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COMMERCIAL EFFICIENCY OF POULTRY ASSOCIATIONS IN CENTRAL ECUADOR

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SUMMARY
This study evaluated the efficiency according to the commercial structure of poultry associations located in the central area of Ecuador. It used the MICMAC method and Logit and Probit econometric models, using a sample composed of 213 poultry associations located in the province of Tungurahua. The results showed that the factors with the greatest impact on efficiency were the disinfection system for the entry of people to the farms and the correct use of biosecurity measures within the farm. These variables were directly linked to the commercial structure of each association, as they reflected the degree of organization, sanitary control and technical preparation existing in the marketing processes. These structural aspects showed that the strengthening of these practices boosted competitiveness and showed that the entities that adopted these mechanisms presented better economic performance, greater possibilities of trade integration and a solid participation within the regional agro-productive system. The research was framed in the field of economic and business sciences, with emphasis on agricultural commercial management, its contributions contributed with a direct basis to design strategies that supported competitiveness.

Keywords: Commercial efficiency, poultry, biosecurity, econometrics, competitiveness, agricultural management.

INTRODUCTION

In central Ecuador, poultry production is one of the main agricultural activities due to its impact on food security and its contribution to local economies. The province of Tungurahua stands out for concentrating a large number of poultry associations that supply the regional market. These organizations, made up of small and medium-sized producers, face challenges that weaken their sustainability and limit their ability to compete on equitable terms within the national market. According to the , the national poultry sector registered constant growth over the last three decades, with a production that exceeded 279 million chickens in 2019, a figure that reflects its strategic relevance in the agri-food system.(Corporación Nacional de Avicultores del Ecuador, 2021)

Faced with the current demand for products with certified quality and the tightening of sanitary standards, poultry associations require analytical instruments that facilitate the identification of strengths, weaknesses and internal structural relationships Pérez Ramírez et al., . The specialized literature highlights that technical assistance, systematic recording of production, and the adoption of biosafety protocols are closely related to organizational and commercial efficiency. These actions allow us to improve production and consolidate a commercial structure capable of meeting the traceability, safety and sustainability requirements demanded by the market.(2024)

In Latin America, recent studies have documented the usefulness of the MICMAC structural analysis as a tool to examine the influence of technical and organizational factors on complex production systems, by classifying components according to their level of influence and dependence. In turn, the Logit and Probit econometric models have been effective in evaluating links between variables and economic results in agricultural sectors, where many decisions are expressed in binary terms. In the Ecuadorian case, there is still little integration of both methodological approaches in research focused on poultry associations from a commercial perspective.

In this context, the purpose of this study is to analyze the commercial efficiency of poultry organizations established in the province of Tungurahua. To achieve this objective, the MICMAC method is applied in order to determine the structure of influence and dependence between the elements that make up the commercial system. In addition, the Logit and Probit models are used, supported by tools such as marginal effects and the ROC curve to establish significant relationships between variables and levels of commercial performance. This methodological strategy offers a comprehensive diagnosis that can serve as a basis for formulating proposals aimed at strengthening the competitiveness of the sector in central Ecuador.

The article is structured in six sections. In the introduction, the relevance of poultry farming in the central area of Ecuador is established and the objective of evaluating commercial efficiency based on its organizational structure is proposed. The literature review develops the main approaches on efficiency, commercial structure, distribution channels and studies related to poultry associations, with emphasis on rural contexts in the region.

The methodology is based on a quantitative approach, with an explanatory study and a non-experimental cross-sectional design. For the analysis, the MICMAC method is applied and econometric models such as Logit and Probit, marginal effects and Roc curve are used. The work uses an institutional database that includes 213 poultry associations. The results section presents the classification of variables according to their influence and dependence, as well as coefficients that show the impact of factors such as veterinary care and biosafety practices. In the discussion, these relationships are interpreted and compared with previous studies that identify the structural weight of these elements within the commercial system. Finally, in the conclusions, the fulfillment of the proposed objectives is ratified, the incidence of organized technical practices is recognized and institutional strengthening is proposed as a strategy to optimize the commercial performance of the poultry sector in the province of Tungurahua.

1 LITERARY REVIEW

Commercial efficiency

Commercial efficiency will be examined from various perspectives, influenced by approaches, including economic, structural and operational. Ramírez Méndez et al., argue that this behavior is related to the fulfillment of institutional objectives through the minimum use of resources. In this framework, technical efficiency consists of achieving maximum results with a limited amount of inputs. On the other hand, Janqui Esquivel and Segundo Valencia associate the concept with

productivity, pointing out that an effective entity transforms inputs by optimizing processes and minimizing losses. Sánchez Cruz et al., , suggest that, within the commercial field, an effective sales team achieves its goals through strategic coordination between marketing and customer management, with the support of technology and the control of indicators such as conversion rate or average closing time.(2021)(2022)(2025)

Efficiency will be analyzed from complementary approaches, depending on the field of study. Jaramillo Mejía and Manjarrez Fuentes explain that productive efficiency implies the optimal use of resources and the elimination of waste, which distinguishes competitive companies. On the other hand, Inzunza Mejía et al., define organizational efficiency as the ability of an institution to achieve strategic objectives with cost and time reduction, and integration of people, processes, and structures. Ventura Hernández et al., , incorporate control over the use of financial resources and their profitability. Finally, López Rodríguez et al., link commercial efficiency with the achievement of sales goals, through operational coordination, use of technologies and adequate management of human talent. (2025) (2024)(2024)(2025)

Indicators to evaluate commercial effectiveness

Business performance can be measured using quantitative and strategic indicators. Toapanta Cunalata identifies among the most relevant the conversion rate, the cost per customer and the duration of the acquisition cycle. Torres Briones et al. recommend complementing these metrics with others related to marketing and commercial management, such as team productivity and return on investment (ROI). For their part, Vásquez Liguicota y Flores Flores points out that, in small and medium-sized companies, the profit margin and inventory turnover are decisive in evaluating operational performance. These indicators provide insight into how business decisions affect institutional profitability.(2025)(2024)(2025)

