The regression estimate is subsequently converted into an ideal outlet benchmark and compared with the observed count to construct the green, yellow, and red zoning classifications.

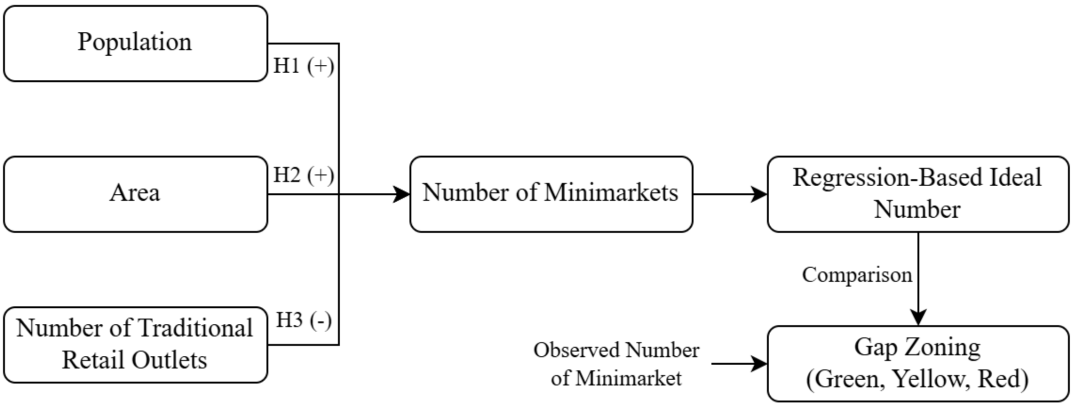

Figure 1. Research Framework of the Study

Source: Authors' elaboration, 2026.

H1: Population size is positively associated with the number of minimarkets.
H2: Land area is negatively associated with the number of minimarkets after controlling for population size and traditional retail outlets.
H3: The number of traditional retail outlets is negatively associated with the number of minimarkets.

The three hypotheses are tested through the signs and statistical significance of the regression coefficients. The predicted values from this model are then used for the subdistrict-level gap analysis and zoning procedure described below.

Model Specification and Estimation

The ideal number of minimarkets in each subdistrict is estimated using a multiple regression model incorporating key variables related to market potential and competitive structure, including population size, land area, and the number of traditional retail outlets. The model adopts a reduced-form specification that captures observed market outcomes through proxies for consumer demand and local competitive conditions (Agusalim et al., 2026). The empirical model is specified as follows:

$$N_i = \beta_0 + \beta_1 P_i + \beta_2 A_i + \beta_3 TS_i + \varepsilon_i$$

where N_i denotes the ideal number of minimarkets in subdistrict i, P_i represents population size, A_i denotes land area, and TS_i indicates the number of traditional retail outlets. The coefficients β_0, β_1, β_2, and β_3 capture the effects of each explanatory variable, while ε_i represents the error term reflecting unobserved factors. The regression results provide a more precise and data-driven estimate of the appropriate number of minimarkets in each subdistrict, which can inform expansion planning and more efficient market development strategies.

To evaluate the results of multiple regression analysis, this study examines the coefficient of determination (R^2), the F-test, and the t-test (Gujarati, 2021). The coefficient of determination measures the proportion of variation in the dependent variable explained by the regression model. A higher R^2 value, approaching 1, indicates stronger explanatory power, whereas a lower value suggests that the model explains only a limited share of the observed variation. The F-test assesses the overall significance of the model by determining whether the independent variables jointly have a statistically significant relationship with the dependent variable. The t-test, in turn, evaluates the partial significance of each independent variable.

Estimation of the Ideal Number of Minimarkets

The regression produces a predicted number of minimarket outlets for each subdistrict, denoted by $\widehat{N}_i$. This predicted value is used as the baseline estimate of the ideal number of minimarkets. Because policy planning requires count data, the prediction is converted into an integer:

$$N_{I,i} = r(\widehat{N}_i)$$

where $N_{I,i}$ denotes the integer estimate of the ideal number of minimarkets in subdistrict i, and $r(\cdot)$ denotes a nearest-integer rounding function.

Regression estimates are point predictions and should not be interpreted as exact planning targets. Statistical interval literature emphasizes that interval-based interpretation can communicate prediction uncertainty and population variability more appropriately than a single point estimate (De Gryze et al., 2007; Meeker et al., 2017). The corridor used in this study, however, is not presented as a formal statistical prediction or tolerance interval. It is a pre-specified policy-evaluation corridor designed to accommodate model approximation, measurement uncertainty, and local heterogeneity. A symmetric band of plus or minus 20 percent around the model estimate is adopted as a pragmatic threshold so that small differences between observed and predicted outlet counts do not automatically produce different zoning decisions. To assess the dependence of the classification on this choice, sensitivity analysis is also conducted using alternative corridors of plus or minus 5, 10, 15, and 25 percent.

$$N_{L,i} = 0.8 \times N_{I,i}$$

$$N_{U,i} = 1.2 \times N_{I,i}$$

where $N_{L,i}$ and $N_{U,i}$ denote the lower and upper bounds of the optimal range, respectively. Thus, the regression approach yields two outputs at the subdistrict level: the integer ideal value $N_{I,i}$ and the optimal range from $N_{L,i}$ to $N_{U,i}$.

