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COMPETITIVENESS ANALYSIS OF THE SMALL-SCALE EXTENSIVE SHEEP PRODUCTION SYSTEM IN THE SOUTHEAST REGION OF HIDALGO

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ABSTRACT

The objective of this study was to evaluate the comparative advantage of grazing in the competitiveness of the small-scale sheep production system in Singuilucan, Hidalgo, Mexico. For this purpose, data from 51 production units were analyzed, chosen from a simple random sampling. The information was obtained through an interview with 120 questions, organized into technical variables, economic aspects and social aspects of the producer. The Policy Analysis Matrix (PAM) was used to analyze the impact of grazing on competitiveness, in two scenarios: in the first, the low cost structure was studied under the traditional form of production, which uses grazing as feeding basis; while in the second, the cost was simulated by counting the purchase of feed, as well as hiring workforce. The results revealed that grazing as a feeding basis (real scenario), instead of commercial feed (simulated scenario), increases the profitability of the sheep system in 53%, which translates into a cost reduction (32%) and an increase in the utility of $10,830 (ten thousand eight hundred thirty pesos per farm) for each productive cycle of four months. The high dependency on grazing and family workforce observed in the simulated scenario indicate that the small-scale sheep production in Singuilucan could be vulnerable, if the micro-regional advantages that these factors contribute were to be lost, which would translate into a competitive reduction of approximately 62%.

Keywords: family workforce, production costs, political analysis matrix, sensitivity analysis, sheep sector.

INTRODUCTION

Sheep production is one of the most important livestock activities in Mexico, since it contributes with the economic and social sustainability of peasant families (Herrera *et al.,* 2019). It requires low management, investment and in fact it does not demand all the work time of producers (Salinas-Martínez *et al.,* 2022). This industru produces wool (2 million tons/year), meat (14 million tons/year), milk (28 million tons/year) (FAOSTAT, 2019) and due to its particular characteristics, the species is bred in the whole world under different productive conditions (from extensive to highly extensive systems) and feeding conditions (from grazing diets to total mixed rations), geographic areas, and through the use of breeds, populations and diverse crosses, because of their high nutritional content and environmental adaptability (Cannas *et al.,* 2019).

In this scenario, small-scale sheep production has an important role since it generates economic sustenance, jobs, and care for ecosystems to conserve biodiversity (Marino *et al.,* 2016); it is considered an economic option that allows facing poverty (Salinas-Martínez *et* *al.,* 2022), since it represents one of the most extended livestock production activities in Mexican rural zones because of its flexibility and forms of produciton that take advantage of byproducts and harvest residues, which it transforms into products of high biological and economic value for the families that carry out this activity (Herrera *et al.,* 2019). This has allowed recent changes in sheep breeding, where increasingly more peasants attempt to become sheep breeders, going from a simple forced backyard activity for saving or marginal exploitation of pastureland, to a potential business that is economically profitable, since the producer can count on good prices, unsatisfied demand and domestic market growth (Hernández-Marín *et al.,* 2017).

With these characteristics, sheep production faces different challenges to continue its rising path within Mexican livestock production systems; one of the main ones is related with feeding, variable that represents the highest cost for flocks and largely affects their health, the quality of the products, and their environmental impact (Simões *et al.,* 2021), which is why it has been a widely studied sector. In this regard, authors such as Silva *et al.* (2022), have reported that a good feeding alternative is the use of pastures for the livestock, which decreases production costs in addition to generating positive effects in the environment by reintegrating nutrients to the land, reducing greenhouse gas emissions in comparison to stabling, using less energy, and improving carbon efficiency within the context of climate change.

However, despite the importance of the sheep breeding activity in Mexico, few studies have been developed with the objective of evaluating these productive systems based on their accounting and financial structure. In particular, in the study region (Singuilucan), the information about economic analyses that study small-scale sheep systems is limited, generating with that an area of opportunity, to develop studies that could contribute useful information for producers to make better decisions (Argilés and Slof, 2001). With this scenario, the following hypothesis was suggested: the small-scale sheep production systems in Singuilucan based on grazing and family workforce have higher profitability and competitiveness than the intensive systems. The method of Policy Analysis Matrix (PAM) was used as reference to analyze this behavior, considered one of the most widely accepted methodologies to estimate the economic-financial behavior in the agricultural sector (Salcedo, 2007), since it allows efficiency in production, comparative advantage, and impacts of economic policy on competitiveness of the productive systems (Posadas-Domínguez *et al.,* 2018). Under this approach, the study's objective was to evaluate the production cost and its impact on competitiveness of the small-scale extensive sheep production system in the southeast of Hidalgo.