Various internal and external factors influence commercial efficiency. Olmo Vera and Brusca Alijarde, highlight the role of staff training and the digitalization of processes in increasing productivity and reducing costs. According to Forneron Pedrozo and Villalba Chamorro, they state that performance improves when there is effective coordination between marketing and sales, supported by technologies that automate tasks. Monge García emphasizes that the organizational climate, motivation and incentives are decisive in the performance of the sales team. Taken together, these factors demonstrate that business effectiveness depends on strategic management of human capital and support systems.(2021)(2024) (2024)

Marketing of poultry products

Family production units in rural areas employ direct channels such as local markets, farm sales, and home deliveries, which will generate a strong connection with nearby consumers. This relationship strengthens consumer confidence by facilitating direct contact with producer Matte Martins et al., . In countries such as Cuba and others in South America, integrated systems from farm to distribution have strengthened commercial channels and improved traceability López et al., .(2021)(2022)(2020)

The adoption of technologies, cooperation with suppliers and a flexible operating structure will favor the optimization of distribution times and costs Zambrano Barcia et al., . Hernández Moreno and Vázquez Ruiz highlight the importance of digital marketing, the use of social networks and brand positioning to access expanded markets. Sánchez Cruz et al., point out that certain industries take advantage of the location of their plants and establish alliances with distributors to position themselves in the face of commercial opening, which strengthens both operational scale and logistics efficiency.(2023)(2020)(2025)

In Cuba, a price model based on profit margins has been applied to maintain competitiveness according to the target market Rojas Hernández et al., therefore, Mero Chávez et al., highlight that proper management adjusts prices according to internal costs, demand and regulations. Ventura

Hernández et al. analyze how, in open contexts, leading companies adapt their rates based on market information. Overall, the studies conclude that pricing in the poultry sector is based on marginal costs, competitive analysis, and regulatory adaptability. (2022)(2022)(2024)

Factors that affect commercialization (logistics, quality, demand, regulations)

Consumer acceptance of the product will depend on quality and post-production handling. Rodríguez Naranjo et al. mention health, safety and adequate distribution as factors that reduce losses in the value chain. On the other hand, Mendoza Vargas et al., indicate that logistics, and in particular temperature-controlled transport and traceability, is essential to maintain product freshness and reduce waste. In addition, Cortés Castillo et al. clarify that local demand is conditioned by price, confidence in national production and consumption habits, which affects both commercial strategies and sales volumes. Aguirre Henao et al. emphasize that compliance with health and food safety regulations is an essential requirement to access formal and export markets. (2025) (2023)(2025)(2025)

The scarcity of land in provinces such as Cotopaxi and Chimborazo will limit production, with family farming predominating as a source of income Salinas Bajaña et al.,. For their part, Tisalema Shaca et al., highlight the growth of the poultry industry in Tungurahua thanks to the infrastructure and road network available, which has boosted rural employment. Arévalo Ortiz et al., identify a solid network of family poultry production, supported by the genetic diversity of the Creole hen, distributed in Cotopaxi, Tungurahua, Chimborazo and Bolívar. (2025) (2024)(2025)

Poultry farming will play a fundamental role in the economy and food security of the center of the country. Pérez Ramírez et al., calculate that this sector contributes around 3% to the national GDP, generates more than 300,000 jobs and produces eggs and meat with a total value of 3,700 million dollars in 2021. Jerez Salas et al., recognize the genetic diversity of Creole hens, an essential poultry resource for sustainability and local production. In addition, Hortúa López et al. indicate that backyard poultry farming helps to supplement the food and income of rural families, especially in female-headed households, which is essential for food security in the central Sierra. (2024)(2025)(2022)

The poultry sector in the region faces several interconnected challenges and opportunities. Soto Arrieta and Flórez Acevedo mention the great genetic variability present in native birds, but they also warn about the decrease in this diversity due to the lack of programs for its improvement and conservation. Matabanchoy Tulcán et al., identify deficiencies in environmental management and waste management, which requires new regulations and improvements in technical practices. Barandica Hurtado et al. observe that the limited local production of inputs such as corn and soybeans increases costs and reduces competitiveness vis-à-vis neighboring countries.(2025) (2024)(2025)

Previous studies and research background

The economy of central Ecuador is based on family agriculture and livestock. Casas Cirón and Carvalho Iglesias, in Cotopaxi and Chimborazo small-scale production is common, where access to land and technology is limited, Pino Proaño et al., mention that Tungurahua is considered an important point for agribusiness, since it has good infrastructure and distribution routes. Soto Arrieta and Flórez Acevedo indicate that these provinces have a high concentration of local hens, which is linked to poultry farming and the economy of the region, the area combines family production with a growth in poultry farming.(2022) (2025)(2025)

Poultry farming plays an important role in the economy and food security of the central Sierra. Alvarado Vélez et al., point out that this sector provides more than 300,000 jobs in the country, with a significant presence in Tungurahua and Chimborazo. Yánez highlights the genetic importance of local hens in the region, which supports sustainable production. Cajilema Quijosaca et al. explain that, in rural areas, poultry farming contributes to family nutrition and economic

income. Overall, poultry farming has an impact on the economic, social and nutritional dimensions.(2025)(2025)(2025)
The poultry sector presents challenges, such as rising costs and poor environmental management. Paredes Cabezas et al. warn about dependence on imported inputs, such as corn, which increases prices. Fiallos Guerrero et al. point out deficiencies in waste management and sanitation in small farms. For their part, Hidalgo López et al., identify opportunities linked to genetic biodiversity and the increase in demand. Strengthening the sector requires investment in technology, regulatory adjustments, and conservation of native breeds.(2025)(2025)(2024)

2 METHODOLOGY

The research is aimed at establishing causal relationships based on the empirical analysis of quantifiable data. A quantitative approach of an explanatory type was applied, with a non-experimental cross-sectional nature. Under this approach, the relationships between variables without direct intervention were evaluated, based on information collected at a single point in time. This strategy allowed us to recognize key elements within the organizational and health management dynamics that characterize the poultry associations of the central zone of Ecuador, with special attention to the provinces of Tungurahua.