Gap Analysis and Zoning Classification

Gap analysis evaluates the alignment between the observed and ideal number of minimarkets in each subdistrict. Let $N_{O,i}$ denote the observed number of minimarkets. The gap is defined as:

$$G_i = N_{O,i} - N_{I,i}$$

A negative value of G_i indicates that the observed number of minimarkets is below the estimated ideal level. A positive value indicates that the observed number exceeds the estimated ideal level. For zoning, the same optimal corridor is used:

$$N_{L,i} = 0.8 \times N_{I,i}$$

$$N_{U,i} = 1.2 \times N_{I,i}$$

Each subdistrict is classified into three zones using the following rules. A subdistrict is classified as a green zone if:

$$N_{O,i} < N_{L,i}$$

A subdistrict is classified as a yellow zone if:

$$N_{L,i} \leq N_{O,i} \leq N_{U,i}$$

A subdistrict is classified as a red zone if:

$$N_{O,i} > N_{U,i}$$

The green zone indicates that the observed number of minimarkets is below the lower bound of the optimal range, suggesting potential room for outlet expansion. The yellow zone indicates that the observed number lies within the optimal range; policy attention should focus on spatial distribution, service quality, and operational efficiency. The red zone indicates that the observed number exceeds the upper bound of the optimal range, suggesting the need for growth control and evaluation of outlet concentration, service overlap, or market saturation.

The required adjustment is calculated to support policy interpretation. For green-zone subdistricts, the number of additional minimarkets required to reach the lower bound is:

$$A_i = N_{L,i} - N_{O,i}$$

For subdistricts not classified as green zones, the adjustment is:

$$A_i = 0$$

For red-zone subdistricts, the excess number of minimarkets above the upper bound is:

$$E_i = N_{O,i} - N_{U,i}$$

For subdistricts not classified as red zones, the excess is:

$$E_i = 0$$

In the yellow zone, both adjustment measures equal zero because the observed number remains within the regression-based optimal corridor. This procedure allows consistent comparison across subdistricts and provides an empirical basis for policy recommendations on minimarket planning and control.

RESEARCH RESULTS AND DISCUSSION

Existing Conditions and Spatial Distribution of Minimarkets in Bogor Regency

The existing minimarket structure in Bogor Regency is examined from two perspectives: brand composition and spatial distribution across subdistricts. In 2025, the regency had 1,359 minimarkets distributed across 40 subdistricts. This figure reflects the established capacity of daily retail services and provides an initial indication of competition intensity and service proximity to residential areas. The relatively large number of outlets indicates substantial minimarket penetration across Bogor Regency; however, subdistrict-level analysis is required to distinguish areas with potential outlet concentration from those with remaining room for expansion.

Figure 2 shows that the market is dominated by national chains. Indomaret accounts for 698 outlets, or 51.36 percent of the total, followed by Alfamart with 538 outlets, or 39.59 percent. The remaining 123 outlets, or 9.05 percent, are operated by other brands. This composition indicates that the minimarket market in Bogor Regency is largely controlled by two major chains, while other operators may represent local networks, cooperatives, or independent outlets serving specific market niches. In competitive terms, the dominance of the two leading chains is likely associated with stronger expansion capacity, supply-chain networks, and standardized services, making high-concentration areas arenas of location-based competition and proximity to daily activity flows.

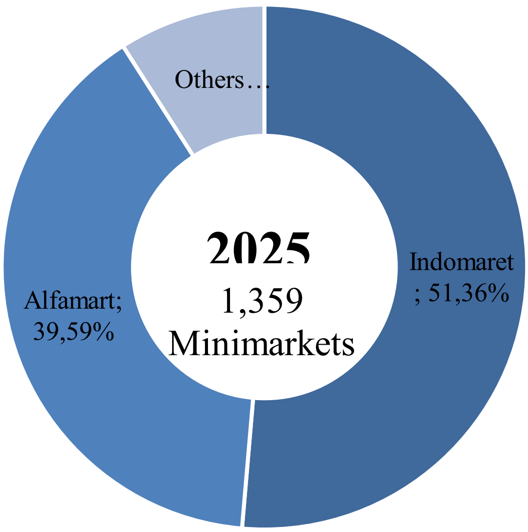

Figure 2. Number and Percentage of Minimarkets by Brand in Bogor Regency, 2025

Source: Department of Trade and Industry of Bogor Regency (2025)

Table 1 shows that minimarkets are unevenly distributed across subdistricts and are concentrated in several locations. The highest number is found in Cibinong, with 125 outlets (9.20 percent), followed by Cileungsi with 100 outlets (7.36 percent), Gunung Putri with 97 outlets (7.14 percent), and Bojong Gede with 96 outlets (7.06 percent). Other subdistricts with relatively high counts include Gunung Sindur (62 outlets; 4.56 percent), Klapanunggal (51 outlets; 3.75 percent), and Ciomas (48 outlets; 3.53 percent). By contrast, the lowest counts are recorded in Sukajaya (5 outlets; 0.37 percent), Tenjolaya (6 outlets; 0.44 percent), Nanggung (7 outlets; 0.52 percent), and Tenjo (8 outlets; 0.59 percent). These differences indicate that minimarket services are more intensive in subdistricts that function as residential and activity centers, whereas penetration remains limited in more rural or spatially dispersed areas.