THEORETICAL FRAMEWORK

The concept of competitiveness has evolved in the history of economic thought, embracing different approaches, from classical theories of mercantilism that introduced the notion of commercial rivalry between nations, to absolute advantage, theories of competitive, comparative and neoclassical advantages (Voinescu and Moisoiu, 2015). As instrument of analysis, the concept of competitiveness is very broad and it has been used to evaluate businesses, countries and economic agents from a macroeconomic level to a microeconomic level (Arias, 2022), based on their relationship with financial development, the increase in production, and employment (Paéz *et al.,* 2021).

Recently, as business competitiveness has increased, entrepreneurs must find strategies to overcome competition in their respective fields (Schymik, 2018); one way of achieving this is through business analysis in function of the internal resources that they use, which allows creating several advantages over their competitors (Farida and Setiawan, 2022). Among the most widely recognized, according to the fundamental theory by David Ricardo (1817), the comparative advantage is found, which establishes that the geographic locations of the businesses allow producing cheaper goods and services than their competitors, when they assign their resources to those that have a comparative advantage. Based on the postulates of this theory, this study analyzes the comparative advantage that grazing contributes to profitability and competitiveness in small-scale sheep production in Singuilucan, Hidalgo, Mexico. This research attempts to generate evidence on how the exploitation of natural resources in the region of study confers sheep producers a differentiated advantage that allows them to reduce the production cost and increase the utility. Then, through a simulated scenario, the study analyzes what the financial impacts on the utility would be if producers lost the comparative advantage provided by grazing as the main source of feed in sheep production.

METHODOLOGY

Study area

The study was conducted in the municipality of Singuilucan, Hidalgo, Mexico, located in the southeast of the state of Hidalgo between coordinates 20° 08' of latitude North and 98° 38' of longitude West; it has an altitude of 2,400 to 3,100 masl, sub-humid temperate climate with rainfall of 500 to 800 mm and rains from May to September (INEGI, 2017).

General description of the small-scale sheep production system

According to the work by Salinas-Martínez *et al.* (2022), the small-scale sheep production system in the study region was characterized by having farms with 3 to 130 sheep, their diet is based in more than 85% on grazing in free or rented zones, and the finalization time per sheep under this productive scheme is 4 months. The technical management is basic, with low technology adoption, and the backyard system predominates with minimal use of artificial insemination (less than 5% of the farms). The workforce is formed basically by family members. The flock genetics are composed mainly by pure breeds such as Hampshire and crosses of these with Suffolk, Dorper and Creole biotypes (that do not constitute breeds). In more than 50% of the farms, selling sheep constitutes the sole source of income and it is nearly all directed to trade in the *barbacoa* market.

Analysis of scenarios

This study analyzed two scenarios. The first (real scenario) evaluates the structure of costs with the aim of analyzing the level of current profitability and the comparative advantage of grazing in the sheep production system. The second (simulated scenario) studied the costs of opportunity and the evaluation of the economic impact when the advantage of grazing is lost, simulating the purchase of 100% of feed in local fodder suppliers, as well as hiring the workforce, considering payment for it by day.

Statistical sample

A simple random sampling was used to select 51 farms from a total of 1,000 small-scale sheep production systems, which allowed evaluating the characteristics of competitiveness of the sheep system. To obtain the sample size, 30 pilot surveys were applied in production units of the region under study, and the results found that 90% of the farms surveyed presented competitiveness; this percentage was later used to estimate the sample size, according to the method proposed by Cochran (1977). The sample estimation was done with 95% confidence and tolerable error of 8%. With these characteristics, a sample of 51 production systems was obtained, based on the following formula:

$$n_0 = \frac{NZ^2 pq}{d^2 \left(N-1\right) + Z^2 pq} \tag{1}$$

where n_0: size of the sample; N: size of the population; Z^2: critical value of Z, calculated with the tables from the normal curve area, also called level of confidence; p: approximate proportion of the phenomenon in study; q: proportion of the population of reference that does not present the phenomenon in study; d^2: level of absolute accuracy, referring to the range of the interval of confidence intended in the determination of the average value of the variable in study (Aguilar-Barojas, 2005).

$$n_0 = \frac{(1000)(1.96)^2(0.9)(0.1)}{(0.08)^2\left(1000-1\right)+(1.96)^2(0.9)(0.1)} = 51 \tag{2}$$

Obtaining the information

The information was obtained using a procedure already standardized by Herrera *et al.* (2019), who consider, through a direct survey with producers, obtaining information about technical variables that describe the production process and herd management, as well as economic aspects to understand the profitability of the farms and social aspects, related to the family environment of the producer.

