INKUBIS: Jurnal Ekonomi dan Bisnis
Volume 8, Issue 3, 1-13
e_ISSN: 2775-3913
https://inkubis.polteksci.ac.id/index.php/ink/index
DOI: doi.org/10.59261/inkubis.v8i3.309

Quail Breeder Typology and Analysis of Business Performance Differences in Sleman Regency

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Article Info:
Article history:
Received: May 18, 2026
Revised: July 06, 2026
Accepted: July 25, 2026

Keywords:
Business Performance; Cluster Analysis; Farmer Typology; Quail Farming; Technical Efficiency

Abstract

Background: Quail farming in Indonesia faces substantial business risks due to feed-price volatility, with feed accounting for approximately 69% of total production costs, and unstable farm-gate egg prices. Despite operating with similar production inputs, farmers demonstrate considerable variation in productivity and technical efficiency. However, cluster-based studies examining the typology of quail farmers remain limited in the Indonesian agribusiness literature.
Objective: This study aimed to identify the typology of quail farmers and examine differences in business performance among farmer groups in Sleman Regency, Special Region of Yogyakarta.
Methods: This study employed a quantitative approach using survey data collected from 30 laying-quail farmers selected through purposive sampling. K-means cluster analysis was used to classify the farmers according to age, farming experience, and marketing adaptation strategies. Furthermore, a one-way analysis of variance (ANOVA) was conducted to examine differences in egg productivity and technical efficiency among the identified clusters.
Results: The farmers were classified into three typologies: traditional, semi-adaptive, and adaptive. Traditional farmers tended to be older, had more farming experience, and relied on conventional marketing channels involving intermediaries. In contrast, adaptive farmers were generally younger and employed direct-to-consumer marketing strategies. Despite these typological differences, the ANOVA results revealed no statistically significant differences in egg productivity (p = 0.565) or technical efficiency (p = 0.486). These findings suggest that adaptive behavior has not yet resulted in measurable performance advantages.
Conclusion: This study contributes to a better understanding of farmer heterogeneity in the quail-farming sector and provides evidence-based policy implications for designing targeted agricultural extension programs tailored to each farmer typology. These programs should focus specifically on strengthening the digital marketing capabilities of traditional farmers and improving institutional access for adaptive farmer groups.

To cite this article: Millaty, M., Nugraha, B. S. P., Dewi, M. P., & Putri, M. (2026). Quail breeder typology and analysis of business performance differences in Sleman Regency. INKUBIS: Jurnal Ekonomi dan Bisnis, 8(3), xx–xx. https://doi.org/10.59261/inkubis.v8i3.309

INTRODUCTION

The laying quail farming sector in Indonesia plays a strategic role as a provider of animal protein and as a driver of the rural economy. However, this commodity is characterized by high business risk, particularly due to fluctuations in feed prices, which account for 69.21 percent of total production costs. In addition, quail egg prices at the farmer level remain unstable. These conditions contribute to considerable business uncertainty, requiring farmers to possess strong adaptability to maintain business sustainability.

According to Statistics Indonesia BPS (2023), national quail egg production reaches approximately 235,000 tonnes annually, with Yogyakarta Province contributing significantly as one of the major producing regions. Economically, quail egg farming provides income opportunities for thousands of smallholder households; however, the sector remains vulnerable to market fluctuations. This situation highlights the need for a deeper understanding of farmers' adaptive capacity and typological differences that contribute to variations in business performance (Mottet & Tempio, 2017).

Field observations indicate that although farmers utilize relatively similar numbers of quails and production inputs, their business performance, particularly in terms of productivity and technical efficiency, tends to vary. These differences suggest variations in adaptability and business management capabilities, which are influenced not only by technical factors but also by farmers' individual characteristics.

From the perspective of human capital theory, investment in human resources, including education, training, skills, and experience, enhances individual productivity and contributes to improved business performance and output. Therefore, farmers' individual characteristics, particularly age and business experience, are important factors that may influence their ability to manage enterprises efficiently and achieve optimal performance. This argument is supported by Xue (2024), who found that age and experience influence technical efficiency, although the direction and magnitude of these effects may vary depending on the scale of the farming enterprise. Similarly, research on dairy farms conducted by Bajrami (2017) demonstrated that variations in technical efficiency among farmers are influenced by multiple factors, including farmer characteristics and the ability to manage production inputs, which ultimately determine business productivity levels.