Table 1. Number of Minimarkets by Brand and Subdistrict in Bogor Regency, 2025

No.	Subdistrict	Indomaret	Alfamart	Others	Total	
					Number	Percent
1	Babakan Madang	27	14	6	47	3.46
2	Bojong Gede	53	35	8	96	7.06
3	Caringin	15	12	0	27	1.99
4	Cariu	7	6	0	13	0.96
5	Ciampea	11	12	4	27	1.99
6	Ciawi	14	12	5	31	2.28
7	Cibinong	64	46	15	125	9.20
8	Cibungbulang	13	13	0	26	1.91
9	Cigombong	14	6	0	20	1.47
10	Cigudeg	12	7	0	19	1.40
11	Cijeruk	9	5	0	14	1.03
12	Cileungsi	45	41	14	100	7.36
13	Ciomas	22	15	11	48	3.53
14	Cisarua	15	14	5	34	2.50
15	Ciseeng	11	10	1	22	1.62
16	Citeureup	24	16	3	43	3.16
17	Dramaga	9	11	6	26	1.91
18	Gunung Putri	52	36	9	97	7.14
19	Gunung Sindur	34	23	5	62	4.56
20	Jasinga	10	8	0	18	1.32
21	Jonggol	25	18	3	46	3.38
22	Kemang	26	15	2	43	3.16
23	Klapanunggal	21	26	4	51	3.75
24	Leuwiliang	8	12	0	20	1.47
25	Leuwisadeng	9	7	0	16	1.18
26	Megamendung	11	7	3	21	1.55
27	Nanggung	5	2	0	7	0.52
28	Pamijahan	8	6	1	15	1.10
29	Parung	14	18	4	36	2.65
30	Parung Panjang	23	12	3	38	2.80
31	Ranca Bungur	7	6	0	13	0.96
32	Rumpin	13	9	1	23	1.69
33	Sukajaya	2	3	0	5	0.37
34	Sukamakmur	5	7	1	13	0.96
35	Sukaraja	22	17	5	44	3.24
36	Tajurhalang	12	14	2	28	2.06
37	Tamansari	13	7	1	21	1.55
38	Tanjungsari	6	4	0	10	0.74
39	Tenjo	5	3	0	8	0.59

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40	Tenjolaya	2	3	1	6	0.44
	Bogor Regency	**698**	**538**	**123**	**1,359**	**100**

Source: Department of Trade and Industry of Bogor Regency (2025)

Figure 3 further illustrates the spatial distribution of minimarkets across subdistricts. Outlet concentration is higher in areas associated with activity centers and mobility corridors, while the number of outlets declines toward peripheral and more dispersed subdistricts. Analytically, this pattern suggests that minimarket distribution follows effective market demand: outlets cluster where routine demand and accessibility are relatively high. These findings provide a basis for assessing the consistency between existing outlet distribution and local market potential, particularly in identifying subdistricts with possible over-concentration and those that may still require additional modern retail services.

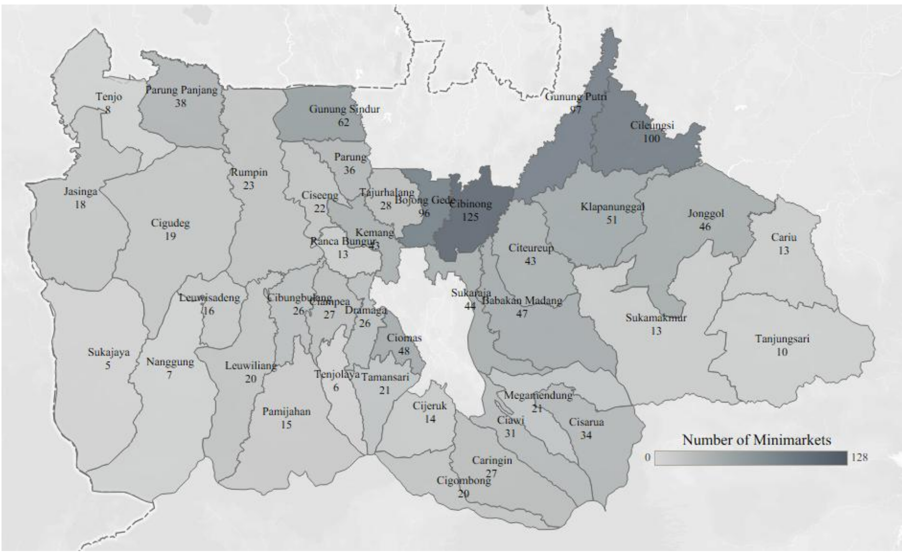

Figure 3. Spatial Distribution of Minimarkets by Subdistrict in Bogor Regency

Estimated Ideal Number of Minimarkets by Subdistrict Based on Regression Results

The ideal number of minimarkets is estimated using a regression approach to capture the empirical relationship between minimarket numbers and their determinants at the subdistrict level. The resulting estimate represents the number of minimarkets that is empirically consistent with the spatial-economic characteristics and retail structure of Bogor Regency. The explanatory variables include population size, land area, and the number of traditional retail outlets, representing market size, spatial conditions, and the local retail environment.

Figure 4 shows the correlations among the research variables. The number of minimarkets is strongly correlated with population, with a coefficient of approximately 0.901 and statistical significance. This result supports the view that population size is the main driver of minimarket growth because a larger market increases transaction potential and outlet viability. The correlation between minimarkets and area is negative (approximately -0.297) and statistically significant, indicating that larger administrative areas do not necessarily have more minimarkets. This pattern may reflect more dispersed settlement structures in larger areas. The correlation between minimarkets and traditional retail outlets is weak and slightly negative, suggesting a limited bivariate relationship.

