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MULTI-FACTOR ANALYSIS OF PROFITABILITY DRIVERS OF LOCAL RABBIT PRODUCTION IN ZAMBOANGA PENINSULA REGION, MINDANAO, PHILIPPINES

Rovelito L. Narita

Department of Agribusiness, College of Business Administration, Jose Rizal Memorial State University, Tampilisan Campus, Tampilisan, Zamboanga del Norte, 7116 Philippines.

Abstract: Literature supporting empirical evidence on the financial viability of rabbit production in the Philippines is limited. This study was conducted to examine the profitability drivers of rabbit production in the Zamboanga Peninsula, focusing on its potential as a sustainable alternative to traditional livestock production, protein source and its capacity to augment household income. The research employed MRL (multiple linear regression) analysis to identify key factors influencing profitability, utilising a sample of 123 rabbit raisers randomly selected from the list in the Provincial Agriculture Offices. Data were collected during the first half of 2024 through personal interviews with the aid of an interview schedule validated by experts. Model specification was done to ascertain heteroscedasticity and multicollinearity issues in the data. The log-log model for expense categories and log-linear for profitability drivers having the lowest Akaike information criteria (AIC) were chosen for its better fit, providing a more accurate representation of the data. Results indicate that larger farms achieve significantly higher gross and net incomes, benefiting from economies of scale. Expense categories such as feed cost, veterinary expenses and labour costs positively and significantly influenced profitability, while outlay on utilities and cost of stocks negatively affected financial performance. The study also revealed that farming experience, feeds used, training attendance, breed type and marketing practices do not significantly influence profitability, implying that management practices and operational scale are more important considerations for rabbit profitability. Knowing the relationship and influence of these profitability drivers of rabbit production can help identify strategies to optimise returns, support the adoption of rabbit farming and improve the livelihoods of rural households in Philippines. The findings suggest the expansion of rabbit farming operations of up to more than 100 head per farm to optimise profitability.

Key Words: economies of scale, multiple linear regression, rabbit raising, profitability, Asia.

INTRODUCTION

In the Philippines, addressing poverty and ensuring food security remain significant challenges. Given its dense population and a significant portion residing in rural regions, securing access to nutritious food is imperative to enhance livelihoods and mitigate food insecurity (Bairagi *et al*., 2022).

As a response to the challenging impact of poverty, nutrition and the need for alternative protein sources, the Department of Agriculture (DA) has turned its attention to rabbit farming as a viable solution. The onslaught of African Swine Fever, which has significantly impacted the local pork industry, leading to soaring pork prices, heightened the urgency to explore alternative sources of meat and income for Filipino households (Gomez, 2024). Rabbit farming emerges as a promising avenue to address this pressing issue.

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The Department of Agriculture in their directives suggest Filipinos should venture into rabbit raising as an alternative source of income and protein. The agency's *MC No. 20 s. 2022* (Department of Agriculture, 2022) acknowledges the increasing interest of many Filipino farmers in raising rabbits for meat production due to the ease in propagation and minimal production costs and hence the agency has initiated efforts to support importation of rabbit breeding stocks.

The endeavour to explore alternative sources of income and food, such as rabbit farming, arises from various factors. Challenges like diminishing agricultural land, environmental limitations and the repercussions of natural calamities often impede conventional livestock production methods. As a result, households seek alternative avenues to augment their income while diversifying their food sources.

Rabbit farming has the capacity to contribute significantly to Sustainable Development Goals objectives such as reducing poverty, enhancing food and nutrition security, and ultimately striving towards the goal of zero poverty (United Nations, 2024)

The profitability of smallholder agribusiness ventures, particularly in the context of rabbit production, has garnered considerable scholarly attention worldwide. Studies such as those by Karikari and Asare (2009) provided an economic analysis of smallholder meat rabbit production in Ghana, highlighting that intensive breeding programmes could significantly enhance profitability, evidenced by a shorter payback period and increased annualised rate of return.

Wongnaa *et al.* (2023a) explored the viability of commercialising rabbit production, noting that commercialised rabbit producers in Ghana exhibited higher gross margins and net income compared to non-commercialised producers. This study also emphasised the integration of rabbit production with other enterprises and the importance of institutional support for market infrastructure and governmental policies. Complementing this, Mukaila (2023) investigated the economic performance of small-scale rabbit production in Nigeria, revealing that stock size, education and labour availability positively influenced profitability, while mortality and feeding costs were significant negative factors.

Adanguidi (2020) analysed the profitability and competitiveness of rabbit value chains in Benin, and found that processed rabbit meat was the most profitable and competitive, with feed outlay constituting a significant portion of production costs. Meanwhile, Paladan (2022) identified management practices as a critical component in rabbit farming in the Philippines, noting that inadequate knowledge and market reliability posed significant challenges.

The socioeconomic characteristics influencing rabbit production profitability were further examined by Adedeji *et al.* (2015) in Nigeria, who found a positive correlation between gross margin and years of experience, despite the constraint of an unreliable market.

Dionisio *et al.* (2023) highlighted the demographic characteristics and marketing practices of rabbit raisers in the Philippines, revealing that most of them sold live animals primarily at their residences during the pandemic due to safety related concerns. Wongnaa et al. (2023b) also investigated the welfare impacts of commercialising rabbit production in Ghana. Findings revealed that commercialisation led to increased household income and reduced food expenditure, though non-food expenditures were higher.

Zamaratskaia *et al.* (2023) underscored the potential of rabbit meat in maintaining food security in Ukraine, emphasising its efficient feed conversion and lower resource usage compared to traditional meats. However, Esmail *et al.* (2023) noted that consumer acceptability of rabbit meat in the Philippines was hindered by its limited market availability.