The level of commercial efficiency achieved by poultry farms depends to a large extent on technical conditions, applied sanitary practices and aspects related to their internal structure. Marmelstein et al. apply data envelopment analysis to evaluate the performance of productive units based on variables such as feed intake, mortality, final weight, age at slaughter and housing conditions. These variables make it possible to determine the rational use of resources and establish levels of efficiency according to internal control and technical organization. The analysis shows that commercial efficiency arises from the balance between infrastructure, health planning and operational capacity. This approach states that performance does not depend solely on the volume produced, but on structural coordination and compliance with established parameters. The combination of technical and health variables facilitates accurate measurement of performance. The incorporation of these elements strengthens decision-making in poultry systems with profitability and sustainability objectives.(2024)

The study was supported by a secondary database provided by Agrocalidad, corresponding to the 2023 Poultry Technical Cadastre. This official source integrated validated information from 213 organizations. Variables related to biosafety practices and organizational aspects were incorporated, such as veterinary assistance, presence of showers, cleaning of tools, use of lime, type of organization and technical training. All these variables were coded in binary format (1 = yes, 0 = no), which allowed their analysis using econometric models that use dichotomous responses, such as the Logit and Probit models.

The statistical analysis included estimates by logistic regression and cumulative probability, with the aim of determining the relationship between the independent variables and commercial efficiency, considered as a dependent variable. This analysis was complemented by the MICMAC structural approach, which allowed the variables to be classified according to their level of influence and dependence on the commercial system. The value of the log-likelihood (−65.251 and −40.908) evidenced an adequate adjustment, while the marginal effects facilitated the interpretation of the variation in the probability of efficiency against each variable.

Finally, ROC curves were generated to test the predictive capacity of the models, evaluated by means of sensitivity, specificity and area under the curve. The integration of these approaches facilitated a systemic interpretation of the behavior of poultry associations. Regarding the ethical criterion, the analysis used anonymized institutional data. The principles of confidentiality and

responsible use of information were respected, without compromising the identity of individuals or requiring informed consent.

3 RESULTS

This section presents the findings obtained from the analysis of the variables that make up the commercial structure of poultry associations, according to the information collected, key relationships are identified between the factors evaluated and their effect on the performance of the units. The evidence provides a clear understanding of the operation of the system, as well as the elements that determine its efficiency in the current context of the sector.

3.1. Diagnosis of the structure and commercial efficiency of the poultry sector in the central area of Ecuador.

Through the MICMAC method, it was possible to represent in detail the relationships between the most relevant organizational variables that affect the commercial efficiency of the poultry associations of Tungurahua. Through the influence matrices, it was possible to recognize the factors that have the greatest impact on the performance of the sector and that must be prioritized in strategic decision-making.

3.1.1. Identification of study variables

Based on the data obtained from the poultry registry, 8 variables are identified that are used within the MICMAC method, related to the commercial structure. The information detailed in Table 1 comes from an official source that supports the analysis carried out.

Table 1. Identification of variables related to the commercial structure

Number	Long Name	Short Name
1	The food is protected from the external environment	Alim_prot
2	Morbidity/Mortality Reports	Rets_salud
3	It has a record of feed consumption, water, production	Regis_consum
4	Does the farm use correct biosecurity measures in its opinion	Med_bioseg
5	Do you have a stamping plan?	Plan_sacri
6	The land has a location	Terreno_ub
7	Condition of the facilities	Estad_inst
8	The food is stored in	Alma_alime

Source: prepared by Karen Pilla and Denisse Pimbo (2025)

Figure 1. Direct Influence Matrix (MDI) of the commercial efficiency of poultry associations.

	1 : Alimt_prot	2 : Rets_salud	3 : Rgis_consu	4 : Med_bioseg	5 : Plan_sacri	6 : Terreno_ub	7 : Estad_inst	8 : Alma_alime
1 : Alimt_prot	0	3	3	3	1	3	2	2
2 : Rets_salud	3	0	3	3	1	3	2	2
3 : Rgis_consu	3	3	0	2	1	3	2	2
4 : Med_bioseg	3	3	2	0	1	3	2	2
5 : Plan_sacri	2	2	2	2	0	2	1	1
6 : Terreno_ub	3	3	3	3	1	0	2	2
7 : Estad_inst	2	2	2	2	1	3	0	1
8 : Alma_alime	2	2	2	2	1	3	1	0

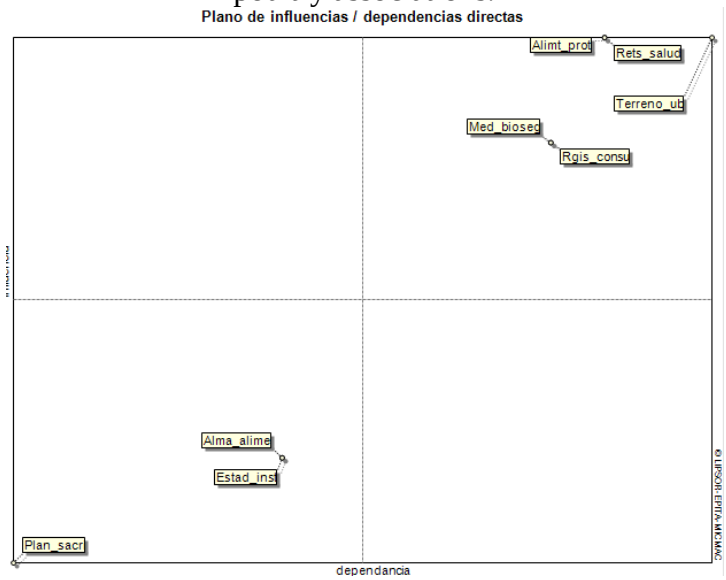
Source: prepared by Karen Pilla and Denisse Pimbo (2025). In original Spanish language

The 8 variables identified were evaluated for intervariable influence in an 8 x 8 matrix as can be seen in Figure 1. Influences range from 0 to 3, with the possibility of identifying potential influences of 0: No Influence, 1: Weak, 2: Moderate Influence, and 3: Strong Influence.

