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EVALUATION OF FACTORS INFLUENCING FARM PROFIT IN EXTENSIVE RUMINANT SYSTEMS USING STRUCTURAL EQUATIONS

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Abstract: Extensive livestock farming in general is more sustainable than intensive methods. However, its profitability is usually low, which can affect the motivation of young people to take up livestock rearing, and often leads them to seek employment elsewhere. The aim of this paper is to study the factors affecting the *Farm profit* of extensive ruminant farms in marginal areas of Southern Chile. To achieve this, we used Structural Equation Modeling (SEM), which provides an in-depth view of the relationships of different variables (items) with *Farm profit* (target variable). The exogenous construct that we obtained (*Structural variable*), consisting of the items *Grazing area*, *Hired labor* and *Total Livestock Units (LU),* exerts a direct, significant explanatory influence on the endogenous construct (*Economic variable*), which includes the items *Hay cost*, *Total sales* and *Economic records*, showing a significant, positive slope in the target variable (*Farm profit*). These structural variables largely condition the entire economic process. However, business decisions linked to farm management influence structural factors and affect the value of income, expenditure and *Farm profit*. Studying the factors which influence *Farm profit* sheds light on the main weaknesses of the system in terms of the financial operation, as well as on potential improvements, encompassing the social, technical and environmental dimensions.

Keywords: Southern Chile, Cattle production, Sheep production, Structural variables, Economic variables.

INTRODUCTION

During recent decades, livestock production has become more intensive worldwide, and there is a general tendency to see intensive farming as the only possible route to development (PAZ & BRUNO, 2013). Nevertheless, pasture-based livestock farming systems still has a major role to play. Although animals raised through these systems often receive supplementary feeding, this is generally not very abundant, and the systems can therefore rightly be called extensive (BERNUÉS et al., 2011).

In order to maintain the environmental balance and conserve resources, there has been considerable interest currently in studying the sustainability of all production processes. According to several authors, extensive systems tend, in general, to be more sustainable than intensive ones (AGUILAR-JIMENEZ et al., 2019; VALDIVIESO et al., 2019). These types of systems should therefore be maintained, and they have the following main benefits: a) they make use of resources which otherwise would be wasted, b) they help to prevent depopulation of many marginal areas that are not suitable for cultivation, c) they help maintain the environmental equilibrium and d) high quality food is produced (BERNUÉS et al., 2011; BEDOIN & KRISTENSEN, 2013; KAMILARIS et al., 2020). In general, extensive systems produce dual-purpose or exclusively meat animals and are located in less favorable areas, e.g., dry or mountainous zones (BERNUÉS et al., 2011; IÑIGUEZ, 2011). In addition, they need very few resources to operate, which means they are not greatly affected by variations in the prices of raw materials. At the same time, the *Farm profit* (calculated as the difference between total sales and total costs) is usually low, which constitutes the main problem for their maintenance; if the *Farm profit* is low, it makes it an unattractive proposition for the younger generation, who are more likely to seek employment elsewhere (GARCÍA-MARTÍNEZ et al., 2011; NAHED-TORAL et al., 2013; NAHED-TORAL et al, 2018; AVILEZ et al., 2018).

AVILEZ et al. (2018) carried out the characterization of the extensive ruminant production systems of the Aysén Region of Chile. From a multivariate analysis, they obtained interest groups which clarified how the productive systems in the study area worked (MEJÍA-GIRALDO et al., 2016). Later, AVILEZ et al. (2021) assessed the sustainability of these systems. The results of this research revealed systems with medium-low use of external resources, thus favoring sustainability; however, certain deficiencies affected their sustainability, either directly or indirectly. Among these featured the medium-low level of *Farm profit*, which is a common occurrence on extensive farms, as previously mentioned. Several factors influence low *Farm profit*: small farm size, difficulty in achieving land ownership and making investments, low technification and difficulty for farmers to collect data, and lack of adequate commercialization channels. The results of AVILEZ et al. (2018) show the highest and the lowest *Farm profit* (€13,044 vs €2,740 per year) in the cluster in which farms have the highest and the lowest size, respectively (593 ha of *Grazing area* and 56 *LU* vs 81 ha and 13 *LU*) and the highest and lowest presence of *Hired labor,* respectively (60% and 0% of farms). Larger farms have higher *Total costs*, but they also have higher *Total income*, which, more importantly, results in a higher *Farm profit*. In terms of costs, there are significant differences in the *Farm profit,* depending on the costs of *Hired labor*. According to AVILEZ et al. (2021), the farms that have a greater presence of *Hired labor* are the largest (423 ha of *Grazing area* and 57 *Total Livestock Unit, LU* as average) and those with the highest