Individual characteristics, such as age and business experience, reflect the accumulation of human capital, including knowledge, skills, and adaptive capacity in business management. In the context of modern agribusiness, human capital encompasses not only formal education but also the ability to continuously learn and adapt to changes in the business environment. High levels of human capital have been shown to improve productivity, efficiency, and decision-making quality among business actors (Brimah et al., 2025). In this study, human capital directly contributes to farmer typology formation by determining adaptive capacity and marketing strategy adoption, which are expected to differentiate business performance outcomes among farmer groups.

Farmers' knowledge and skills are considered intangible assets that determine productivity (Becker, 1989). In this context, age and business duration serve as proxies for accumulated human capital. Age reflects maturity in decision-making and risk perception, whereas business duration represents a learning-by-doing process that develops technical intuition in responding to market dynamics. Therefore, farmers with longer business experience tend to allocate inputs more efficiently and minimize business risks, resulting in improved efficiency and performance.

However, previous studies on quail farming have predominantly focused on technical production aspects, while approaches that classify farmers based on their characteristics and adaptation strategies remain limited. Each breeder possesses different combinations of characteristics, resulting in diverse adaptation patterns. These differences may create distinct farmer typologies with varying business behaviors and strategies for managing risks. Studies examining quail breeder typology by integrating sociodemographic variables and marketing adaptation behavior through cluster-based approaches remain scarce in the Indonesian agribusiness literature.

A typological approach using cluster analysis is important for identifying farmer groupings based on similarities in their characteristics. Understanding farmer typology enables researchers to examine how adaptation strategies are formed and how these differences relate to business performance. Furthermore, comparative analysis using the analysis of variance

(ANOVA) test is required to determine whether significant differences exist in business performance among the identified farmer groups.

The selection of age, business duration, and marketing strategy as typology-forming variables is theoretically grounded in human capital theory Becker (1989) adaptive management frameworks. Age and business duration serve as proxies for accumulated human capital, reflecting experiential knowledge and decision-making maturity. Meanwhile, marketing strategy represents farmers' practical adaptive capacity and market orientation, which are important behavioral indicators of agribusiness resilience. Collectively, these variables capture both structural and behavioral dimensions of farmer typology, providing a comprehensive and theoretically justified foundation for clustering analysis.

Sleman Regency is one of the centers for laying quail farm development in Daerah Istimewa Yogyakarta (DIY), located in the northern part of the province and directly bordering Central Java Province. Based on data from the Sleman Regency Agriculture, Food, and Fisheries Office (2024), approximately 57% of quail farmers in Yogyakarta Province are in Sleman Regency. Furthermore, the quail population in Sleman Regency has shown a relatively increasing trend over time. The population reached 951,367 quails in 2014, increased to 951,941 in 2015, and continued to rise to 952,552 in 2016 (BPS, 2022). Sleman Regency provides favorable conditions for livestock business development, supported by relatively good market accessibility, making it a suitable area for small- and medium-scale quail farming activities. Its position as a quail farming center makes Sleman Regency a relevant research location for examining business management dynamics and farmer performance in responding to business risks.

The novelty of this study lies in its integrated typological approach, which combines sociodemographic characteristics (age and business duration) with marketing adaptation behavior to segment quail breeders, a combination that has rarely been examined in the Indonesian quail agribusiness context. Unlike previous studies that primarily emphasize technical production aspects, this study explicitly connects farmer typology with business performance indicators, providing a more comprehensive framework for understanding farmer heterogeneity and its implications for agribusiness policy development.

Based on this background, this study aims to identify the typology of quail breeders based on age, business duration, and adaptation strategies, as well as to analyze differences in business performance among the identified breeder groups.