3.1.2. Understanding the relationship between variables

Once the 8 variables have been defined, a scheme is established that represents the relationship between the levels of influence/dependence of each element of the system, as can be seen in Figure 2.

Figure 2. Map of variables by direct influence/dependence on the commercial efficiency of poultry associations.



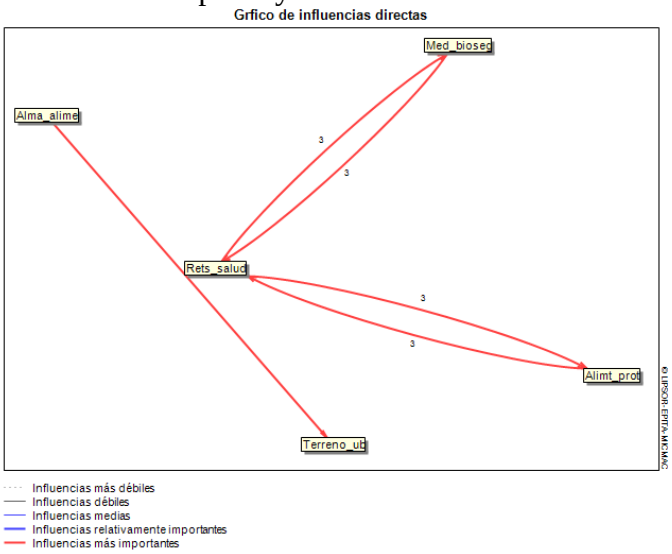
Source: prepared by Karen Pilla and Denisse Pimbo (2025)

The plane of direct influences/dependencies shows the distribution of factors in quadrants II and IV. It is observed that the second quadrant groups components with limited capacity on the

system, but presents a high dependence on others. In this section are (Regis_consum), (Med_bioseg) and (Terreno_ub), these elements depend on external conditions or planned actions, which reflects a sensitive structure exposed to changes in the environment. In the fourth quadrant, aspects with little structural weight are concentrated, that is, with a low level of influence and dependence, this group includes (Plan_sacri), (Estad_inst) and (Alma_alime), their position indicates that they do not play a determining role in the system nor are they affected, without the capacity to influence commercial efficiency or to receive impacts on other indicators. Other variables such as (Alim_prot) and (Rets_salud) reflect high levels of dependency without showing a relevant influence. This behavior suggests that they function as terminal outcomes, depend on the overall state of the system, and reflect its performance without any modification.

The observed configuration does not present variables with a dominant influence, this condition proposes the need to reinforce structural elements that boost commercial efficiency. According to Godet, he mentions that the absence of clearly driving components limits the ability to adapt and sustain efficient operation in the face of internal or external changes. (2005)

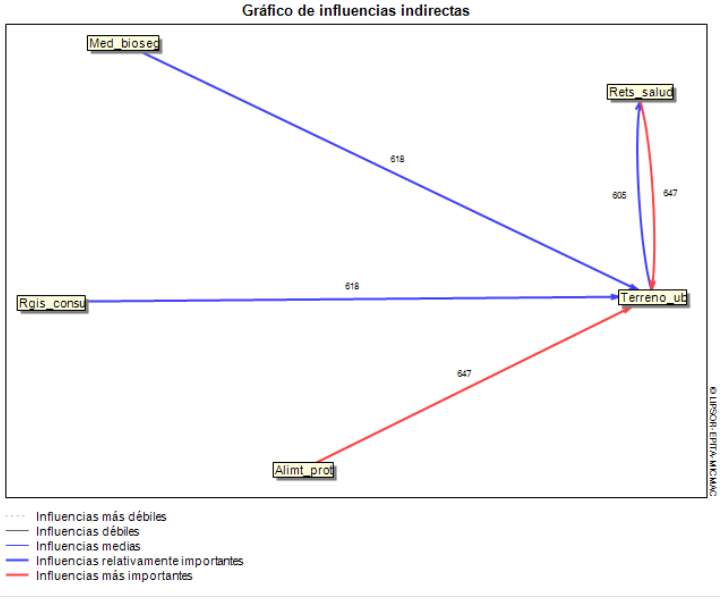
Figure 3. Relationship of direct influence between variables on the commercial efficiency of poultry associations.



Source: prepared by Karen Pilla and Denisse Pimbo (2025)

The graphical analysis of the direct influences shows the structural interaction between the key factors of the poultry trade system. The most important incidents, represented by red lines, indicate variables with a high capacity to modify the behavior of others. Among the factors with the greatest impact are (Med_bioseg), which occupies a key position as it directly affects (Alim_prot), (Rets_salud) and (Terreno_ub) which affects three strategic dimensions. This position highlights their role within technical and health management. On the other hand, (Alma_alime) and (Terreno_ub) have an impact on factors associated with health control and internal organization. These relationships reflect that certain basic conditions determine the quality of technical control, traceability and order of commercial processes.