Ayeni *et al.* (2023) demonstrated the positive impact of rabbit production on rural household income in Nigeria, identifying factors such as age, extension interactions and credit access as significant determinants of income.

Despite these studies, a gap remains in empirical evidence regarding the profitability and sustainability of rabbit farming in the Philippines, particularly in the Zamboanga Peninsula Region. Understanding the specific drivers of profitability and the challenges faced by rabbit farmers in this region is essential for guiding policy interventions and supporting the growth of the industry.

To better understand the financial dynamics of rabbit farming, this study draws on the concept of economies of scale. Economies of scale refers to the cost advantages that enterprises gain as they increase their scale of operation, leading to lower per-unit costs (Smith, 1776, as cited in Samuelson & Nordhaus, 2010). Originally introduced by

Adam Smith in the Wealth of Nations through the pin factory example, the concept explains how increased production volumes can enhance profitability by spreading fixed cost over more units. The relationship is central to the profitability analysis in this study, as it examines how larger operations can achieve better economic outcomes.

In the case of rabbit farming, economies of scale can play a significant role in driving profitability. Larger farms are likely to benefit from various factors that reduce the average cost per unit of output, including fixed costs distribution, specialisation and efficiency, market access and bargaining power. Larger farms can spread fixed costs (e.g., housing, equipment) over a greater number of rabbits, reducing the cost per rabbit. Larger farms often have the advantage of purchasing feed and other inputs in bulk at lower prices. As farms increase in size, they may adopt more specialised production techniques and management practices that enhance efficiency and output. Larger operations might have better access to markets and greater bargaining power, allowing them to secure better prices for their products and inputs.

Recognising the imperative of addressing this need, this study is conceptualised to provide concrete insights into the profitability of rabbit farming for farmers and enthusiasts. It draws upon the experiences of rabbit raisers who participated as respondents, thereby contributing valuable empirical evidence to the scientific literature on rabbit production in the country. This study specifically addresses research questions such as: Which specific expense category in rabbit production exhibits the highest or has the most significant impact on profitability? Does profitability vary significantly among small, medium and large-scale production levels? How do various factors such as years of experience, rabbit breed, feed types, marketing practices and training attendance collectively impact profitability in the local rabbit production of Zamboanga Peninsula Region, Philippines?

MATERIALS AND METHODS

Study area

Zamboanga Peninsula, located in the southern part of the Philippines, comprises three provinces: Northern Zamboanga, Zamboanga Sibugay and Southern Zamboanga (Figure 1).

The region is characterised by a tropical climate, with significant rainfall throughout the year and a pronounced dry season. Agriculture is a major economic activity, with the region known for its diverse crops, predominantly rubber, coconut and rice (PhilAtlas, 2024). Livestock farming, particularly rabbit raising, is emerging as an important supplementary source of income for many households (Braganza, 2024). The area's population is predominantly rural, with a rich cultural heritage and a strong sense of community.

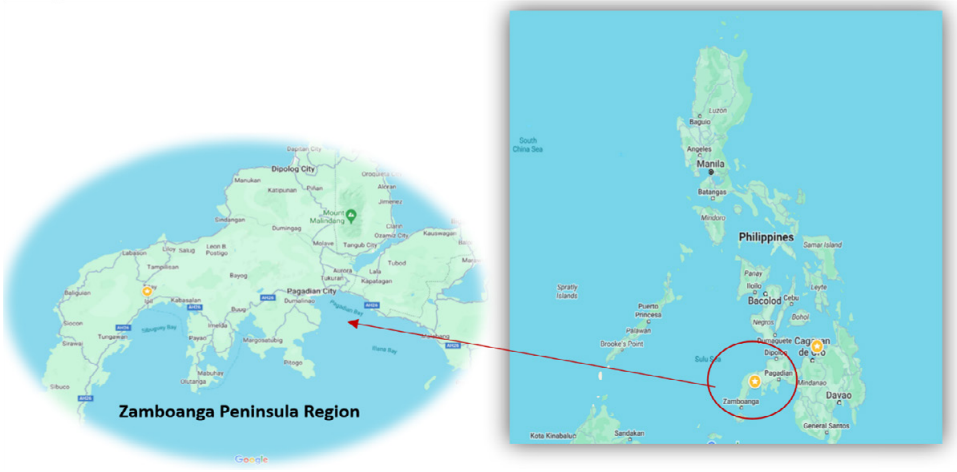

Figure 1: Map of Zamboanga Peninsula, Philippines (Google Maps, 2024).

Sampling procedure and data collection

The study employed a multi-stage random sampling technique, obtaining 123 rabbit raisers as respondents from the top 5 producing municipalities among the three provinces of the region. Sample size was determined using Cochran's formula. Participants were located through coordination with local agricultural offices and barangay (neighbourhood) key informants, usually the barangay or village officials. They were reached personally in their homes and in their farms. Data gathering occurred from January to May 2024.

The interviews were conducted using a pre-structured questionnaire, which was validated by experts in the field to ensure its relevance and inclusiveness in capturing the necessary information regarding rabbit production. The questionnaire was divided into two main sections. The first section collected data on the respondent's socioeconomic and demographic characteristics, including age, gender, education level, household size and income source. The second section focused on the financial aspect of rabbit production, where respondents provided detailed information on cost incurred (such as feed, labour and veterinary expenses) and returns derived from rabbit raising. For the financial data, respondents were asked to recall their cost and revenues from the last six months, ensuring that information gathered reflected recent and relevant experiences.