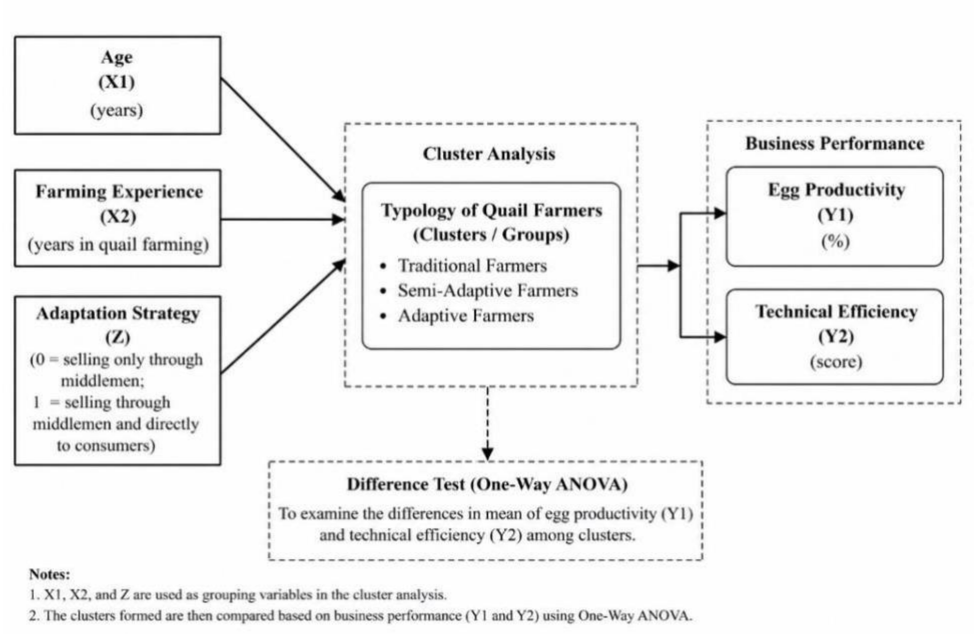

Figure 1. Research Model of Breeder Typology and Business Performance Analysis

METHOD

This study used a quantitative approach aimed at identifying farmer typology and analyzing differences in business performance based on the groups formed. The research was conducted in Sleman Regency, Daerah Istimewa YogyakartaProvince, which was purposively selected considering that this area is one of the main centers of quail egg production at the regional level. Data collection was conducted in 2025 through field surveys and structured interviews with laying quail farmers.

The population in this study consisted of laying quail farmers in Sleman Regency. A sample of 30 respondents was selected using the purposive sampling method. This sample size was considered adequate because, in quantitative research, a minimum sample size of 30 respondents meets the basic assumptions of statistical analysis, particularly based on the principle of normal distribution in the Central Limit Theorem, which states that a sample size of ≥30 can represent a population adequately (Sekaran & Bougie, 2016; Sugiyono, 2019). Therefore, the number of samples used in this study was considered sufficient to describe the managerial characteristics and business scale of farmers in the study area. Furthermore, for K-Means cluster analysis with k = 3, a minimum of 30 observations provides approximately 10 observations per cluster, which meets the recommended minimum for stable centroid estimation (Hair et al., 2019). Additionally, for One-Way ANOVA involving three groups, this sample size provides adequate statistical power when moderate to large effect sizes are observed.

Data analysis was conducted through two main stages: cluster analysis and difference testing using ANOVA. Cluster analysis was applied to classify farmers into several groups (typologies) based on their characteristics. The K-Means Cluster method was selected because it can efficiently group a moderate number of observations. The variables used for cluster formation included:

1. Farmer age (X1)
2. Business duration (X2)
3. Marketing strategy (Z), consisting of:
   0 = selling through middlemen
   1 = selling through middlemen and directly to consumers

The number of clusters used in this study was three groups (k = 3), which were determined based on the research objective of establishing breeder typologies, namely: 1) Traditional breeders. 2) Semi-adaptive breeders. 3) Adaptive breeders.

The results of the cluster analysis produced groups of breeders with similar characteristics in terms of age, business experience, and marketing adaptation strategies. After the farmer groups were established, the analysis was continued with a difference test using One-Way Analysis of Variance (ANOVA). This test was conducted to determine whether significant differences existed among clusters in terms of livestock business performance. The variables examined included:

Egg productivity (Y1) was measured as the ratio of total eggs produced per day to the total population of laying quails and was expressed as a percentage using the Hen Day Production (HDP) rate. Technical efficiency (Y2) was measured using an output-input ratio approach, calculated as the actual egg output relative to the maximum potential output based on feed utilization and flock inputs. This approach is consistent with partial efficiency measurements commonly applied in smallholder livestock studies when complete frontier production data are unavailable. The efficiency value ranged from 0 to 1, where higher values indicated more efficient production systems.

The variables tested were:

1. Egg productivity (Y1)
2. Technical efficiency (Y2)

The hypotheses tested were:

1. H0: There was no difference in the mean values among clusters.
2. H1: There was a difference in the mean values among clusters.