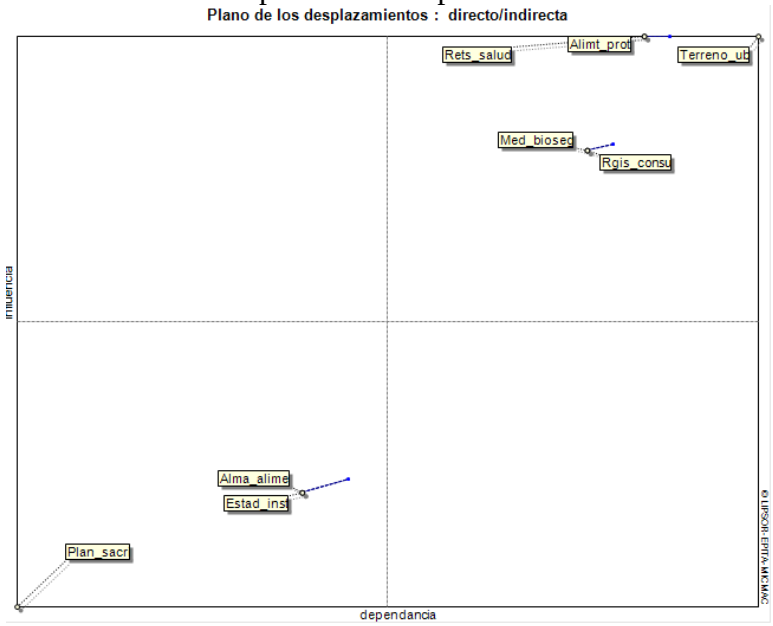
Figure 4. Relationship of indirect influence between variables on the commercial efficiency of poultry associations.



Source: prepared by Karen Pilla and Denisse Pimbo (2025)

The graph of indirect influences represents the non-immediate connections between the variables. The most marked trajectories indicate cumulative impacts, where certain elements, although not directly intervening, manage to modify other variables through chained effects. In this analysis, variable (Terreno_ub) is positioned as the most affected point, as it receives indirect influence effects from variables such as (Rets_salud), (Regis_consum) and (Med_bioseg), this reflects a high level of sensitivity to structural and health decisions. Evidence suggests that commercial efficiency is not only defined by direct relationships, but also by chained effects that are within the system, which allow identifying factors that guide decisions towards components with greater capacity to respond to complex scenarios.

Figure 5. Intervariable displacement map of direct and indirect influence



Source: prepared by Karen Pilla and Denisse Pimbo (2025)

The displacement plane indicates the variation that exists in the position of the variables when comparing direct and indirect effects. The dotted lines indicate a change in the position of

the variable, from the initial to the end, after considering the indirect influence, although most of the variables remain within the same quadrant, there are exceptions that present movements in their levels of influence or dependence. In this case, (Terreno_ub) is the variable that remains with the greatest structural weight, the behavior shows sensitivity to others, (Regis_consum) and (Med_bioseg), generate moderate changes.

The (Estad_inst) presents an increase in its influence, unlike (Alma_alime) and (Estad_inst) that retain a marginal role, that is, the final location reflects a limited participation in the dynamics of the system.

3.1.3. Mapping of factors influencing the efficiency and commercial structure of poultry associations

The results of the analysis allow us to establish key relationships between the variables that are part of the commercial structure of poultry associations. Direct influences show the incidence of health and operational aspects on the performance of the system, while indirect relationships reveal the scope of indicators that affect secondarily through chains of structural impact. The absence of a variable with a dominant influence highlights the need to consolidate internal components capable of acting as articulating axes of the commercial model. The behavior among the factors analyzed exposes a high dependence on their internal configuration, which is justified by the design of strategies focused on process control, structural articulation and the solidity of commercial performance.

Table 2. Structural classification of the variables analyzed

Number	Variable	Classification
1	The food is protected from the external environment	Variable that receives influence
2	Morbidity/Mortality Reports	Variable that receives influence
3	It has a record of feed consumption, water, production	Variable that influences and depends
4	Does the farm use correct biosecurity measures in its opinion	Variable that influences others
5	Do you have a stamping plan?	Variable with little influence and little dependence
6	The land has a location	Variable that receives influence and accumulates indirect effects
7	Estado_de_las_instalaciones	Variable with little influence and little dependence
8	The food is stored in	Variable with little influence and little dependence

Source: prepared by Karen Pilla and Denisse Pimbo (2025)

3.2. Estimation of probabilistic factors that determine commercial efficiency in poultry associations

The analysis of the Logit and Probit models allows us to understand the probabilistic behavior of commercial efficiency, through variables that, according to the MICMAC method, exhibit different degrees of influence and dependence. These conditions reveal the significance of factors and their

ability to operate as articulating axes within the network of commercial disclosures that make up poultry entities.

According to the results of the structural analysis, veterinary care, disinfection system and application of showers with change of clothes are located in areas with high relevance. This classification is validated by econometric models, where positive and significant coefficients are recorded, which confirms their status as strategic elements as observed in the Tabala3.

	LOGIT	PROBIT	LOGIT	PROBIT	LOGIT
	The food is protected from the external environment	Morbidity/Mortality Reports	It has a record of feed consumption, water, production	Does the farm use correct biosecurity measures in its opinion	Do you have a stamping plan?
Intercept	-1.424970 (1.160934)	-5.989655 (679.000959)	-18.661489 (2899.120083)	-0.950727 (0.660637)	-17.665768 (1762.674244)
Is there access to the information on the property by the owner?	-0.826189 (1.613811)	-1.943737 (773.022920)	-1.616003 (3369.022104)	-2.197554 (1.133954)	-1.116237 (2076.875536)
The farm has veterinary assistance	3.812073* (1.495675)	7.077663 (369.489231)	18.978668 (1716.220293)	1.203716 (0.781495)	15.228324 (1098.358367)
The water consumed by the animals comes from the drinking water network	0.185141 (1.426973)	0.508740 (0.696090)	0.450256 (1.221204)	0.560541 (0.617504)	0.448230 (1.148365)
Disinfection system for people entering farms	20.855763 (3420.987692)	1.164390** (0.441340)	2.061174** (0.720575)	1.812140*** (0.468668)	0.749301 (1.136805)
Showers and change	0.393057 (1.686255)	1.056004** (0.353549)	1.357510* (0.577129)	1.012060** (0.309380)	1.630135* (0.793376)

of clothes are used					
Log-likelihood	-11.326	-40.908	-60.860	-65.251	-112.426
N	213	213	213	213	213

Table 3. Estimation of the Logit and Probit models for variables associated with the commercial efficiency of poultry associations.