Participation in the study was voluntary and informed consent was obtained from all respondents prior to their inclusion. Respondents were assured of anonymity and confidentiality of their responses and data were collected and handled in accordance with ethical standards to protect the privacy and rights of the participants.

Data treatment

Expense Category

Profitability is analysed using several financial metrics like Net Profit, Gross Profit Margin, Return on Investment (ROI), and Per Unit Profit. These metrics were chosen to capture different aspects of profitability, to provide a detailed picture of the economic health and efficiency of rabbit raising.

Net Profit was calculated as the difference between total revenue and total expenses, reflecting the actual profitability after accounting all the costs. Gross Profit Margin is the percentage of revenue that remains after subtracting the variable costs (i.e., feed, veterinary expenses and labour), indicating how efficiently the operation generates profit from its income. ROI measured the profitability of the investment in rabbit raising, indicating how well the investment was utilised to generate profits. Per Unit Profit calculated the profit generated per rabbit, helping to understand profitability at a micro-level.

To determine the impact of each expense category on profitability, MRL analysis was employed. This statistical technique allows for estimation of the relationship between the dependent variable (profitability) and multiple independent variables (expense categories).

The original regression model is expressed as follows:

$$\begin{aligned}\text{Profitability}=&\beta_0+\beta_1\,\textit{Feed Costs}+\beta_2\textit{Cost of Stocks}+\beta_3\textit{Veterinary Exp}+\beta_4\textit{Infrastructure Invt}+\\&+\beta_5\textit{Labour Costs}+\beta_6\textit{Transpo Exp}+\beta_7\textit{Utilities Exp}+\varepsilon\end{aligned}\quad(1)$$

where: β_0 is the intercept; $\beta_{1...7}$ are the coefficients for each expense category; and ε is the error term.

Determinants (Drivers) of Profitability

The dependent variable in this study, profitability, is a continuous variable representing the net profit from rabbit production. The independent variables were treated as follows:

Production level. A categorical variable which was divided into three categories based on the number of rabbits raised: small farms (<50 head), medium farms (51-100 head), and large farms (>100 head). This categorisation allowed for the analysis of profitability across different scales of production.

Years of Experience. This continuous variable captured the number of years the farmer had been involved in rabbit raising, providing insight into how experience impacts profitability.

Breed Type. This categorical variable was coded to reflect different breeds of rabbits raised, such as 1 for New Zealand White, 2 for American Chinchilla; 3 for Satin Rabbit; 4 for Flemish Giant; 5 for Champagne d'Argent. This coding facilitated the examination of breed-specific effects on profitability.

Feeds Used. Various feed types used by the farmers were categorised, such as 1 for commercial pellets; 2 for forages or cut and carry; 3 for combination. This is to analyse their impact on production efficiency and profitability.

Marketing Practices. Different methods used for marketing rabbit products were categorised, such as 1 for Relationship Marketing/word of mouth; 2-Direct selling; 3- Buyer contact (physical), 4- Internet/Social Media Marketing; to assess how marketing strategies influence profitability.

Training Attendance. This categorical variable indicated whether the farmer had attended any training sessions on rabbit production (coded as 1 for Yes and 0 for No), allowing for the analysis of the effect of training on rabbit profitability.

The original regression model is expressed as follows:

$$\text{Profitability}=\beta_0+\beta_1 \textit{Production level}+\beta_2 \textit{Years of Raising Rabbit}+\beta_3 \textit{Breed Type}+\beta_4 \textit{Feeds used}+\beta_5 \textit{Marketing Practices}+\beta_6 \textit{Training Attendance}+\varepsilon \quad (2)$$

where: β_0 is the intercept; $\beta_{1\ldots6}$ are the coefficients for the determinants of profitability; and ε is the error term.

Model specification for expense categories and profitability

The primary statistical analysis used in this study was MRL (multiple linear regression), which allowed assessment of the impact of various independent variables on the dependent variable, profitability.

To ensure the robustness and validity of the regression model, the researcher explored four functional forms: linear, log-linear, linear-log and log-log models. These different functional forms were tested to determine the best model specification. The selection criteria for the best model included adjusted R^2, mean squared error (MSE), log-likelihood ratio and Akaike information criteria (AIC).

Based on these criteria, the log-log model was identified as the best model to use. The log-log model had the lowest AIC value, and log-likelihood suggesting it provided the best fit for the data among the four functional forms. Although the adjusted R^2 was not the highest, the log-log model resolved issues of heteroscedasticity and multicollinearity better than the other models. The significant *P*-values from the F-test also indicated that the model was statistically significant (Table 1).

The transformed MRL model is based on the log-log model and is hence used in the discussion of results and is specified below:

$$\text{Log(Profitability)}=\beta_0+\beta_1 \textit{log(Feed Costs)}+\beta_2 \textit{log (Cost of Stocks)}+\beta_3 \textit{log (Veterinary Exp)}+\beta_4 \textit{log (Infrastructure Invt)}+\beta_5 \textit{log (Labour Costs)}+\beta_6 \textit{log (Transpo Exp)}+\beta_7 \textit{log (Utilities Exp)}+\varepsilon \quad (3)$$

where: Log (Profit)- is the natural logarithm of the variable profit; β_0 is the intercept; $\beta_{1\ldots7}$ are the coefficients for the determinants of profitability; and ε is the error term.

Table 1: Comparison of model fit statistic using the four functional forms on the expense categories of rabbit production, Zamboanga Peninsula, 2024.