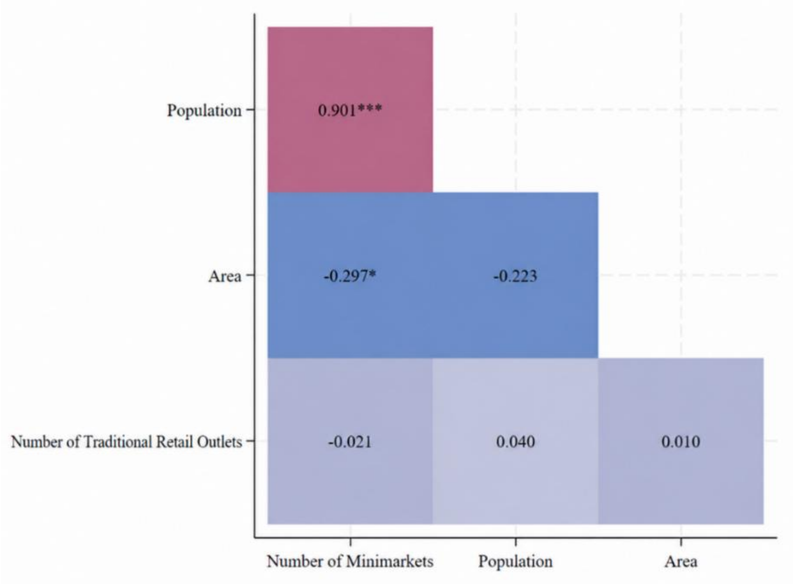

Figure 4. Correlation among Research Variables

The regression estimates in Table 2 show that population has a positive and statistically significant effect. The coefficient of 33.87 means that an additional 100,000 residents is associated with approximately 34 additional minimarket outlets, with significance at the 1 percent level. Area has a negative and statistically significant effect, with a coefficient of -0.06 per km², indicating that larger subdistricts tend to have fewer minimarkets after controlling for other factors. The number of traditional retail outlets has a negative but statistically insignificant coefficient (-0.54), suggesting a possible substitution pattern that is not strongly supported by the data. The model performs well, with an R-squared of 0.8239, meaning that the explanatory variables account for 82.39 percent of the variation in minimarket counts across subdistricts. The F-test also indicates that the model is jointly significant. Diagnostic tests further indicate that the assumptions underlying the OLS estimator are satisfactorily met. The residuals are normally distributed according to the Shapiro–Wilk test, multicollinearity is negligible as reflected by VIF values ranging from 1.00 to 1.05 with a mean of 1.04, and both the Breusch–Pagan/Cook–Weisberg and White tests provide no evidence of heteroskedasticity. In addition, the Ramsey RESET test does not indicate model misspecification at the 5 percent significance level. Although these diagnostic tests support the adequacy of the OLS specification, robust standard errors are retained to provide more conservative statistical inference.

Taken together, the empirical results support H1 and H2 but do not support H3. The positive population coefficient is consistent with the market-threshold mechanism of central place theory and the market-attractiveness mechanism of retail gravitation. The negative land-area coefficient, conditional on population size, indicates that spatial dispersion and higher distance frictions reduce the concentration of viable retail demand. The insignificant traditional-retail coefficient suggests that modern and traditional outlets may coexist through product differentiation, service differences, and neighborhood-based consumer relationships rather than operate through a uniform substitution mechanism.

Table 2. Factors Affecting Minimarket Growth

Variable	Coefficient	95% Confidence Interval
Population (100,000 persons)	33.87***(2.21)	[29.39 to 38.34]
Area (km²)	-0.06*(0.03)	[-0.12 to -0.01]
Number of Traditional Retail Outlets (100 outlets)	-0.54(0.64)	[-1.84 to 0.75]
Constant	Included	[-16.79 to -0.15]
R-squared	0.8239	
F-statistic (Prob > F)	89.73 (0.0000)	
Number of Observations	40	

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Robust standard errors are in parentheses.

Based on the coefficients in Table 2, the ideal number of minimarkets in each subdistrict is calculated and reported in Table 3 using the format A [B-C], where A is the point estimate, B is the lower bound (0.8 x A), and C is the upper bound (1.2 x A). At the regency level, the regression yields a benchmark estimate of 1,379 outlets, with an evaluation corridor ranging from 1,104 to 1,655 outlets. This range represents the number of minimarkets empirically consistent with the observed relationships between outlet numbers and the territorial characteristics included in the model.

At the subdistrict level, the highest ideal values are found in large-population areas. Cibinong has the highest estimate at 117 outlets [94-141], followed by Bojong Gede and Cileungsi at 91 outlets [73-110] each, and Gunung Putri at 89 outlets [72-107]. Other subdistricts with relatively high estimates include Citeureup (62 [50-75]), Sukaraja (61 [49-74]), Ciomas (49 [40-59]), and Ciampea (45 [36-54]). By contrast, the lowest estimates are found in Cariu (2 [2-3]), Tanjungsari (4 [4-5]), and Sukajaya (7 [6-9]). This pattern shows that when population, area, and traditional retail are considered jointly, ideal demand remains concentrated in subdistricts that function as settlement and activity centers, while some areas have lower estimated needs because their effective markets are smaller or more dispersed.

Overall, the regression-based estimate integrates population size, land area, and the number of traditional retail outlets within a single empirical framework. It therefore provides a data-driven benchmark for formulating subdistrict-level recommendations for minimarket development.