The decision-making criteria were:

1. If the significance value (Sig.) > 0.05, H0 was accepted.
2. If the significance value (Sig.) ≤ 0.05, H0 was rejected.

If the ANOVA results showed significant differences, the analysis was followed by a Post Hoc test using Tukey's HSD to identify the specific groups with significant differences. However, if the ANOVA results were not significant, no further post hoc testing was conducted.

Before conducting the One-Way ANOVA, the assumptions of normality and homogeneity of variance were tested. The normality of data distribution within each group was assessed using the Shapiro-Wilk test, which is recommended for sample sizes below 50, and the Kolmogorov-Smirnov test. Homogeneity of variance among groups was examined using Levene's test. The Shapiro-Wilk test results indicated that egg productivity (p = 0.142–0.387) and technical efficiency (p = 0.198–0.421) were normally distributed within each cluster ($p > 0.05$). Furthermore, Levene's test confirmed the homogeneity of variance for both variables ($p = 0.234$ and $p = 0.312$, respectively). These results confirmed that the parametric ANOVA procedure was appropriate for analyzing the dataset.

RESULTS AND DISCUSSION

Results

Characteristics of quail breeders

Based on the age distribution of quail farmers in Sleman Regency, most farmers are in the age group of 35–50 years (50%), followed by those aged >50 years (40%), while farmers aged <35 years account for only 10%. This composition indicates that the quail farming sector is still dominated by middle-aged to older productive-age farmers, with relatively low participation from the younger generation. The age distribution of quail farmers in Sleman Regency is presented in Table 1.

Table 1. Age Distribution of Quail Farmers in Sleman Regency

Age Group (years)	Number (people)
< 35	3
35 - 50	15
> 50	12
Total	30

Source: Primary Data (2025), processed

Discussion

The dominance of farmers aged 35–50 years indicates that quail farming businesses tend to be managed by individuals with maturity in decision-making and sufficient experience in managing business risks. From a human capital perspective, productive age is associated with managerial ability, accumulated experience, and efficiency in managing production inputs (Xue et al., 2024). Abdulai (2014) stated that farmers' age significantly affects technical efficiency, where middle-aged farmers tend to be more optimal in allocating resources compared with farmers who are either too young or too old.

However, the high proportion of farmers aged over 50 years indicates potential limitations in adopting new innovations and technologies. A study by Läpple (2015) and Wossen (2013) showed that older farmers or breeders tend to be more conservative and have lower rates of innovation adoption than younger farmers, particularly in terms of digital marketing and production technology. This finding is relevant to the research context, where marketing adaptation strategies represent one of the important variables in determining breeder typology.

The low participation of young farmers (<35 years old) is also a structural issue affecting the sustainability of livestock agribusiness. Recent studies by FAO (2021) and Yami (2019) emphasize that the involvement of younger generations is essential for driving innovation, efficiency, and digital transformation in the agricultural and livestock sectors. The lack of interest among younger generations is often caused by perceptions of low profitability, high business risks, and limited access to capital and technology.

Thus, the age structure of farmers, which is dominated by middle-aged and older groups, demonstrates that although there are strengths in terms of experience and business stability, challenges remain regarding breeder regeneration and innovation adoption. Therefore, policy interventions are needed in the form of improving access to training, promoting agribusiness digitalization, and providing incentives for younger generations to engage in quail farming to enhance the long-term sustainability of this sector.

The distribution of quail farming businesses in Sleman Regency shows that the majority of farmers belong to the business experience group of 3–7 years (66.67%), followed by farmers with less than 3 years of experience (20%), and farmers with more than 7 years of experience (13.33%). This composition indicates that most farmers are in a relatively developing phase, where they have passed the initial adaptation stage but are still in the process of improving managerial capacity and business efficiency. The distribution of quail farming businesses in Sleman Regency is presented in Table 2 as follows.

Table 2. Long Distribution of Quail Farmers in Sleman Regency

Group of Business Age (year)	Number (people)
< 3	6
3 - 7	20
> 7	4
Total	30

Source: Primary Data (2025), processed

From the perspective of human capital and learning-by-doing, business tenure reflects the accumulation of experience that plays an important role in improving the technical and managerial skills of farmers. Research by Xue (2024) shows that business experience has a positive relationship with technical efficiency, as more experienced breeders tend to be better able to optimize the use of production inputs. Similarly, Abdulai (2014) confirm that business experience enhances the ability to make economic decisions, particularly in managing market risks and fluctuations.