Model fit measures	Linear-linear model	Log-linear model	Linear-log model	Log-log model
Adjusted R^2	0.912	0.344	0.580	0.485
F-test (prob>F)	0.00	0.00	0.00	0.00
MSE	6647.1	0.882	14475	0.780
Heteroscedasticity (hettest)	0.000	0.656	0.000	0.740
Multicollinearity (VIF)	4.89	4.93	3.10	3.09
Log-likelihood	–1253.03	–118.68	–1348.75	–107.13
AIC values	2522.062	253.368	2713.508	230.250

MSE: mean square error; VIF: variance inflation factor; AIC: akaike information criterion.

Model specification for profitability drivers

In analysing the profitability drivers, independent variables included both continuous and categorical variables, such as farm size, years of experience, breed type, feed types, marketing practices and training attendance. Since most of these regressors are categorical variables, model transformation using the different functional forms is not applicable.

Upon examining feasible functional forms, the log-linear model exhibits a significantly higher adjusted R^2 of 0.61 compared to 0.26 for the linear-linear model, indicating its superior ability to explain the variance in profitability. Additionally, the log-linear model demonstrates a substantially lower MSE of 0.68 compared to 19172 for the linear-linear model, signifying its better predictive accuracy. The higher log-likelihood value of –94.44 for the log-linear model, in contrast to –1383.85 for the linear-linear model, further supports its superior fit to the data.

Moreover, the multicollinearity issue was assessed using the variance inflation factor (VIF), and the Breusch-Pagan test for heteroscedasticity. The log-linear model effectively addresses heteroscedasticity, as indicated by the non-significant *P*-value of 0.89 for the heteroscedasticity test, whereas the linear-linear model exhibits significant heteroscedasticity.

Heteroscedasticity refers to the problem where the variance of the residuals is not constant across all levels of the independent variables. This can lead to inefficient estimates and affect the validity of hypothesis tests. To address this issue, the profitability data was transformed using a log-linear model. This transformation helps stabilise the variance and improves the model fit and statistical power, making the regression results more reliable and interpretable (Gujarati, 2021).

Lastly, the log-linear model boasts a substantially lower AIC value of 202.87 compared to 2781.71 for the linear-linear model, suggesting a better balance between model fit and complexity. Consequently, considering these comprehensive evaluations, the log-linear model emerges as the preferred choice for the final model specification. The comparison of model fit statistics using linear and log-linear functional forms for profitability drivers of rabbit production is shown in Table 2.

The transformed MRL model is specified as follows:

$$\text{Log (Profitability)}=\beta_0+\beta_1 \textit{Farm Size}+\beta_2 \textit{No of Years Raising Rabbit}+\beta_3 \textit{Breed of Rabbit}+\beta_4 \textit{Feeds Used}+ \beta_5 \textit{Marketing Practices}+\beta_6 \textit{ Training Attendance}+\varepsilon \quad (4)$$

where: Log (Profit) is the natural logarithm of the variable profit; β_0 is the intercept; $\beta_{1...7}$ are the coefficients for the determinants of profitability; and ε is the error term.

After the transformation, the model obtained a X^2=0.02 and (P<0.89) indicating that the heteroscedasticity issue was resolved.

The analyses were carried out using Stata 18.0 software.

Table 2: Comparison of model fit statistic using linear and log-linear functional forms for profitability drivers of rabbit production, Zamboanga Peninsula, 2024.

Model fit measures	Linear-linear model	Log-linear model
Adjusted R^2	0.26	0.61
F-test (prob>F)	0.00	0.00
MSE	19172	0.68
Heteroscedasticity (hettest)	0.00	0.89
Multicollinearity (VIF)	1.05	1.07
Log-likelihood	–1383.85	–94.44
AIC values	2781.71	202.87

MSE: mean square error; VIF: variance inflation factor; AIC: akaike information criterion.

RESULTS AND DISCUSSION

Demographic characteristics of rabbit raisers

Rabbit raisers in the area are dominated by a young population, with 68.3% being 35 yr old or younger. This is followed by 13.8% aged between 56 and 65 yr, and a very small proportion of 0.81% aged above 66 yr (Table 3). This trend towards youth involvement in rabbit farming aligns with findings from Mukaila (2023) in Nigeria, where a significant portion of rabbit farmers were also found to be in their early adulthood, attracted by the relatively low capital investment required and the potential for quick returns. Similarly, Chiron *et al.* (2022) found that younger French rabbit farmers are more inclined to adopt innovative and pro-welfare practices compared to their older counterparts. This finding highlights how age influences not only the decision to enter rabbit farming but also the willingness to embrace new and improved practices, indicating that younger farmers are often more open to change and innovation in their farming methods.

Gender distribution shows a higher number of male respondents, with 61.8%, compared to 38.2% female. This is consistent with the gender dynamics observed in similar studies across various countries. For instance, Adedeji *et al.* (2015) noted that men were more likely to be engaged in rabbit farming in Nigeria, a trend that may be attributed to traditional gender roles in agriculture. However, the relatively significant participation of women (38.2%) in this study signifies the potential gender-inclusive development in the rabbit farming sector.

Marital status revealed that 64.2% of rabbit raisers are married, while 34.2% are single. Only a small fraction is widowed (1.6%). Ayeni *et al.* (2023) in Nigeria, has a similar finding that married individuals were more engaged in smallholder rabbit farming. This could suggest that married individuals see rabbit farming as a stable source of additional household income.