Table 3. Ideal Number of Minimarkets Based on Regression Estimates by Subdistrict in Bogor Regency

No.	Subdistrict	Regression Estimate	No.	Subdistrict	Regression Estimate
1	Babakan Madang	26 [21-32]	21	Jonggol	34 [28-41]
2	Bojong Gede	91 [73-110]	22	Kemang	38 [31-46]
3	Caringin	33 [27-40]	23	Klapanunggal	23 [19-28]
4	Cariu	2 [2-3]	24	Leuwiliang	30 [24-36]
5	Ciampea	45 [36-54]	25	Leuwisadeng	16 [13-20]
6	Ciawi	25 [20-30]	26	Megamendung	26 [21-32]

7	Cibinong	117 [94-141]	27	Nanggung	17 [14-21]
8	Cibungbulang	42 [34-51]	28	Pamijahan	41 [33-50]
9	Cigombong	20 [16-24]	29	Parung	33 [27-40]
10	Cigudeg	26 [21-32]	30	Parung Panjang	29 [24-35]
11	Cijeruk	21 [17-26]	31	Ranca Bungur	13 [11-16]
12	Cileungsi	91 [73-110]	32	Rumpin	31 [25-38]
13	Ciomas	49 [40-59]	33	Sukajaya	7 [6-9]
14	Cisarua	29 [24-35]	34	Sukamakmur	12 [10-15]
15	Ciseeng	27 [22-33]	35	Sukaraja	61 [49-74]
16	Citeureup	62 [50-75]	36	Tajurhalang	36 [29-44]
17	Dramaga	29 [24-35]	37	Tamansari	28 [23-34]
18	Gunung Putri	89 [72-107]	38	Tanjungsari	4 [4-5]
19	Gunung Sindur	33 [27-40]	39	Tenjo	12 [10-15]
20	Jasinga	18 [15-22]	40	Tenjolaya	13 [11-16]
	Bogor Regency			**1,379 [1,104-1,655]**	

Source: Author's Estimation Results

Figure 5 displays the spatial distribution of the regression-based ideal number of minimarkets in Bogor Regency. The map reflects the combined effects of variables empirically associated with minimarket growth, particularly population size and the negative effect of land area after the other variables are controlled. The spatial pattern indicates that higher ideal demand is concentrated in subdistricts serving as settlement and activity centers, while subdistricts with smaller or more dispersed effective markets have lower estimated needs.

The highest estimated demand is concentrated in the central and eastern parts of the regency. Cibinong records the highest estimate at 117 outlets, followed by Bojong Gede and Cileungsi with 91 outlets each, and Gunung Putri with 89 outlets. These subdistricts have large populations and relatively high activity intensity. Several other subdistricts also show medium-to-high estimated demand, including Citeureup (62), Sukaraja (61), Ciomas (49), and Ciampea (45), indicating that ideal demand extends beyond the main urban centers to surrounding subdistricts with relatively strong markets.

The map also shows low estimated values in Cariu (2), Tanjungsari (4), and Sukajaya (7). These lower values do not imply the absence of retail service needs. Rather, they indicate that the demographic and spatial characteristics included in the model are not empirically associated with a large number of minimarket outlets in these areas. For such subdistricts, modern retail development should be more selective and focused on settlement nodes or main corridors rather than dense outlet distribution.

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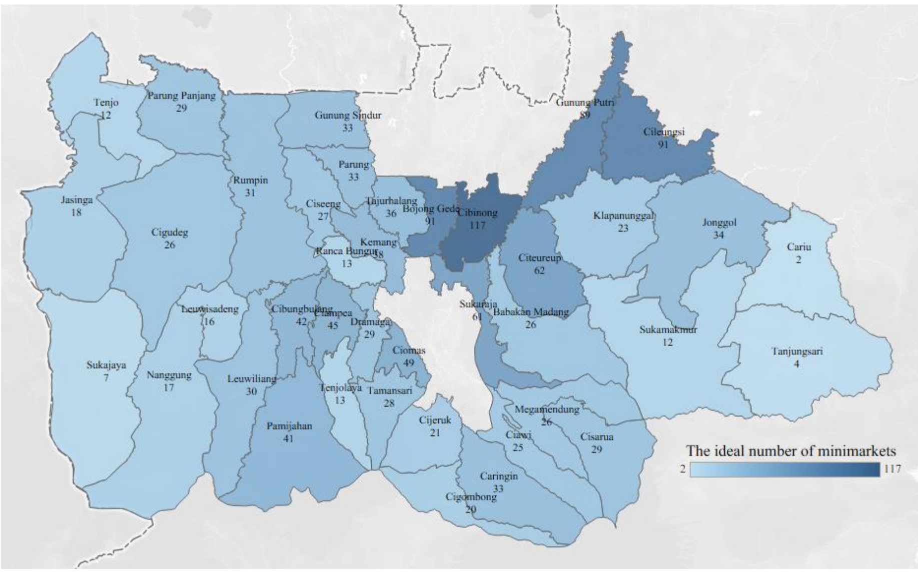

Figure 5. Spatial Distribution of the Ideal Number of Minimarkets Based on Regression Estimates by Subdistrict in Bogor Regency

Zoning of Minimarket Gaps Based on Regression Estimates

In this section, gap zoning is constructed using the ideal values generated by the regression model. The definition of need therefore reflects not only population size but also territorial characteristics captured by the explanatory variables. Because the evaluation uses an optimal demand corridor, the gap is interpreted as a range. Each subdistrict is classified into a green, yellow, or red zone according to the position of the observed number of minimarkets relative to the estimated optimal range. The resulting zoning classification is presented in Table 4.