Farm profit (€16,858 per year); on the other hand, those that have no *Hired labor* have an average of 157 ha of *Grazing area*, 32 *Total LU* and €8,709 per year of *Farm profit*. The aim of this paper is to study the factors influencing the *Farm profit* of extensive ruminant farms in marginal areas of Southern Chile. To achieve this, we have used Structural Equation Modeling (SEM), which gives an in-depth insight into the relationships of the different variables with *Farm profit* (target variable) in order to estimate the level of correlation and the structural relationships of these variables (MEJÍA-GIRALDO et al., 2016). SEM allows us to analyze simultaneously the relationships between the dependent and independent variables involved in the analysis of a target variable (OLIVAS et al., 2013).

The best-known multivariate techniques (for example, regressions) have the common limitation of explaining only one relationship at a time. In contrast, SEM techniques examine a number of dependent relationships simultaneously, and their popularity is evidenced by recent publications in fields as diverse as marketing, social sciences, human health, education, and animal production and health (BERTOT et al., 2017). SEM involves two types of approach: as a confirmation of the underlying structural theory of the phenomenon in question (BERTOT et al., 2017), and as an exploratory method based on empirical data, using construct analysis or latent variables (variables which are not directly measurable) (RODRÍGUEZ-NAVARRO & ASÚN, 2016). We have chosen the latter approach for the present work.

MATERIAL AND METHODS

AREAOFSTUDY AND DATACOLLECTION

The present work is based on a previous study carried out in 2017 in the Rio Ibáñez district of the Aysén Region of Chile, 48°16′00″S, 71°56′00″W (AVILEZ et al., 2021), in which 29 farms were studied (13% of the total number of farms in the district), with all the farmers belonging to the “Bajada Ibáñez” farmers’ association.

Among the 61 variables studied in the previous study, we selected 26 for the present work, of which 9 were qualitative and 17 quantitative (Table 1), with all the former being binary (0,1). The selection of variables was carried out taking into account the various means of obtaining *Farm profit*.

PARTIAL LEAST SQUARES STRUCTURAL EQUATION MODELING (PLS-SEM)

To find the relationships between the observed variables, termed indicators or items, and the target variable (*Farm profit*), we used structural equation modeling (SEM), and when choosing the items, we opted for those with a high coefficient of variability, thereby ensuring a good explanatory capacity. The SEM technique used in this work was exploratory, based on empirical data, and used latent variables (known as constructs). The model was estimated using Partial Least Squares Structural Equation Modeling (PLS-SEM), a method for estimating structural equation models based on variance (ROLDÁN & SÁNCHEZ-FRANCO, 2012). This way of modeling was chosen because (i) it is relatively new; (ii) the study approach is both explanatory and predictive for the target variables; (iii) the research model can be complex, depending on the type of relationship (direct or mediated through constructs) between the hypotheses;

and (iv) this method defines the nature of the target variables. As a result, the study is based on a composite measurement model with a formative design approach (as opposed to the reflective design used when hidden intermediate variables are already known to exist), which means that items and constructs represent different variables, although there are correlations between them. Finally, formative design is the recommended option for out-of-sample prediction when the sample size is not excessively large and there is a correlation between the items and constructs (BECKER et al., 2013). For all these reasons, we decided to use PLS-SEM in this study (SARSTEDT et al., 2016), supported by *SmartPLS 3.2.4* software (RINGLE et al., 2015).