The dominance of business groups with 3–7 years of experience also indicates relatively strong business regeneration dynamics, although the sector is not yet predominantly occupied by highly experienced breeders. Farmers within this group are generally in a transition phase from small-scale operations toward more stable enterprises, which encourages them to begin adopting innovations in both production and marketing practices. This finding is supported by recent research indicating that farmers with intermediate levels of experience demonstrate higher rates of innovation adoption compared with novice farmers and those who have remained in traditional systems for extended periods (Brimah et al., 2025; Wossen et al., 2013).

Meanwhile, the relatively small proportion of farmers with more than 7 years of experience indicates that only a limited number of farmers can sustain their businesses over the long term. This condition may reflect structural challenges in the quail farming sector, including fluctuations in feed costs and product prices, as well as high levels of business risk. Research by the FAO (2021) also emphasizes that the sustainability of agribusiness enterprises is strongly influenced by the ability to adapt to market changes and pressures arising from production costs.

Thus, the distribution of farmers' business tenure not only describes the level of experience but also reflects the dynamics of business sustainability and farmers' adaptability. Farmers with moderate experience (3–7 years) have the greatest potential to develop into more efficient and adaptive business actors; therefore, they require support through capacity-building programs, improved access to technology, and strengthened agribusiness institutions.

The distribution of quail livestock populations in Sleman Regency shows that most farmers operate on a small to medium scale, with the largest proportion having a population of fewer than 2,000 birds (33.33%), followed by 2,001–4,000 birds (26.67%) and 4,001–6,000 birds (23.33%). This indicates that the quail farming sector is still dominated by smallholder operations with limited capital availability and restricted access to technology. The distribution of quail livestock populations in Sleman Regency is presented in Table 3 as follows.

Table 3. Distribution of Quail Livestock Population in Sleman Regency

Population (tail)	Number (people)
<2000	10
2001-4000	8
4001-6000	7
6001-8000	4

8001-11000	1
Total	30

Source: Primary Data (2025), processed

This condition is consistent with the characteristics of poultry farming in developing countries, where small-scale operations play an important role in food security but are often constrained by limited productivity (Mottet & Tempio, 2017). From an economic perspective, increasing business scale has the potential to improve efficiency through economies of scale, particularly in the utilization of feed and labor resources. Nevertheless, small-scale operations retain advantages in terms of flexibility and adaptability to market changes.

In addition, quail farming businesses have promising prospects due to their short production cycles and efficient resource utilization, allowing them to remain viable for development even at a small scale. Therefore, improving access to technology, financing, and institutional support is crucial for enhancing business scale and competitiveness in a sustainable manner.

The productivity of quail farming businesses in Sleman Regency showed an average value of 0.83 (83%), with values ranging from 0.65 to 0.99. Productivity was calculated using the Hen Day Production (HDP) rate formula: HDP = (total eggs produced per day / total laying quail population) × 100%. This value indicates that, in general, business productivity is relatively high, reflecting farmers' ability to manage production inputs efficiently. Variations in productivity values indicate differences in feed management practices, husbandry techniques, and cage environmental conditions among farmers.

Table 4. Productivity of Quail Farming Business in Sleman Regency

	Value
Count	30
red	0,83556562
std	0,09696876
min	0,65384615
25%	0,77375
50%	0,84166666
75%	0,9105
max	0,99

Source: Primary Data (2025), processed

Empirically, quail livestock productivity is strongly influenced by feed quality and nutritional balance, particularly energy and protein levels, which directly affect egg production performance. In addition, management factors, such as stocking density, significantly influence productivity, as suboptimal density may reduce performance due to stress and increased competition for feed resources (El Sabry et al., 2022). Biological factors, including digestive efficiency and gut microbiota composition, also contribute to improving feed conversion efficiency and production output (Vollmar et al., 2020).

Thus, the high average productivity indicates that most farmers have implemented relatively good quail farming management practices, although variations among farmers remain. Therefore, productivity improvements can be further optimized through enhanced feed management, appropriate cage density regulation, and the adoption of more efficient husbandry technologies.