As shown in Table 4, the regression-based zoning framework classifies 15 subdistricts as green zones, 17 as yellow zones, and 8 as red zones. Red-zone subdistricts include Babakan Madang, Cariu, Ciawi, Gunung Sindur, Jonggol, Klapanunggal, Parung Panjang, and Tanjungsari. These areas have observed outlet counts above the upper bound of the estimated optimal range, suggesting the need for growth control and closer evaluation of potential service concentration. Yellow-zone subdistricts have gap ranges that cross zero, indicating a relatively balanced condition in which policy should focus on spatial distribution, service quality, and outlet efficiency. Green-zone subdistricts have gap ranges that remain negative, indicating that the observed number of outlets falls below the lower bound of the regression-based benchmark corridor. The largest negative deviations are found in Pamijahan, Sukaraja, Citeureup, Ciampea, and Cibungbulang, suggesting potential room for additional outlets subject to further assessment of accessibility, settlement patterns, and local regulations.

Table 4. Minimarket Gap Based on Regression Estimates

No.	Subdistrict	Gap Range	Zone	No.	Subdistrict	Gap Range	Zone
1	Babakan Madang	[16 to 27]	Red	21	Jonggol	[6 to 19]	Red
2	Bojong Gede	[-14 to 24]	Yellow	22	Kemang	[-3 to 13]	Yellow
3	Caringin	[-13 to 1]	Yellow	23	Klapanunggal	[24 to 33]	Red
4	Cariu	[11 to 12]	Red	24	Leuwiliang	[-16 to -4]	Green

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5	Ciampea	[-27 to -9]	Green	25	Leuwisadeng	[-4 to 4]	Yellow
6	Ciawi	[1 to 11]	Red	26	Megamendung	[-11 to 1]	Yellow
7	Cibinong	[-16 to 32]	Yellow	27	Nanggung	[-14 to -7]	Green
8	Cibungbulang	[-25 to -8]	Green	28	Pamijahan	[-35 to -18]	Green
9	Cigombong	[-4 to 4]	Yellow	29	Parung	[-4 to 10]	Yellow
10	Cigudeg	[-13 to -2]	Green	30	Parung Panjang	[4 to 15]	Red
11	Cijeruk	[-12 to -3]	Green	31	Ranca Bungur	[-3 to 3]	Yellow
12	Cileungsi	[-10 to 28]	Yellow	32	Rumpin	[-15 to -2]	Green
13	Ciomas	[-11 to 9]	Yellow	33	Sukajaya	[-4 to -1]	Green
14	Cisarua	[-1 to 11]	Yellow	34	Sukamakmur	[-2 to 4]	Yellow
15	Ciseeng	[-11 to 1]	Yellow	35	Sukaraja	[-30 to -5]	Green
16	Citeureup	[-32 to -7]	Green	36	Tajurhalang	[-16 to -1]	Green
17	Dramaga	[-9 to 3]	Yellow	37	Tamansari	[-13 to -2]	Green
18	Gunung Putri	[-10 to 26]	Yellow	38	Tanjungsari	[6 to 7]	Red
19	Gunung Sindur	[23 to 36]	Red	39	Tenjo	[-7 to -2]	Green
20	Jasinga	[-4 to 4]	Yellow	40	Tenjolaya	[-10 to -5]	Green
Bogor Regency		Green			15		
		Yellow			17		
		Red			8		

To examine the robustness of the proposed zoning framework, a sensitivity analysis was performed using alternative evaluation corridors of ±5%, ±10%, ±15%, ±20%, and ±25% around the regression estimates. As reported in Table 5, narrower corridors produce a more stringent classification by increasing the number of green and red zones, whereas wider corridors shift more subdistricts into the yellow zone. The ±20% corridor provides a balanced classification that distinguishes meaningful deviations from the regression benchmark without overinterpreting relatively small prediction differences. These results support the use of the ±20% corridor as a pragmatic evaluation criterion for retail zoning rather than as a universal statistical threshold.

Table 5. Sensitivity of Zoning Classification to Alternative Evaluation Corridors

Evaluation Corridor	Green Zones	Yellow Zones	Red Zones
± 5%	19	7	14
± 10%	19	11	10
± 15%	18	14	8
± 20% (main specification)	15	17	8
± 25%	13	20	7

Figure 6 presents the spatial distribution of the zoning results. Green zones are concentrated mainly in the western and southern parts of the regency, indicating that observed minimarket numbers in many of these subdistricts remain below the lower bound of the regression-based benchmark corridor. Yellow zones appear in several subdistricts near activity centers and buffer corridors, indicating that their observed outlet counts remain within the regression-based benchmark corridor. Red zones form limited clusters, particularly in subdistricts that function as activity nodes or development corridors, where outlet numbers exceed the upper bound of the regression-based benchmark corridor. Overall, the regression-based zoning distinguishes areas with potential room for expansion, areas requiring optimization, and areas requiring closer evaluation and possible growth control.