The majority of rabbit raisers come from small households, with 73.2% having 1 to 3 members, 21.9% having 4 to 7 members, and only 4.9% belonging to larger households of 8 to 10 members. This contrasts with studies from other regions such as Wongnaa *et al.* (2023), where larger household sizes were common among rabbit farmers.

Educational attainment among rabbit raisers is relatively high, with 55.3% college graduates and 27.6% having attended some college. Only a small portion have completed high school, with 10.57% high school undergraduate and 4.1% high school graduates. This suggests that rabbit raisers in the study area are generally well-educated, in contrast to the findings of Karikari and Asare (2009) that a significant number of rabbit raisers had a lower educational level.

Experience in rabbit raising ranges from having 1 yr or less with 47.2, 43.9% with 2-3 yr, and only 8.9% having 4-5 yr of experience. This indicates that many rabbit raisers are relatively new to the activity. This is consistent with Paladan (2022), where many rabbit farmers in the Philippines were found to be new to the activity, possibly due to the growing awareness and promotion of rabbit farming as an alternative livelihood. The low experience levels imply the need for training and capacity building to improve productivity and profitability.

Membership in organisations is notably low, with only 14.6% belonging to a group. This is also true in the northernmost part of the Philippines, as noted by Dioniso *et al.* (2023). The lack of organisational involvement could limit access to resources, market opportunities and collective bargaining power, which are crucial for scaling up operations and enhancing profitability.

When it comes to breeds, the New Zealand White utilised primarily for meat production is the most popular, raised by 68.3% of the respondents. Other breeds include American Chinchilla (6.5%), Satin Rabbits (4.1%), Flemish Giants (4.9%), and Champagne d'Argent (8.1%). This diversity in breeds indicates a mix of purposes, including both meat production and pet markets.

The experimental findings of Fadare and Fatoba (2018) indicate that the New Zealand White and Havana Black breeds are particularly advantageous in humid tropical environments, demonstrating superior reproductive traits compared to the Californian and Palomino Brown breeds. Understanding breed-specific performance can help in making informed decisions regarding breed selection and programme implementation that would be best suited in local conditions in tropical regions like the Philippines.

Table 3: Demographic characteristics of rabbit raisers, Zamboanga Peninsula, Philippines, 2024 (n=123).

Characteristics	Frequency (f)	Percentage (%)
Age		
1- 35 years and below	84	68.29
2- 36 to 45 yr	9	7.32
3- 46 to 55 yr	12	9.76
4- 56 to 65 yr	17	13.82
5- 66 yr and above	1	0.81
Sex		
1- Male	76	61.79
2- Female	47	38.21
Marital status		
1- Single	42	34.15
2- Married	79	64.23
3- Widow(er)	2	1.63
Household size		
1- 1 to 3 members	90	73.17
2- 4 to 7 members	27	21.95
3- 8 to 10 members	6	4.88
Educational attainment		
1- Elementary graduate	3	22.44
2- High School undergraduate	13	10.57
3- High School graduate	5	4.07
4- College undergraduate	34	27.64
5- College graduate	68	55.28
No. of years raising rabbit		
1- 1 yr or less	58.	47.15
2- 2-3 yr	54	43.90
3- 4-5 yr	11	8.94
Organisation membership		
1- Member (with)	18	14.63
2- Not a member (without)	105	85.37
Breeds raised		
1-New Zealand White	84	68.29
2- American Chinchilla	8	6.50
3- Satin Rabbits	5	4.07
4- Flemish Giants	6	4.88
5 -Champagne d'Argent	10	8.13
Average area used for rabbit production		
1- 100 m^2 and below	99	80.49
2- 101 m^2 to 250 m^2	6	4.88
3- 251 m^2 to 500 m^2	6	4.88
4- 501 m^2 and above	12	9.75
Income source		
1- Wage/salary	46	37.40
2- Property income	24	19.51
3- Farm income	50	40.65
4- Pension	3	2.44
Trainings attended on rabbit production		
1- None	99	80.49
2- DA/govt agency sponsored	4	3.25
3- YouTube	15	12.20
4 - Facebook	5	4.07

DA: Department of Agriculture.

Regarding the area utilised for rabbit production, 80.5% of raisers use spaces of 100 m^2 or less, while only small percentages use larger areas: 4.9% for both 101-250 m^2 and 251-500 m^2, and 9.8% for 501 m^2 and above. This implies that most rabbit farming operations are relatively small-scale. This is comparable to findings by Adanguidi (2020) in Benin, where small-scale production was also prevalent. Small-scale operations could imply limited production capacity, but they also entail easier management and lower overhead costs, which are critical factors for new or resource-constrained farmers.

Income sources among rabbit raisers are diverse, with 40.7% relying on farm income, 37.4% on wages or salaries, 19.5% on property income and 2.4% on pensions. This means that rabbit raising is often supplemented by other income streams or an additional or alternative source just like in Ghana, as reported by Wongnaa (2023b), where rabbit farming is often supplemented by other income stream.

Training attendance related to rabbit production is low, as 80.5% of respondents have no formal training. A small portion has received training from government agencies such as the Department of Agriculture (3.3%), while others have turned to YouTube (12.2%) and Facebook (4.1%) for information. This is a common issue in many developing regions, as mentioned by Zamaratskaia *et al.* (2023) in Ukraine, where lack of formal training was a significant barrier to productivity. The critical need for formal training programmes is evident, as they are essential for improving rabbit farming practices and profitability, particularly in regions where rabbit farming is still emerging as a mainstream agricultural activity.