It is also important to note that, in most cases, the PLS algorithm converges, with high statistical power obtained even with small samples, and the method is robust against missing data (HENSELER et al., 2009).

The estimation and evaluation of a structural equation model basically involves that of two models: (i) the measurement model, which registers the relationships between the observed variables (the items) and the constructs; and (2) the structural model, which shows the relationships between the constructs and the target variable. The factor loadings are shown in the estimations, and relate the items to the constructs. The square of a factor loading represents the proportion of variance explained by an item compared with a construct, and researchers recommend factor loadings greater than 0.30, which is equivalent to explained variances of over 9% (COSTELLO & OSBORNE, 2005).

The results show the validity and usefulness of the PLS model or structural equations to obtain the significant factors that influence the target variable *Farm profit*. In the discussion, emphasis is placed on the relationships between the different items and the constructs involved in the model, following the main aim of this work.

RESULTS

The estimated structural equation model, as proposed, consists of a formative exogenous construct, which we have named the *Structural variable*, defined by the items *Grazing area*, *Hired labor* and *Total LU*. This construct exerts a direct, significant explanatory influence on a second construct (endogenous variable), which we have called the *Economic variable*, which is also formative and is defined by the items *Hay cost*, *Total sales* and *Economic records*, thus giving the economic data on the farm. In turn, this second construct is an explanatory variable, with a positive, significant slope in the target variable, *Farm profit*. Figure 1 shows the proposed, estimated model produced using the technique of Partial Least Squares Structural Equation Modeling (PLS-SEM), with the factor loadings in the item-construct relationships.

For each of the formative variables, we examined the asymmetry and kurtosis, finding absolute values of below 1.3 and 1.5 for asymmetry and kurtosis, respectively, which indicates a good approximation to normality.

As observed, the first construct (*Structural variable*) is an exogenous variable (i.e., with no factor loading) and the second construct (*Economic variable*) is an endogenous variable. The model is strong, since the two factor loadings are very high.

MEASUREMENT MODEL

The results of the measurement model are presented in Table 2, showing the significance of the relationships between items and constructs.

The measurement model reveals that the items are correlated with the constructs, and the t values indicate reliability.

STRUCTURAL MODEL

Table 3 shows the R^2 values. The goodness of a model is determined through the goodness-of-fit of each of the structural relationships, which are measured by the R^2 of each endogenous variable (second construct and targ et variable). According to FALK & MILLER (1992), these values must be greater than 0.1 in order to consider that the model has sufficient predictive capacity.

The predictive measure of the model is based on the parameters shown in Table 4.

The results summarized in Table 4 confirm that the structural model has a good predictive relevance for the two endogenous variables (second construct and target variable). Finally, the SRMR coefficient has been calculated to measure the goodness of the adjustment of the structural model (HENSELER et al., 2016). In this case, SRMR = 0.074 is suitable, since an adjustment of less than 0.08 is usually required.

DISCUSSION

FACTORS INFLUENCING FARM PROFIT

This discussion focuses on the relationships between the items, constructs and target variables involved in the model, in order to determine the factors influencing *Farm Profit* (the main aim of the study).

Among the items related to the first construct, known as the *Structural variable*, two (*Grazing area* and *Total LU*) have significative differences with the third (*Hired labor*). Where there is *Hired labor*, the *Grazing area* is almost triple and the *Total LU* almost doubles in value when there is none (AVILEZ et al., 2021). In this context, the work by AVILEZ et al. (2018) shows that cluster 3 contains the largest farms, which are those with the greatest presence of *Hired labor* and the highest *Farm profit*. This confirms that, in general, larger farms obtain higher *Farm profits*. In contrast, the value of *Farm profit per LU* is similar in three of the four clusters obtained by AVILEZ et al. (2018), despite the fact that they differ greatly in terms of average farm size. This latter variable has the lowest value in cluster 1 in the study, due mainly to deficient farm management, which leads, as mentioned above, to a lower proportion of farmers believing that the farm will continue over the future generations (only 40 %). In any case, farms need to be a minimum size in order for the workforce to be efficient (SARRIA et al., 2014).