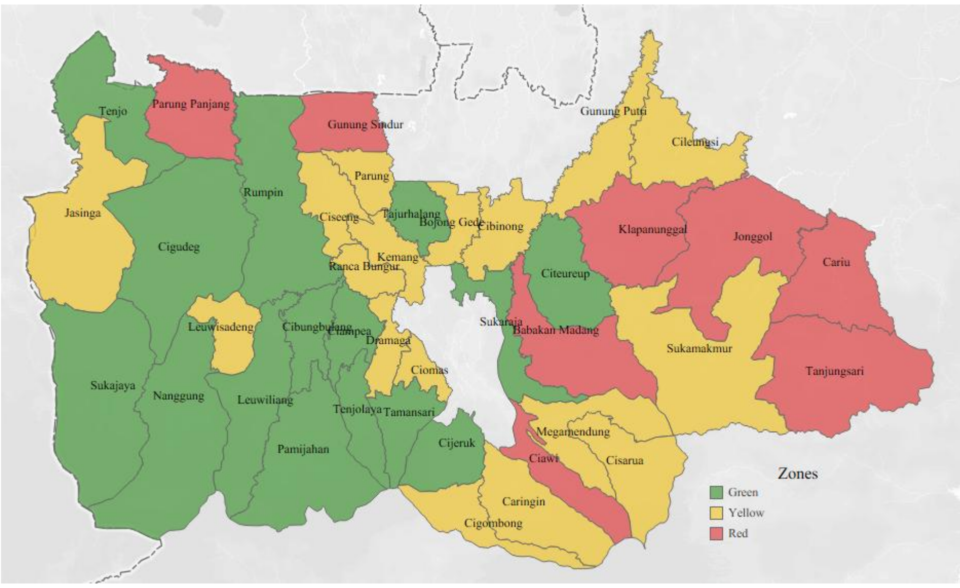

Figure 6. Zoning of Minimarket Gaps Based on Regression Estimates

The regression-based gap analysis in this study should be interpreted as a diagnostic comparison between the observed number of minimarkets and the estimated ideal number generated by the regression model. The gap represents the extent to which the observed number of minimarkets in each subdistrict deviates from the model-estimated benchmark, which is derived from key territorial characteristics, including population size, land area, and the number of traditional retail outlets.

This interpretation is important because the estimated ideal number of minimarkets is not constructed from a normative service standard, but from empirical relationships observed across subdistricts in Bogor Regency. A negative gap indicates that the existing number of minimarkets is below the regression-based benchmark, suggesting potential room for additional outlets. A positive gap indicates that the existing number exceeds the estimated benchmark, suggesting a need for closer evaluation of outlet concentration and potential market overlap. Subdistricts within the benchmark corridor may be regarded as relatively balanced in planning terms, although further attention may still be required regarding spatial distribution, accessibility, and service quality.

Economic and Spatial Interpretation of the Findings

The positive relationship between population size and minimarket numbers is better understood as a market-threshold mechanism rather than merely a statistical association. Central place theory suggests that retail services become economically viable when the surrounding population generates a sufficiently large and recurrent demand base, while retail gravitation emphasizes the attractiveness created by consumer mass. In the context of minimarkets, densely populated subdistricts provide frequent demand for low-value daily purchases and allow retail chains to organize inventory replenishment, distribution, and outlet monitoring more efficiently. Population concentration therefore supports both demand-side viability and supply-side network efficiency, particularly for large retail chains with integrated distribution systems and stronger expansion capacity (Rahman, 2022). This mechanism explains why minimarkets are concentrated in Cibinong, Bojong Gede, Cileungsi, and Gunung Putri, which function as major residential and activity centers. Evidence from Jabodetabek also indicates that minimarket expansion follows population concentration, settlement development, and accessibility (Atmaja & Nurussalwa, 2024). International studies similarly show that demographic concentration, accessibility, and the spatial organization of consumer activities are central determinants of retail location and performance (Ahn, 2019; Fang et al., 2024; Formánek & Sokol, 2022; Gao et al., 2025).

The negative relationship between land area and the number of minimarkets should not be interpreted as evidence that a larger territory directly reduces retail demand. After population size is controlled, a larger administrative area generally represents a more dispersed spatial structure, lower population density, greater distances between settlement clusters, and less concentrated daily mobility. From the perspective of retail gravitation, these characteristics increase spatial friction and reduce the effective market that can be reached by an individual outlet. Two subdistricts with similar populations may therefore support different outlet densities when one has compact settlements and connected mobility corridors, while the other consists of geographically separated villages. This interpretation is consistent with studies showing that retail agglomeration is shaped by urban functions, convenience, road connectivity, and travel-time accessibility rather than administrative size alone (Li et al., 2025; Liao et al., 2022; C. Lu et al., 2023; Neto et al., 2025).

The concentration of minimarkets around major settlement and mobility nodes also reflects the simultaneous operation of agglomeration benefits and competitive cannibalization. Business location models show that proximity to activity centers, major roads, public transport, and other commercial establishments shapes retail location choices by improving accessibility and potential customer flows (Mahmud & Habib, 2024). Retail clustering can reduce consumer search costs, facilitate multipurpose shopping, strengthen the visibility of commercial locations, and generate cumulative customer flows. However, when outlets serve substantially overlapping catchment areas, additional stores may redistribute transactions among nearby outlets rather than generate new demand. Ahn (2019) shows that the balance between agglomeration economies and competition among chain stores depends on market structure and differentiation across store formats. Kim et al. (2024) likewise find that agglomeration can create demand-side benefits by lowering consumer search costs, whereas Chenarides et al. (2024) demonstrate that entry by a low-price retail format can reduce incumbent retailers' markups. These competing mechanisms imply that red-zone status should be treated as a signal for examining outlet overlap, network density, and potential cannibalization, rather than as direct evidence of excess supply.