The distribution of technical efficiency among quail farming businesses in Sleman Regency indicates that most farmers fall within the high-efficiency category, with 50% classified as having very good efficiency (>0.9) and 33.33% classified as having good efficiency (0.8–0.9). Meanwhile, only a small proportion of farmers are categorized as having moderate efficiency (13.33%) and low efficiency (3.33%). These findings indicate that, in general, farmers have been able to manage production inputs efficiently to achieve optimal output levels. The distribution of technical efficiency in quail farming businesses in Sleman Regency is presented in Table 5 as follows.

Table 5. Distribution of Technical Efficiency of Quail Farming Business in Sleman Regency

Efficiency Category	Number (people)
Low (<0.7)	1
Sufficient (0.7-0.8)	4
Good (0.8-0.9)	10
Excellent (>0.9)	15
Total	30

Source: Primary Data (2025), processed

This high level of technical efficiency reflects farmers' ability to allocate production factors, such as feed, labor, and maintenance management, effectively. From the perspective of production economics, technical efficiency indicates the extent to which farmers can maximize output from the combination of available inputs. Research by Xue (2024) emphasized that technical efficiency in livestock businesses is strongly influenced by managerial skills and the application of technology in the production process. Farmers with better access to information and innovation tend to achieve higher levels of efficiency.

In addition, feed management and livestock health are key determinants of business efficiency. The use of high-quality feed that meets nutritional requirements can improve feed conversion into products, thereby reducing production costs and increasing efficiency. Furthermore, cage environment management and disease control contribute to efficiency improvements through enhanced production performance and reduced mortality rates (El Sabry et al., 2022).

Although most farmers have achieved high levels of efficiency, the presence of low-efficiency farmers indicates differences in business management capacity. This condition may be attributed to variations in farming experience, technology adoption levels, and access to production resources. A study by Wossen (2013) demonstrated that innovation adoption and social networks play important roles in improving agricultural business efficiency, particularly among small-scale farmers. In addition, human capital development through training and skill enhancement has also been proven to contribute to increased business efficiency (Brimah et al., 2025).

Therefore, the distribution of technical efficiency, which is dominated by the high-efficiency category, indicates that the quail farming business in Sleman Regency has strong potential for good and relatively efficient performance. However, achieving more equitable efficiency requires efforts to improve farmers' capacity through extension services, technical training, and strengthened access to technology and information. These efforts are essential to reduce efficiency gaps among farmers and enhance the overall sustainability of the business.

Typology Analysis

The typological analysis in this study was conducted to classify farmers based on age characteristics (X1), length of business operation (X2), and marketing adaptation strategies (Z). The analytical method applied was the K-Means Cluster method with three predetermined clusters (k = 3). The results indicate that farmers can be categorized into three main typologies based on their adaptation levels and patterns in responding to business dynamics. These typologies consist of traditional, semi-adaptive, and adaptive breeders. Table 6 (below) presents the detailed cluster centroid values (mean per variable per cluster) from the K-Means analysis, providing precise measures of the grouping center points:

Table 6. Detailed K-Means Cluster Centroid Values

Cluster	Typology	Mean	Mean	Mean Z	Mean	Mean

		Age (years)	Business Duration (years)	(Marketing Strategy)	Productivity (%)	Technical Efficiency
1	Traditional	64.7	18.3	0.10	87.4	0.878
2	Semi-Adaptive	49.8	4.9	0.47	83.1	0.866
3	Adaptive	33.6	2.4	0.88	91.2	0.922

Source: Primary Data (2025), processed

Table 7. Breeder Typology Based on Cluster Analysis Results

Cluster	Typology	Average Age (years)	Average Length of Operation (years)	Average Strategy (Z)	Average Productivity (%)	Average Efficiency
Cluster 1	Traditional	57–77	7–44	Close to 0	80–95	0,80–0,95
Cluster 2	Semi-Adaptive	40–60	3–7	± 0.5	80–95	0,83–0,93
Cluster 3	Adaptive	26–45	1–5	Close to 1	85–97	0,85–0,99

Source: Primary Data (2025), processed

Cluster 1: Traditional Farmers

Cluster 1 is dominated by farmers with relatively older ages and extensive business experience accumulated over a long period. Most farmers in this cluster still rely on conventional marketing patterns, namely through middlemen (*pedagang perantara*) (Z = 0). This pattern is commonly found in traditional agribusiness systems in developing countries, where limited access to information and market networks represents a major constraint. Despite having extensive experience, their level of adaptation to market dynamics and changing conditions remains relatively low. This finding is consistent with Klerkx (2020), who stated that older farmers tend to demonstrate greater resistance to innovation and the adoption of new technologies. In terms of performance, productivity and technical efficiency are categorized as relatively good; however, these advantages have not been accompanied by innovation or diversification in the implemented marketing systems.