Cost and return analysis

Table 4 presents a comparison of the profitability across farms sizes: small (less than 50 head), medium (51-100 head), and large (greater than 100 head). Gross income, expenses, net income, gross profit margin, returns on investment and per unit profit are scrutinised to determine trends in profitability among these categories.

Table 4 illustrates that as farm size increases, so does gross income. Large farms boast significantly higher gross income figures compared to their smaller counterparts, indicative of their larger-scale operations and sales volumes. This points to the potential advantages of scale in generating revenue within the agricultural sector.

Table 4: Average cost and return analysis of rabbit raising across farms in Php (1 PHP=0.016 EUR), Zamboanga Peninsula, Philippines, 2024 (n=123).

Particulars	Small farms (<50 head) (n=74)	Medium (51-100 head) (n=44)	Large farms (>100head) (n=5)
Gross income	10 872.87	30 961.52	155 160.10
Less: (Expenses)			
Cost of stocks	3383.03	11 545.45	33 000.00
Feed cost	1189.26	3794.57	11 900.00
Veterinary expenses	307.78	529.84	2100.00
Transport expenses	399.80	342.50	1180.00
Labour cost	3600.00	3600.00	23 240.00
Infrastructure expenses	345.14	463.47	2760.00
Utilities	189.18	309.81	1090.00
Total cost	9414.19	20 585.64	75 270.00
Net income (Profit)	1458.69	10 375.86	79 920.10
Gross Profit Margin	1803.82	10 839.35	82 650.10
Returns on Investment (%)	13.42	33.51	51.51
Per Head Profit	145.87	207.52	799.20

These findings align with the research by Tey and Brindal (2015), which states that larger operational scales and greater operational efficiency positively impact farm profitability. The study highlights that farms leveraging economies of scale and enhancing input-output efficiency tend to be more profitable. This is evident in the higher gross income reported for larger farms in this study, which suggests that scaling up operations provides tangible financial benefits and underscores the advantages of larger-scale agricultural practices in achieving improved revenue outcomes.

Moving on to expenses, it becomes evident that larger farms incur substantially higher costs across various categories such as stocks, feed, labour and infrastructure. This is expected, as larger operations require more resources and infrastructure to maintain and expand production. Despite these elevated costs, large farms manage to maintain higher net incomes, underscoring their ability to effectively manage expenses and generate considerable profits.

Moreover, this corroborates the findings of Scialfa *et al.* (2022) in Argentina, which revealed that while small-scale operations can contribute to farm diversification and income, they often face significant economic challenges. The low profit margin per rabbit, as evidenced by the mere USD 0.06 per animal, stresses the importance of achieving higher productivity and better feed efficiency to enhance profitability. This reinforces the idea that while both large and small-scale operations have the potential for profitability in rabbit farming, the scale of operation significantly influences the degree of financial success and that small-scale operations must navigate the delicate balance of costs and returns to remain viable and profitable.

The analysis of gross profit margin reveals that large farms outperform small and medium farms in terms of efficiency in cost management and revenue generation. Large farms exhibit the highest gross profit margins, indicating that a significant portion of their revenue surpasses the costs associated with production. Baruwa (2014) provides a comprehensive analysis of rabbit farming profitability in Nigeria, detailing that an enterprise with 100 matured rabbits achieved the highest returns, with a profit margin of 41.06% and a return per Naira invested of 1.7. This highlights the critical role of efficient cost management and revenue generation in achieving high profitability. He also emphasised the benefits of economies of scale, as larger farms tend to show better financial performance.

Moreover, ROI demonstrate that large farms yield the highest returns relative to their initial investment. This suggests that the investments made in expanding and operating large-scale farms are yielding substantial profits, reinforcing the notion of scalability and efficiency in resource utilisation.

These findings align with the analysis of commercial rabbit breeding enterprises in the Central Federal District of Russia by Velkina and Nifontova (2021) where profitability was closely tied to effective sales revenue management and cost control. The study identified that enterprises saw profit increases due to positive dynamics in sales, further emphasising the importance of strategic management in maximising ROI. Conversely, the identification of profitability growth reserves in less successful enterprises highlights that even smaller or less profitable farms can improve their financial outcomes through targeted adjustments.

Finally, the per unit profit analysis reveals that large farms achieve the highest profitability on a per unit basis. This signifies that, despite the higher initial investment and operational costs, large farms are able to achieve economies of scale and optimise production processes to generate higher profits per unit of output (Eady and Prayaga, 2000; Sánchez *et al.*, 2022; Wongnaa, 2023a).

Contribution of specific expense category to profitability

Table 5 presents the outcomes of the MRL analysis, shedding light on how various expense categories influence rabbit profitability. Each regression coefficient reflects the estimated effect on profitability, with positive coefficients indicating a direct impact and negative coefficients suggesting the opposite. Standard errors offer insights into the precision of these estimates, with lower values indicating higher reliability. Moreover, *P*-values help assess the statistical significance of each coefficient, highlighting expenses that significantly affect profitability.

In this analysis, a negative non-significant constant term (β_0) is observed. This represents the baseline profit when all other expense categories are zero. Its negative value indicates that without accounting for specific expenses, the model predicts a negative profitability. This further tells us that there are fixed costs or unaccounted factors that inherently drive the profitability to be negative, or it could be an artefact of the data used to train the model, reflecting scenarios where profitability is low even when expenses are minimal. Cartuche *et al.* (2014) identified that there

Table 5: MRL result on the impact of expense categories on rabbit profitability (n=123). Dependent variable: Profit.