Source: prepared by Karen Pilla and Denisse Pimbo (2025)

3.3. Measuring the relative impact of variables on business efficiency and structure

Marginal effects allow us to understand how small variations in variables can influence the probability that a poultry organization will achieve certain levels of commercial efficiency. In this section, key indicators and ratios will be calculated using the antilogarithm, which will allow a better interpretation of the magnitude and effects of each variable on the performance of the sector.

3.3.1. Estimation and Interpretation

The interpretation of the Logit and Probit models was strengthened by the use of the antilogarithm applied to the estimated coefficients, which allowed the results to be expressed in terms of probability ratios for each independent variable. The analysis makes it easier to recognize which elements reflect the highest degree of incidence within the commercial structure of poultry associations. The individual result of each variable included in the estimate is presented below.

Variable 1. The food is protected from the external environment

Table 4. Estimation of ratios using variable antilogarithm 1

exp(coef(logit_Alimt.protected))					
(Intercept)	Acce.info	Veterinary Exhibition	Drinking water	Infancy	Showers and change
2.405156E-01	4.377141E-01	4.524415E+01	1.203388E+00	1.141676E+09	1.481502e+00
exp(coef(probit_Alimt.protected))					
(Intercept)	Acce.info	Veterinary Exhibition	Drinking water	Infancy	Showers and change
0.4244263	0.6458547	9.5212374	1.0923758	778.6421751	1.2547884

Source: prepared by Karen Pilla and Denisse Pimbo (2025)

The veterinary farm is significant: in the models analyzed within the Logit model, poultry farms that have professional control multiply by 45.11 the probability of keeping the feed in protected conditions. In the Probit model, the effect is evidenced by a 9.52-fold increase. The rest of the factors evaluated are not related to this condition, for this reason they do not contribute significance to the changes analyzed in the conservation of the food in relation to the environment.

Variable 2. Morbidity/Mortality Reports

Table 5. Estimation of ratios using variable antilogarithm 2

exp(coef(logit_Reporte.morbi))					
(Intercept)	Acce.info	Veterinary Exhibition	Drinking water	Infancy	Showers and change
6.595348E-09	9.254601E-02	3.292349e+08	2.794285e+00	7.195526e+00	7.574365e+00
exp(coef(probit_Reporte.morbi))					
(Intercept)	Acce.info	Veterinary Exhibition	Drinking water	Infancy	Showers and change
2.504529e-03	1.431679e-01	1.185196e+03	1.663194e+00	3.203967e+00	2.874861e+00

Source: prepared by Karen Pilla and Denisse Pimbo (2025)

The elements related to the disinfection of personnel and change of clothes show significance in both models. In Logit, disinfection increases the probability of registering morbidity or mortality by 7.19 times, while the use of showers by 7.57 times. In Probit, these factors increase the probability by 3.21 and 2.87 times. Other variables have no relevant relationship with this practice of health registration.

Variable 3. It has a record of feed consumption, water, production

Table 6. Estimation of ratios using variable antilogarithm 3

exp(coef(logit_Rgist.consum))					
(Intercept)	Acc.info	Veterinary Exhibition	Drinking water	Infancy	Showers and change
7.859922e-09	1.986913e-01	1.747152e+08	1.568714e+00	7.855190e+00	3.886504E+00
exp(coef(probit_Rgist.consum))					
(Intercept)	Acce.info	Veterinary Exhibition	Drinking water	Infancy	Showers and change
0.00356595	0.20414304	667.81251879	1.23107254	3.45133572	2.10217783

Source: prepared by Karen Pilla and Denisse Pimbo (2025)

Conditions related to staff hygiene, such as disinfection and changing of clothing, are important in the models examined. In the Logit model, the former increases the probability of retaining health records by 7.85 times, while the latter does so by 3.88 times. In Probit, these elements raise the probability by 4.11 and 2.49 times, respectively. No other significant variables are found for this document management.

Variable 4. Does the farm use correct biosecurity measures in its opinion

Table 7. Estimation of ratios using variable antilogarithm 4

exp(coef(logit_Medidas.bioseg))					
(Intercept)	Acce.info	Veterinary Exhibition	Drinking water	Infancy	Showers and change
0.19395919	0.02140774	7.52495950	2.77857880	22.89507727	6.20750253
exp(coef(probit_Medidas.bioseg))					
(Intercept)	Acce.info	Veterinary Exhibition	Drinking water	Infancy	Showers and change
0.3864601	0.1110745	3.3324778	1.7516190	6.1235363	2 2.7512639

Source: prepared by Karen Pilla and Denisse Pimbo (2025)

The evaluation of biosecurity measures is linked to personal disinfection practices. In the Logit model, the first variable increases the probability that the farm considers its preventive measures as adequate by 22.89 times, while the use of showers increases it by 6.21 times. In the Probit model, the effects are 6.11 and 2.75 times. No significant association with any other factor was found.