Regarding the three items related to the second construct, termed the *Economic variable*, *Total sales* had low values due, among other causes, to the fact that the farmers' families consumed some of the animals produced, especially lambs, or to deficient farm management (reproduction or feeding) (AVILEZ et al., 2018). Concerning *Hay cost*, a significant amount of grazing resources is vital to avoid having to supply to cattle with excessive amounts of concentrate and hay. To achieve this, there must be an adequate *Stocking rate* and the mating periods must also be controlled by separating males from females in the herd at certain times of the year. (RUIZ et al., 2020; REYES et al., 2020; AVILEZ et al., 2021).

As regards Economic records, which is the third item related to the second construct, less than a third of farmers keep them, which is similar to what occurs in many of the extensive farms worldwide (AVILEZ et al., 2018, 2021). Although pastoral systems for ruminant meat production are ideally placed to foster global sustainability, their profitability is, in general, quite low (BERNUÉS et al., 2011; TESSEMA et al., 2014; TORO-MUJICA et al., 2019). For this reason, the technical-financial control of farms must be encouraged by the sector as a whole. In this way, a more satisfactory

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balance between income and expenses can be achieved.

It is also important to take into account the existing relationships between the items that directly affect the constructs and other economic or sociological system variables (see Table 1). Thus, the item *Hired labor* is discriminant for other variables in addition to those mentioned above (*Total costs* are triple and *Total sales* and *Farm profit* are double when there is *Hired labor*) (AVILEZ et al., 2021). The factor of *Farmer is Owner* is discriminant for *Kg of concentrate per LU* (consumption increases by 70% when the *Farmer is owner*); and *Woman living alone* is discriminant for *Bales of hay per LU* and for *Feed Costs per LU* (supply of *Hay bales* is multiplied by six and *Total costs* by three when the farm is run by a *Woman living alone)* (AVILEZ et al., 2021).

STRATEGIES TO INCREASE FARM PROFIT

According to AVILEZ et al. (2021), if the *Farm profit* is low, especially on small farms, running the farm is an unattractive proposition for young people, who tend to seek employment in other activities (tourism, mining, fishing, handicrafts, etc.). It follows that the amount of work done on the farm must be commensurate with the *Farm profit* obtained. The results of AVILEZ et al. (2018, 2021) and the structural equations obtained in the present work show that guidelines for improving *Farm profit* can be drawn up by analyzing the items that influence the constructs and their related variables. To achieve this, it is desirable to aim for increased income or a reduction in expenses (especially with the two most important components of *Total costs*: *Hired labor cost and Hay costs)*.

As for increasing farm income, it is key to take into account the different phases of livestock activity: improved management, improved sales prices of weaned calves and greater participation of the farmer in the fattening process of calves, in the processes of slaughtering the animals and in commercialization. In all these phases, but especially in those of fattening, animal slaughter and marketing, the only existing association in the area may be used (AVILEZ et al., 2021) or others may be created (RUIZ et al., 2020). Whichever is chosen, many improvements depend on how willing and able the farmers are to collaborate, especially on small farms (SCHWAB et al., 2020).