The statistically insignificant relationship between traditional retail outlets and minimarket numbers further indicates that retail competition cannot be adequately represented by outlet counts alone. Modern minimarkets and traditional retailers may compete for similar expenditures in some product categories, while remaining complementary in others. Consumers may differentiate between the two formats according to assortment, price, product freshness, credit arrangements, opening hours, service speed, proximity, and neighborhood relationships. A systematic review by Bonfrer et al. (2022) shows that store-format choice is jointly influenced by location, assortment, pricing, shopping objectives, and household time constraints, while evidence regarding the relative strength of inter-format and intra-format competition remains inconclusive. The rejection of H3 therefore does not imply an absence of competition. Rather, it suggests that competition and coexistence depend on functional overlap and consumer segmentation, which are not captured by the aggregate number of traditional outlets (Bonfrer et al., 2022; Suryadarma et al., 2010).

The zoning results also reveal an important distinction between outlet availability and spatial accessibility. A green-zone classification may indicate potential room for additional minimarkets, but it may also reflect dispersed settlements, limited road connectivity, lower purchasing power, or insufficiently concentrated consumer flows. An area with relatively few outlets is not necessarily commercially suitable for uniform retail expansion. Spatial-equity research shows that a larger number of facilities does not automatically ensure equitable access when outlets remain concentrated in particular locations (Li et al., 2025). Evidence on physical-store survival also indicates that accessible locations, differentiated assortments, and convenient transactions are important for outlet viability (Kupfer et al., 2024). Green-zone policy should therefore prioritize settlement nodes, transport corridors, and genuinely underserved catchment areas rather than distributing new outlets evenly throughout a subdistrict.

A yellow-zone classification similarly does not necessarily mean that retail services are efficiently distributed within the subdistrict. Because the model relies on aggregate subdistrict-level data, an observed outlet count may fall within the benchmark corridor even when most outlets are concentrated along a single road or near one activity center. Peripheral villages may consequently remain underserved despite an apparently balanced aggregate number. This limitation highlights the need to complement the zoning framework with micro-location analysis involving road connectivity, land use, settlement density, points of interest, competitor locations, and consumer mobility. Recent retail-location studies demonstrate that combining demographic, competitor, accessibility, and urban-function data produces a more informative assessment of location suitability than outlet counts alone (Lu et al., 2024; Zhao et al., 2025).

Taken together, the findings indicate that the spatial distribution of minimarkets in Bogor Regency results from the interaction of market thresholds, spatial friction, agglomeration economies, competitive cannibalization, and differentiation between retail formats. The contribution of the zoning framework lies in translating these interacting mechanisms into an initial planning instrument. Green zones signal the need to assess accessibility and commercial viability, yellow zones require evaluation of internal distribution and service efficiency, and red zones call for closer examination of market overlap and network concentration. The classifications should therefore guide the type and location of further policy assessment rather than operate as automatic decisions on outlet approval, restriction, or closure.

From a policy perspective, the proposed zoning framework should be used as an initial screening instrument rather than an automatic licensing rule. Green-zone status does not by itself justify outlet approval, and red-zone status does not automatically imply closure or a permanent prohibition on investment. Local governments should combine the regression-based classification with field verification, road and public-transport accessibility, settlement nodes, formal spatial plans, local competition conditions, and the potential effects on traditional retail. Used in this way, the framework can help prioritize permit evaluation and monitoring while preserving the role of administrative judgment and local evidence.

CONCLUSION

The findings demonstrate that minimarket distribution in Bogor Regency remains spatially uneven, even though the aggregate number of outlets falls within the regression-based optimal corridor. Population size emerges as the primary determinant of minimarket growth, whereas land area has a negative effect, suggesting that outlet development is more closely associated with the spatial concentration of effective demand than with administrative size alone. Comparison between observed outlet counts and the regression-based benchmark shows that several subdistricts may still accommodate additional outlets, while others require spatial and operational optimization or closer assessment for possible growth control. The zoning results classify 15 subdistricts as green zones, 17 as yellow zones, and 8 as red zones. These findings underscore that minimarket planning should not be based solely on aggregate outlet numbers, but should also consider subdistrict-level characteristics, settlement patterns, and empirical benchmarks to support more balanced, efficient, and evidence-based retail development in Bogor Regency.

Several limitations should be considered when interpreting these findings. The analysis relies on cross-sectional data, a relatively small number of subdistrict-level observations, and a limited set of explanatory variables. Consequently, the estimated relationships may be subject to omitted variable bias because several potentially relevant determinants, including household income, road accessibility, settlement density, land-use intensity, consumer mobility, rental costs, and local planning regulations, could not be consistently incorporated at the subdistrict level due to data limitations. In addition, the ±20 percent corridor represents a predefined policy evaluation criterion rather than a formal statistical prediction interval. Accordingly, the zoning classifications should be interpreted as diagnostic benchmarks rather than definitive measures of market demand, supply, or saturation. Future research should employ panel or spatial econometric approaches, incorporate a broader range of explanatory variables, develop model-based prediction intervals where appropriate, and evaluate alternative corridor specifications to further assess the robustness of the proposed zoning framework.

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