Variable 5. Does the farm use correct biosecurity measures in its opinion

Table 8. Do you have a stamping plan?

exp(coef(logit_Plan.sanitary))					
(Intercept)	Acce.info	Veterinary Exhibition	Drinking water	Infancy	Showers and change
2.127425e-08	3.275100e-01	4.107497e+06	1.565538e+00	2.115522e+00	5.104562e+00
exp(coef(probit_Plan.sanitary))					
(Intercept)	Acce.info	Veterinary Exhibition	Drinking water	Infancy	Showers and change
3.452389e-03	3.830445e-01	1.072850e+02	1.321336e+00	1.373265e+00	2.469771e+00

Source: prepared by Karen Pilla and Denisse Pimbo (2025)

The existence of veterinary care and personal hygiene practices are key to having a sanitary culling plan. In the Logit model, veterinary assistance increases the probability of having this plan by 4.11 million, while the use of showers increases it by 5.10 times. In the Probit model, the effect is more credible: 108 times with veterinarians and 2.92 times with the use of showers. In the Probit model, these values correspond to 107.80 and 2.92 times, respectively. The other variables do not show influence on this disposition.

3.4. Validation of the commercial efficiency model

The Hosmer-Lemeshow test allows to determine the goodness of fit of the applied Logit model. The null hypothesis (H_0) proposes a correct fit of the model against the observed data, while the

alternative (H_1) states the opposite. The result obtained within this research is seen in Figure 6 below.

Figure 6. Hosmer's test of the commercial efficiency model

```
        Hosmer and Lemeshow goodness of fit (GOF) test

data:  data$inlf, fitted(logit)
X-squared = 12.851, df = 8, p-value = 0.1171
```

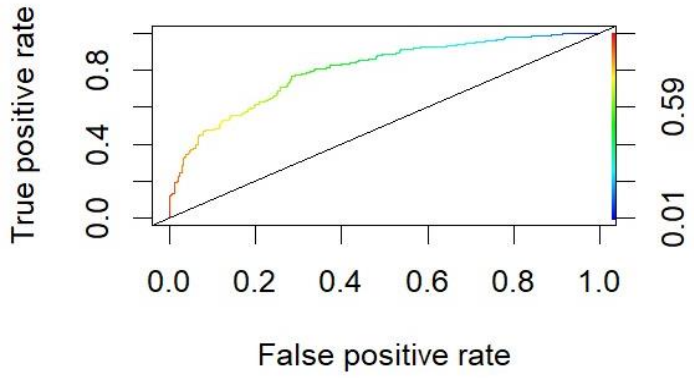
Source: prepared by Karen Pilla and Denisse Pimbo (2025)

Given that the P-Value value obtained (0.1171) exceeds the critical level of significance (0.05), the null hypothesis (H_0) is accepted, i.e. this approach has a correct goodness of fit and it is correct to use it. For this reason, the proposed Logit model meets the necessary criteria to explain the variables that establish a relationship with the commercial efficiency of poultry associations in the central area of Ecuador.

3.5. Determining the performance of the poultry sector

The ROC curve provides a detailed graphical representation of a model's ability to differentiate outcomes. This analysis provides a more accurate interpretation of the factors that affect the sector's performance.

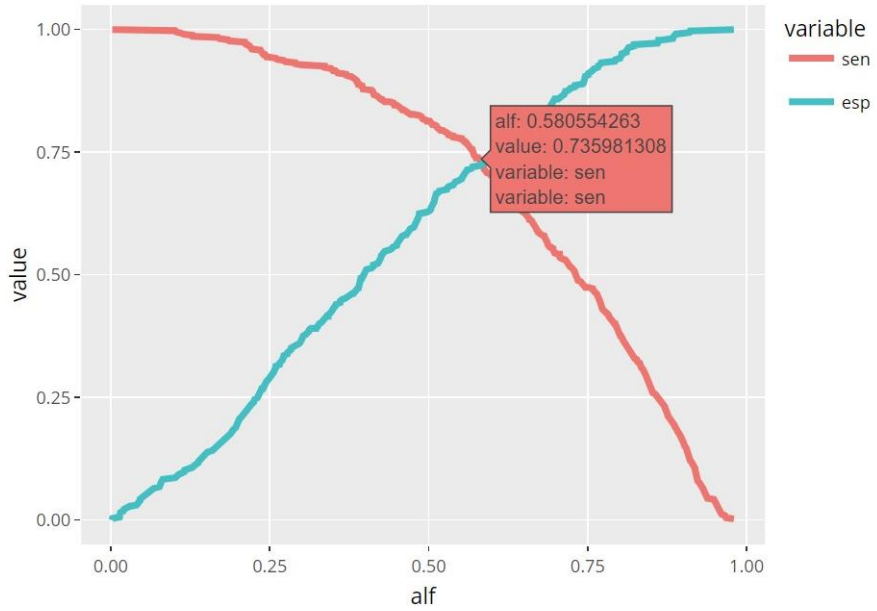
Figure 7. Roc curve applied for the evaluation of performance in the binary classification model in poultry associations.



Source: prepared by Karen Pilla and Denisse Pimbo (2025)

The ROC curve shows an adequate performance of the binary model used in the trading efficiency analysis. Their representation deviates from the diagonal of nondiscrimination, suggesting an ability to differentiate between associations with high and low levels of efficiency. This evidence supports the validity of the model as a tool to classify productive units in the poultry sector.