Improvements in animal management include, in addition to health aspects, techniques of reproduction and feeding which foster sustainable management of the pasture, thus reducing the environmental impact. This involves an improvement in fertility by controlling mating periods and managing reproduction by adapting the animals' greatest nutritional requirements to the season when most natural pasture is available (REYES et al., 2020; RUIZ et al., 2020; AVILEZ et al., 2021). The most difficult phase to carry out is calf fattening, since in the study area, similarly to other extensive areas, calf fattening is hindered by the lack of rain and the low quality of the grasses (BERNUÉS et al., 2011; HORCADA-IBÁÑEZ et al., 2016; CALDERÓN et al., 2012; RODRÍGUEZ-MORENO et al., 2020). To complete calf-fattening, slaughtering and processing in cattle and sheep, agribusinesses and producers need to cooperate more closely, particularly in the case of small producers (TORO-MUJICA et al., 2019; HEPP et al., 2018). Finally, improved marketing can be achieved, for example, with direct sales (TORO-MUJICA et al., 2019; STAMPA et al., 2020), as well as through distribution based on differentiation and quality control in the products (HORCADA-IBÁÑEZ et al., 2016). Quality should be accredited through brands related to cooperatives, breeders' associations, PGIs, pastoral production or the denomination of origin of the production area (GÓMEZ-RAMOS et al., 2006; MARTÍN-COLLADO et al., 2014; RUIZ et al., 2020). Regarding marketing, it is essential for associations to deal with product diversification and to target market niches (BERNUÉS et al., 2011). In all cases, consumers must be made aware of the unique values of extensive production: respect for the environment and biodiversity, animal welfare, interest in human health and providing a livelihood for the rural population (BERNUÉS et al., 2011; BEDOIN & KRISTENSEN, 2013; HORCADA-IBÁÑEZ et al., 2016; NAHED et al., 2018; STAMPA et al., 2020; MORALES-JERRETT et al., 2020).

As for reducing expenses, *Hired labor per LU* can be reduced by increasing, in some cases, productive activity, in other words, increasing *Total LU*, together with a possible increase in livestock diversity in order to increase *Total sales* and *Farm profit*. In this case, the organization of work needs to be studied carefully (BERNUÉS et al., 2011). Although there are cattle on all the farms studied, only 41% produce sheep, and therefore in some cases, the number of sheep or even goats could be increased (AVILEZ et al., 2021). This has added advantages, since when the land is grazed by more than one species, livestock make more efficient use of the vegetation, with a resulting increase in biodiversity (BERNUÉS et al., 2011; MENA et al., 2016; RUIZ et al., 2020), together with a better distribution of tasks throughout the year and a diversification of income. To reduce *Feed costs,* especially *Hay costs*, in some cases, farmers could expand the grazing area by leasing pasture or, if possible, produce more hay (RUIZ et al., 2021).

To envisage the possible evolution of production systems, certain aspects must be taken into account. Firstly, when the *Farmer is Owner* of the land, more concentrate is supplied to the animals, which, despite increasing feed costs, probably improves reproductive efficiency, health, income and ultimately *Farm profit*. It is therefore advisable to encourage an increase in the number of farm owners. Also, it has been reported that when women run a farm, *Woman runs the farm*, the average amount of *Hay purchased* is much higher and the *Feed cost per LU* increases; therefore, functional or management alternatives should be sought to solve this problem. In all cases, according AVILEZ et al. (2021), it is important to encourage farmers to keep *technical-financial records,* which leads to better self-reliance and to higher *Farm profit* in general. The positive, significant relationship between young farmers and a *High level of education* (AVILEZ et al., 2021) can facilitate future advances in the data collection process on farms.

CONCLUSIONS

The meat production from ruminants raised on extensive farms is generally a more sustainable system than that of their intensively-reared counterparts, although *Farm profit* is rather low, especially on small farms.

Obtaining a *Farm profit* which satisfies the needs of the farmer's family is a decisive factor in the continuity of livestock rearing. The younger generation, especially, tend to seek other ways of making a living if their expectations are not met on the farm.

The structural equations allow us to order the production factors that influence *Farm profit* obtained by establishing intermediate structural and economic variables, and the results show that the structural variables largely condition the entire economic process. However, business decisions linked to all the areas of farm management (reproduction, feeding, marketing and technical-financial data collection) modulate the structural factors and contribute to determining the value of income, expenses and *Farm profit*.

Studying the factors which influence *Farm profit* enables us to get a picture of the main weaknesses of the system in terms of financial operations, and the potential improvements which could be made.

DECLARATION OF COMPETING INTEREST AND ACKNOWLEDGEMENTS

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AUTHORS' CONTRIBUTIONS

Juan P. Avilez: funding acquisition, data collection, formal analysis, original draft and review and editing; José Nahed: conceptualization, information systematization, statistical analysis and review; José A. Camúñez: methodology, software, statistical analysis; Daniel Grande: visualization, coordination of writing, review and editing; Yolanda Mena: methodology, review and supervision; Francisco A. Ruiz: special contribution in the writing of the introduction and discussion; José M. Castel: data curation and data analysis, validation and supervision. All authors critically revised the manuscript and approved of the final version.