Expense category	Coefficient	Standard error	*P*-value	Effect size (partial eta squared)
Constant	–2.765	1.679	0.103	
Cost of stocks	–0.125	0.137	0.366	
Feed cost	0.566	0.190	0.004	0.091
Veterinary expenses	0.559	0.200	0.007	0.082
Transport expenses	0.127	0.170	0.456	
Labour cost	0.448	0.241	0.046	0.045
Infrastructure expenses	0.208	0.150	0.169	
Utilities	–0.225	0.250	0.371	
Adjusted R^2(%)	48.5			
AIC	230.25			
Log-likelihood ratio	–107.13			

AIC: Akaike information criterion.

are various traits, such as feed conversion rate, number of kits born alive, and daily gain during fattening, which significantly influence profitability. The negative constant term in this analysis can be seen as a reflection of the broader impact of unmeasured traits or fixed costs, just as Cartuche's study highlights how specific economic weights and traits measure changes in profit. Both analyses underscore the importance of considering all influencing factors and traits to accurately assess and enhance profitability in rabbit production systems.

Expenses such as feed cost, veterinary expenses, transport cost, labour cost and infrastructure (housing) expenses obtained positive coefficients. This suggests that an increase in these expense categories is associated with a rise in profitability. However, only feed cost, veterinary expenses and labour cost are statistically significant. This means that in every 1% increase in feed cost, the profitability increases by approximately 0.56%. Since this increase is statistically significant ($P<0.05$), this indicates that feed cost is a significant predictor of profitability. However, the effect size suggests a moderate effect of feed cost on profitability. This finding negates the result of Mukaila (2023) in their study investigating the economic performance of small-scale rabbit production agribusiness enterprise in Nigeria, which found that feed cost is an inhibiting factor of profitability at par from high mortality due to disease outbreaks. The study obtained a Return on Capital Invested of 1.7, and Operating Ratio 0.4, suggesting that rabbit production is highly profitable and a lucrative venture.

For veterinary expense, it indicates that for every 1% increase, the profitability increases by approximately 0.56%. This suggests that veterinary expenses significantly contribute to profitability with a moderate effect size. In Mukaila (2023) veterinary expense is highlighted as an enhancing factor for profitability, as producers who invest in veterinary care can reduce mortality rates and disease outbreaks, leading to healthier rabbits and higher profitability.

Labour cost has a regression coefficient of 0.44. This implies that for every 1% increase in labour cost, profitability increases by approximately 0.44%. Importantly, this increase is statistically significant ($P<0.05$), indicating that labour cost is a significant predictor of profitability. The substantial impact of labour costs on profitability was found out by Cartuche *et al.* (2014) in their study on economic weights in rabbit meat production. The study indicates that labour costs constitute 18% of total production costs, emphasising their significant role in overall profitability.

On the other hand, utilities expenses have a negative coefficient, indicating that an increase in utilities expense is associated with a decrease in rabbit profitability. However, this decrease is not statistically significant ($P>0.05$).

For the expense category, Cost of Stocks, the regression coefficient is –0.13. This means that for every 1% increase in the cost of stocks, the profitability decreases by approximately 0.13%. However, this decrease is not statistically significant at the conventional significance level ($P>0.05$), as evidenced by the *P*-value of 0.36. The finding is consistent with the observation that larger stock sizes, which benefit from economies of scale, contribute positively to profitability (Mukaila, 2023). Aminu *et al.* (2020) emphasise stock size as a significant factor influencing income. This supports the idea that effective management of stock size, which often involves economies of scale, can have a substantial impact on profitability. Just as Mukaila (2023) highlights the importance of stock size in enhancing

profitability, the findings of Krupová *et al.* (2020) underline the need for careful management of stock-related costs to optimise economic performance, calculating that the economic value of a trait, such as stock size, represents a significant change in profit per doe, per year when the trait mean is increased by one unit.

The adjusted R-squared value, standing at 48.5%, and AIC value of 230.25 justifies the robustness of the regression model in explaining the variability in rabbit profitability based on these expense categories.

Profitability drivers

In Table 6, the profitability drivers of rabbit raising were examined through an MRL analysis.

The constant term is highly significant, with a coefficient of 6.14 (*P*-value <0.001), indicating a positive baseline level of profitability independent of other factors. This further tells us that even when the effects of these identified factors are unaccounted for, there remains a fundamental level of profitability that is not explained by the variables included in the regression analysis.

Among the regressors, production level stands out, with a significant positive coefficient of 1.4409, (*P*-value <0.001). This means that a one-unit increase in the production level is associated with approximately a 144.1% increase in profitability, holding other factors constant. The study of Wongnaa *et al.* (2023b) supports that commercialisation led to increased household income. Economic theory supports that as production volume increases, the per-unit cost decreases, leading to higher profit margins. Larger farms can leverage their size for better market access, competitive pricing and risk diversification, all contributing to greater profitability (Samuelson and Nordhaus, 2010).

In contrast, the number of years of raising rabbits, with a coefficient of 0.0020 and a high *P*-value of 0.986, is not significant, implying that experience alone does not substantially impact profitability. This finding suggests that in rabbit raising, profitability can be achieved regardless of the raiser's experience. Profitability does not vary significantly between raisers with extensive experience and those with little to no experience, which negates the results of Adedeji *et al.* (2015) in Nigeria, who found a positive correlation between gross margin (profitability) and years of experience.

Training attendance, with a positive coefficient of 0.0423 and a *P*-value of 0.596, seems to have no significant impact on rabbit profitability. It is evident in the study area that many rabbit raisers lack formal training in rabbit production and instead acquire their knowledge from watching videos on YouTube and other online platforms.