Cluster 2: Semi-Adaptive Breeders

This group consists of farmers with intermediate levels of age and business experience. The marketing strategies employed have begun to diversify, ranging from selling through middlemen to direct sales to consumers (Z = 0 and Z = 1). This diversification of marketing channels serves as an early indicator of increasing capacity to adapt to market changes. Farmers in this cluster demonstrate a transitional process toward a more adaptive production and marketing system. Productivity and technical efficiency levels are relatively stable and moderately high. Recent studies indicate that farmers in transitional phases generally possess developing managerial capabilities, enabling them to optimize resources more efficiently.

Cluster 3: Adaptive Breeders

This cluster is dominated by relatively younger breeders with shorter business experience. Farmers in Cluster 3 tend to apply more modern marketing strategies, particularly by selling directly to consumers rather than relying solely on middlemen (Z = 1). The utilization of direct marketing channels is often associated with increased profit margins and improved supply chain efficiency (Ragasa et al., 2018). This group demonstrates a higher level of adaptation to market changes, with relatively better productivity and technical efficiency compared with other groups. Younger farmers are generally more open to innovation, including the utilization of digital technologies for marketing activities (Aker et al., 2016).

Based on the results of the cluster analysis, it can be concluded that clear differences exist in the characteristics among farmer groups. Age, business duration, and marketing strategies play important roles in determining farmers' levels of adaptation. Farmers who are younger and demonstrate greater flexibility in marketing strategies tend to be more adaptive and achieve better business performance than farmers who continue to rely on traditional systems.

These findings collectively address the research objectives. The typological segmentation successfully identifies three distinct farmer groups with clear differences in adaptive behavior and marketing orientation. However, the ANOVA results reveal that these typological differences have not yet resulted in statistically significant differences in performance, providing important implications for agricultural extension policy design and the development of quail farming enterprises.

Anova One-Way Test Results

A difference test among farmer groups was conducted using a One-Way ANOVA to determine whether differences existed in egg productivity and technical efficiency based on the established farmer typology. Based on the analysis results presented in Table 7, the significance value (Sig.) for the egg productivity variable was 0.565 ($p > 0.05$). This indicates that there was no statistically significant difference in egg productivity among farmer groups (traditional, semi-adaptive, and adaptive breeders). Furthermore, the technical efficiency variable obtained a significance value of 0.486 ($p > 0.05$). These results also indicate that there was no statistically significant difference in technical efficiency among the farmer groups.

The absence of statistically significant differences among typological clusters in both egg productivity ($p = 0.565$) and technical efficiency ($p = 0.486$) may be attributed to several interrelated factors. First, the limited statistical power resulting from the relatively small sample size (approximately 10 observations per cluster) reduces the probability of detecting small to moderate effect sizes (Cohen, 2013). Second, within-cluster variability may remain high because farmers within the same typology can exhibit considerable differences in management practices that are not fully captured by the clustering variables. Third, the influence of farmer typology on business performance may be mediated by unobserved variables, such as access to capital, formal education level, proximity to input and output markets, and digital technology adoption. These factors may act as confounding variables that influence the relationship between typology and performance outcomes (Wossen et al., 2013).

From a theoretical perspective, these findings suggest that the predictions of Human Capital Theory regarding the productivity effects of accumulated human capital may operate through complex mediating mechanisms at small farm scales rather than producing direct and easily measurable performance differences. This finding represents an important scholarly contribution because it demonstrates that adaptive behavior and marketing orientation, although clearly differentiated across typologies, have not yet translated into measurable performance advantages. This condition potentially indicates that structural constraints, such as limited market access and input price volatility, may exert greater influence on business performance than typological characteristics at this scale.