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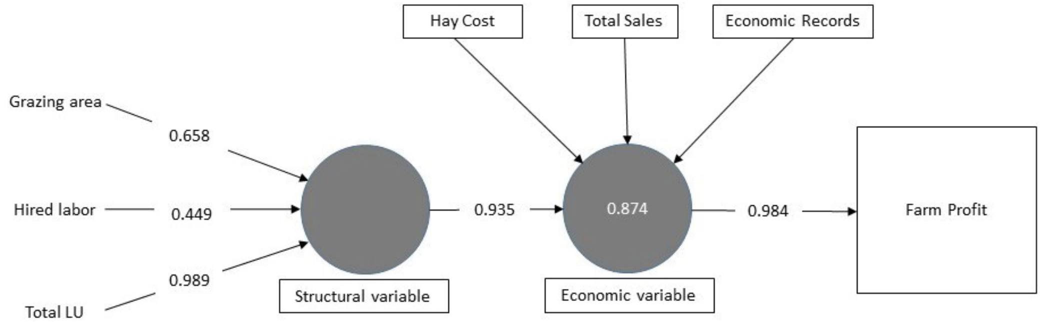

Figure 1. Estimated Model using Partial Least Squares Structural Equation Modeling (with factor loadings).

Variables	Average ± SE	VC (%)	Variables	Average ± SE	VC (%)
Grazing area (ha)	230 (±51)	118	Concentrate per LU (kg)	22 (±3)	63
Total Livestock (Units of LU)	38 (±5)	73	Hay per LU (bales)	3.0 (±1.0)	170
Farmer is Owner of farm (%)	66	73	Concentrate cost (€)	245 (±35)	75
Woman living alone (%)	34	138	Hay cost (€)	514 (±197)	203
Hired labor (%)	28	162	Feed costs (€)	759 (±217)	151
Stocking rate (LU/ha)	0.6 (±0.2)	159	Feed cost per LU (€)	18 (±4)	106
Sheep on farm (%)	41	119	Hired labor cost (€)	601 (±223)	162
Producer's age (years)	53 (±3)	26	Rented cost (€)	31 (±31)	538
Farmer has higher education (%) ##	62	78	Medication cost (€)	57 (±18)	174
Farmer makes hay (%)	83	46	Total costs (€)	1447 (±306)	112
Farmer has traded through an association (%) ###	69	68	Total costs per LU (€)	36 (±7)	97
Farmer keeps production records (%)	72	63	Total sales (€)	12404 (±1887)	81
Farmer keeps economic records (%)	28	162	Farm profit (€)	10957 (±1775)	86

Table 1. Values from variables in Avilez *et al.* (2021) included in the current study (average and standard error or percentage and variability coefficient, VC).

##Secondary or higher education. In all other cases, the farmer have received at least primary education; ###in other cases, farmers sometimes sell animals outside the association

Cause-effect relationships	Factor loading	Standard deviation	t	P
Hay Cost ->Economic variable	0.330	0.180	1.834	0.067
Grazing area ->Structural variable	0.658	0.124	5.329	0.000
Hired labor ->Structural variable	0.449	0.192	2.342	0.019
Total sales ->Economic variable	0.995	0.009	112.595	0.000
Total LU ->Structural variable	0.989	0.048	20.819	0.000
Economic records ->Economic variable	0.608	0.120	5.050	0.000

Table 2. Evaluation of measurement model.

Variables	R^2	Adjusted R^2
Farm Profit	0.968	0.967
Economic variable	0.874	0.869

Table 3. Validation of endogenous variables.

Variables	Factor loading	Standard error	t	P
Structural variable -> Economic variable	0.935	0.067	13.897	0.000
Economic variable -> Farm Profit	0.984	0.019	51.463	0.000

Table 4. Estimation of structural model.