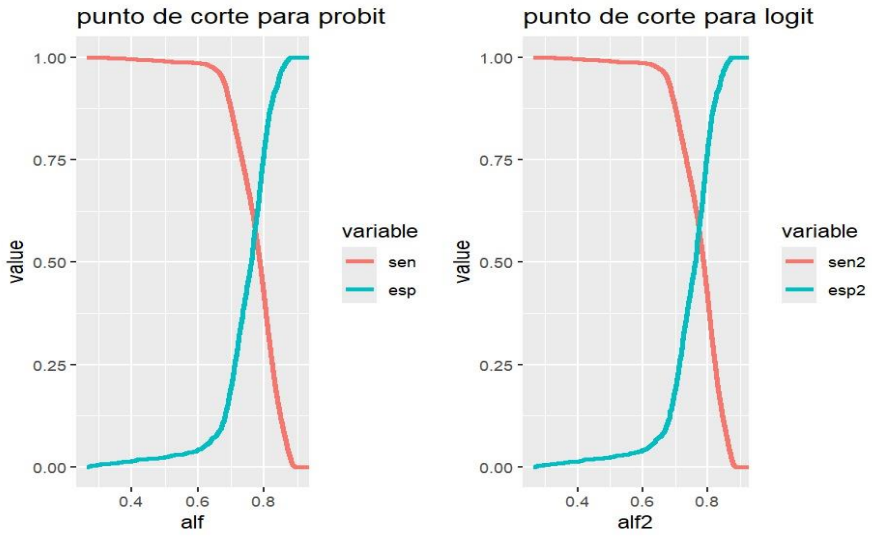
Figure 8. Estimation of the optimal cut-off point in the classification of variables associated with the commercial efficiency of poultry associations.



Source: prepared by Karen Pilla and Denisse Pimbo (2025)

The graph illustrates the threshold that maximizes the model's ability to classify correctly. This point allows for a balance of sensitivity and specificity, which benefits better decisions about which associations can be considered efficient. Identifying the optimal value helps to improve the practical usefulness of the model.

Figure 9. Comparative analysis of the optimal cut-off point in Probit and Logit applied to poultry commercial efficiency,



Source: prepared by Karen Pilla and Denisse Pimbo (2025)

The benchmarking between Logit and Probit shows a proximity between the estimated thresholds. The two models exhibit similar performance when it comes to ranking, although Probit has a more gradual curve that facilitates better handling of continuous variation in probabilities. This agreement strengthens the robustness of the analysis carried out on commercial efficiency.

3.5.1. Analysis of the determinants of the efficiency and commercial structure of poultry associations

The results reflected in the Logít and Probit models position viable veterinary care as the main technical determinant of commercial efficiency. Its effect was clearly reflected on components such as the application of biosecurity measures and food protection. On the other hand, disinfection and the use of showers show a relationship with technical controls and sanitary records with a lower structural weight, the rest of the elements did not show a significant association. The Hosmer-Lemeshow Test validated the Logít model, because the P-Value value exceeds the critical level of significance, while the ROC curve confirmed an adequate discriminant performance. In other words, the two tools present structural coherence in the classification, with adequate optimal thresholds. These findings show that efficiency responds to specific specific technical practices, without a structural articulation that coherently integrates the determining factors.

4. DISCUSSION

The results obtained in the development of the research show a commercial architecture with a high level of dependence, without elements with articulating capacity. Within the MICMAC structural model, a distribution of variables is observed within quadrants II and IV, which implies that there is a commercial configuration without driving components, where efficiency is subject to factors subordinated to external conditions. This condition is justified by Inzunza (2024), which establishes that organizational performance requires coherence between structure, processes, and available resources. Ramírez and Magaña (2021) agree that the lack of functional integration limits performance in associative systems. In the cases evaluated, a fragile operational base is observed, without sufficient conditions to sustain stable development in the face of changing environments.

The findings of the Logit model position veterinary care as the factor with the highest incidence, with a probability index of 45.11 on the willingness to protect the food. This condition responds to what was pointed out by Guevara and Mora (2025), who highlight the importance of sanitary and logistical control in the sustainability of production. The disinfection of personnel reaches a value of 7.19, while the use of showers and change of clothes presents a ratio of 5.10. These hygienic factors are related to key provisions, without being consolidated as part of a solid organizational structure. The rest of the variables do not reflect a significant association, which reaffirms that efficiency responds to specific technical practices. The statistical validity of the scheme is confirmed by the Hosmer-Lemeshow test ($p = 0.1171$). The ROC curve shows an adequate classification capacity, supported by an optimal cut-off point that allows associations to be identified according to their level of use. These elements reinforce the reliability of the results and their applicability in similar production contexts. However, the absence of integration between the parameters reveals a system that lacks strategic business planning, as Sánchez (2025) and Ramírez and Magaña (2021) warn, who point out that commercial efficiency requires structured coordination and optimal use of resources.

In the poultry context of central Ecuador, this evidence acquires relevance, where, according to Alvarado (2025), family production predominates, limited by infrastructure and access to technical services. In this scenario, efficiency arises from specific practices without structural support, which prevents the sustainability of competitive market processes. In addition, as Olmo and Brusca (2021) point out, the lack of integration between specialized training, technology, and

organizational management compromises the commercial performance of poultry units. Among the limitations of the study are the absence of financial, logistical, and internal governance variables, as well as the geographical restriction of the analysis. Based on these results, future research could incorporate dimensions related to strategic planning, associative leadership, and entry into formal markets.

5. CONCLUSIONS

The analysis developed reveals that commercial efficiency in poultry associations in the central area of Ecuador is not determined by an articulated organizational structure, but by the individual application of specific technical actions. The MICMAC model allowed us to identify a system with high dependence, lacking motor variables that dynamize its operation. In addition, the Logit and Probit models highlighted that veterinary care is the only factor with a strong influence on key health practices, while disinfection and the use of showers had a secondary impact. These revealed data validate the objectives of the research, since the existing internal configuration does not provide support for commercial success. In addition, the study supports its findings with rigorous statistical tests, such as the Hosmer-Lemeshow test.

The research provides a technical and empirical basis to improve decision-making in the agribusiness sector, highlighting the need to strengthen structural components that promote sustainable practices. Future studies should assess the impact of governance, collective participation and knowledge management, as well as incorporate financial, logistical and planning variables. In addition, it is recommended to extend the analysis to other regions with differentiated production dynamics to develop more robust models that boost the competitiveness of the Ecuadorian poultry sector.

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