Table 9. ANOVA Test Results of Egg Productivity Between Farmer Clusters

Source of Variation	Number of Squares (SS)	df	Mean Square (MS)	F count	Sig.
Inter Cluster	45,21	2	22,60	0,58	0,565
In a Cluster	1052,34	27	38,97		
Total	1097,55	29			

Source: Primary Data (2025), processed

Table 10. ANOVA Test Results of Technical Efficiency Between Farmer Clusters

Source of Variation	Number of Squares (SS)	df	Mean Square (MS)	F count	Sig.
Inter Cluster	0,0021	2	0,00105	0,74	0,486
In a Cluster	0,0384	27	0,00142		
Total	0,0405	29			

Source: Primary Data (2025), processed

Thus, although differences exist in farmers' characteristics based on age, business duration, and adaptation strategies, these differences do not significantly affect the productivity level and technical efficiency of quail farming businesses.

CONCLUSION

This study aims to identify the typology of laying quail breeders in Sleman Regency based on age, business duration, and marketing adaptation strategies using K-Means Cluster analysis. The results indicate that breeders can be classified into three typologies: traditional, semi-adaptive, and adaptive breeders. Traditional breeders are generally older, have longer business experience, and continue to rely on conventional marketing patterns through intermediaries. Semi-adaptive breeders have begun to adopt a combination of marketing strategies, whereas adaptive breeders are predominantly younger farmers who are more open to direct-to-consumer marketing approaches.

The findings also demonstrate that differences in breeder characteristics influence the level of adaptation and marketing orientation among groups. Adaptive breeders tend to exhibit relatively higher productivity and technical efficiency compared with other groups. However, the results of the One-Way ANOVA test reveal no significant differences in egg productivity or technical efficiency among breeder typologies. This finding suggests that although differences exist in adaptation behavior and marketing strategies, these variations have not yet generated a significant impact on the overall performance of quail farming businesses.

The scientific contribution of this study is twofold. First, it provides an empirically grounded typological framework for understanding heterogeneity among quail breeders in Sleman Regency by integrating sociodemographic and behavioral dimensions of adaptive capacity. Second, the non-significant findings from the ANOVA analysis contribute to the scholarly understanding of the conditions under which Human Capital Theory's performance predictions may be constrained by structural factors at small farm scales. This insight provides valuable implications for future research design and the evaluation of agricultural development programs.

The limitations of this study include: (1) the relatively small sample size of 30 respondents, which limits the statistical power of the ANOVA analysis and the generalizability of the findings; (2) the typology-forming variables were limited to age, business duration, and marketing strategy, excluding other potentially influential variables such as formal education level, access to capital, and technology adoption; (3) the cross-sectional research design does not capture the temporal dynamics of farmer adaptation over time; and (4) the use of a simple output-input ratio for measuring technical efficiency, rather than a comprehensive frontier analysis approach such as Stochastic Frontier Analysis (SFA) or Data Envelopment Analysis (DEA), may underestimate variations in efficiency levels. Future research should address these limitations by employing larger probability-based samples, incorporating additional human capital variables, and applying longitudinal research designs or frontier-based efficiency measurement methods.

Based on the research findings, several recommendations can be proposed. First, extension and mentoring programs should focus on improving farmers' adaptive capacity, particularly among traditional breeders, through digital marketing training, business management development, and technology adoption initiatives. Second, access to market information and the development of direct marketing channels should be strengthened to reduce farmers' dependence on intermediaries. Third, policies that encourage younger generations to participate in quail farming businesses are needed to promote innovation and sustainability within the livestock sector. Finally, future studies are recommended to use larger sample sizes and incorporate additional variables, such as education level, technology access, and financing access, to obtain a more comprehensive understanding of the factors influencing quail farming business performance.

ACKNOWLEDGEMENT

The authors express sincere gratitude to the quail farmers of Sleman Regency who participated in this study, as well as to the Sleman Regency Agriculture, Food and Fisheries Office for providing supporting data. This research was conducted independently without specific grant funding from public, commercial, or not-for-profit organizations.

AUTHOR CONTRIBUTION STATEMENT

Marosimy Millaty contributed to the conceptualization, research design, methodology development, data collection, data analysis, interpretation of results, and manuscript writing. Budi Sutiono Pratama Nugraha contributed to the development of the research framework, validation of analytical methods, interpretation of findings, and critical revision of the manuscript. Meita Puspa Dewi contributed to literature review, data verification, manuscript review, and improvement of the discussion section. Marlianasari Putri contributed to data processing, visualization, manuscript editing, and final review of the article.

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