Similarly, the breed of rabbit, with an almost negligible coefficient of 0.00067 and a *P*-value of 0.999, shows no significant effect on profitability. This implies that the choice of rabbit breed does not significantly determine profitability. It is observed that some raisers opt for breeds such as Champagne d'Argent and Flemish Giants for pet purposes, obtaining higher returns, as pet-type rabbits command higher prices. Conversely, breeds like New Zealand White and American Chinchilla are primarily used for meat production. This conveys that while the breed does not significantly impact overall profitability, the intended market (pet *vs.* meat) plays a crucial role in determining the financial outcomes for rabbit raisers.

Table 6: MRL result on rabbit profitability drivers (n=123). Dependent variable: Profit.

Variables	Coefficient	Standard error	*P*-value	Effect size (partial eta squared)
Constant	6.1434	0.365	0.000	
Production level	1.4409	0.119	0.000	0.622
Nº of years raising rabbit	0.0020	0.117	0.986	
Training attendance	0.0423	0.079	0.596	
Rabbit breed	0.0006	0.043	0.999	
Feeds used	–0.009	0.047	0.841	
Marketing practices employed	0.0618	0.067	0.361	
Adjusted R^2(%)	61.08%			
AIC	202.87			
Log-likelihood ratio	–94.44			

AIC: Akaike information criterion.

The feeds used have a negative but insignificant coefficient of –0.0096, suggesting that variations in feed types do not notably influence profitability. In the study area, raisers utilise various feeding strategies, including commercial feeds alone, own formulations, cut and carry forage and a combination of commercial feeds and forage. This basically implies that higher profitability is geared towards combined feed types of commercial and forage/grasses, but is not statistically significant. Unlike the findings of Micheni *et al.* (2020), which emphasised the importance of feed quality (commercial) in enhancing profitability in rabbit farming, this study shows that the type of feed used does not significantly impact profitability. This divergence may be due to the different feeding practices and the quality of feed available in the study area compared to those in the referenced research.

Rabbits require a balanced diet that includes a variety of grasses and other feeds to support optimal growth and development. The combination of these elements ensures that rabbits receive the necessary nutrients to maintain health and enhance productivity (Lukefahr, 2022).

Marketing practices employed have a positive coefficient of 0.0618, but this too is not statistically significant (P=0.361), implying that while marketing might contribute positively, its impact is not strong enough to influence profitability.

The study reveals that the marketing strategies employed by rabbit raisers in the area include relationship marketing/word of mouth, direct selling, contact buying (physical) and internet/social media marketing. Among these strategies, social media and internet technology have significantly aided the marketing aspect of rabbit production. This finding suggests that while these marketing strategies contribute to some extent, their overall impact on profitability is not as substantial as might be expected. One possible reason is that the market for rabbit meat is still relatively niche, and traditional marketing methods may not yet be fully optimised. However, the high price of rabbit meat in the locality, particularly in Zamboanga City supermarkets, where it commands a price of about Php 450.00 (0.016 EUR) per kilo, indicates an unsaturated demand. This high price point suggests that rabbit meat has great potential in the market. Along these lines, rabbit farmers require assistance and guidance in both rabbit production techniques and marketing strategies from governmental bodies and other organisations in the Philippines to foster more prosperous rabbit farming ventures (Dionisio *et al.*, 2023).

These findings are consistent with the insights from Trocino *et al.* (2019), which emphasise the importance of understanding global production trends and market dynamics. The dominance of China and North Korea in rabbit meat production entails substantial competitive pressures for the Philippines. This international context underscores the need for Philippine producers to refine their marketing strategies and production methods.

The decreasing production shares in the EU, as noted by Trocino *et al.*, indicate that while traditional markets may be contracting, there could be emerging opportunities for Philippine producers to capture niche markets or leverage higher local prices. The unsaturated demand, highlighted by the high local prices, suggests that there is potential for increased profitability if the market can be more effectively penetrated and optimised.

The adjusted R-squared value of 61.08% indicates that the model explains a substantial portion of the variability in rabbit farm profitability, but other unexamined factors likely also play a role. These findings suggest that rabbit farmers should focus on scaling their operations and optimising overall management practices rather than relying solely on experience, specific breeds or feed types to drive profitability.

CONCLUSION AND RECOMMENDATION

The study on the profitability of rabbit raising in Zamboanga Peninsula, Philippines, reveals that the production level or number of animals raised is a significant determinant of profitability, with larger farms achieving higher gross incomes, net incomes and returns on investment compared to small and medium-sized farms. Factors such as cost of stocks, veterinary expenses, transport costs and labour costs were found to positively influence profitability, while utilities expenses had a negative impact. The regression analysis suggests that while certain expenses are critical to profitability, the scale of operations plays a more crucial role in enhancing profitability. Variables such as years of experience in rabbit raising, breed selection and the type of feed used did not significantly impact profitability. Training

attendance and marketing practices also showed non-significant effects on profitability. While certain variables may not directly influence profitability, the high demand and favourable pricing of rabbit meat in local markets present opportunities for profitability enhancement.

Based on the findings, rabbit farmers should consider expanding their production to achieve greater economies of scale. Investments in larger-scale operations can lead to better profitability. Focusing on efficient cost management in areas such as feed, labour and veterinary care can further enhance profitability. It is also recommended that farmers should attend training sessions to stay updated on best practices in rabbit farming, although the study found that experience alone did not significantly impact profitability, it remains important for improving production practices. Marketing strategies should be diversified to include both traditional and digital methods to maximise market reach. In general, strategic scaling and efficient resource management are key to boost profitability in rabbit farming.

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