Economic analysis

The Policy Analysis Matrix was used to analyze the impact of the technical and economic characteristics on the competitiveness of the small-scale sheep production system. According to Monke and Pearson (1989) and Salcedo (2007), the PAM is product of two countable identities: 1) private prices, which define profitability as the difference between income and costs, and 2) social prices, which measure the effects of the divergences (distorting policies and market failures), such as the difference between the parameters observed and those that would exist if the divergences were eliminated.

In the PAM, profitability is measured horizontally through the matrix columns, as presented in Table 1. The profits, which are shown on the right column, are obtained by subtracting the costs that are presented in the two middle columns from the income. Each PAM contains two columns of costs, one for trading inputs and another for internal factors. The inputs included are: fertilizers, pesticides, seeds purchased, feeds, electricity, transport, fuel, depreciation, among others, and they are divided into components of tradable inputs and internal factors.

The data added in the first row of Table 1 provides a measure of private profitability and competitiveness, which refers to the incomes and costs observed derived from the real market prices received or paid by farmers, traders or processors in the agricultural system. There are several indicators of economic efficiency used to measure competitiveness at private prices, which have been reported in different studies as robust enough to analyze an agricultural system financially (Posadas-Domínguez *et al.*, 2014; Salinas-Martínez *et al.*, 2022; Velázquez-Torres *et al.*, 2022). Because of these characteristics, this study used only the first row of the PAM to evaluate the competitiveness of the small-scale sheep system in the southeast of Hidalgo. The construction of the PAM was structured with the following indicators of efficiency (Table 2).

Table 1. Structure of the Policy Analysis Matrix.

Concept	Incomes	Production costs		Profits
		Tradable inputs	Internal factors	
Private prices	A	B	C	D=A-B-C
Social prices	E	F	G	H=E-F-G
Effects of policy	I=A–E	J=B–F	K=C–G	L=D-H=I-J-K

Where A: private income, B: cost of tradable inputs at private price, C: cost of internal factors at private price, D: private benefit, E: social income, F: tradable inputs at social price, G: cost of internal factors at social price, H: social benefit, I: exit transference, J: entry transference, K: transference of internal factors, L: transference of net policy.
Source: Monke and Pearson (1989).

Table 2. Policy Analysis Matrix: Indicators of private profitability and competitiveness.

Concept	Equation
Private profitability	RRP=D/(B+C)
¥Rate of private cost	RCP=C/(A-B)
Added value to private prices	VAP=(A–B)
Intermediate consumption in the total income	PCIP=B/A
Added value in the total income	PVAP=(A-B)/A

¥If the result of the RCP<1 the producer is competitive and receives extraordinary profits, so that the closer to zero the result is, the system analyzed will reflect more competitiveness; if the RCP=1 no extraordinary profits are generated and it is located in the system's equilibrium point; if the RCP>1 the producer is not competitive since the system does not generate the necessary economic benefits to cover the payment of production factors.
Source: Monke and Pearson (1989).

RESULTS AND DISCUSSION

Technical and economic characteristics

Table 3 shows that the owners of the sheep farms have low schooling, with incomplete Primary school (Galván-Antonio *et al.,* 2021), but with more than nine years of experience in this activity. This could make the adoption of technologies in the productive system more difficult (Zenda and Malanen, 2021). However, the years of experience reported in this study are found within the parameters for small-scale sheep production systems in Mexico (Marín-Bernal and Navarro-Ríos, 2014; Salinas-Martínez *et al.,* 2022), although they are lower than the international mean (13.5 years) (De Camargo *et al.,* 2021; Serrano *et al.,* 2022). As consequence, the experience in the activity was used efficiently by the producers, and a high productivity of the farms was observed despite the low level of schooling reported. The average of sheep finalized for this study exceeded 50 heads per production unit, which are traded nearly in their totality in the *barbacoa* market (Table 3) and there is

Table 3. Main technical and economic indicators of the small-scale sheep production system in Singuilucan, Hidalgo.

Characteristics	Average¥	Percentage
Age of producers (years)	58.21±14.77	
Schooling (years)	4.65±4.12	
Years of experience in the activity (years)	9.20±7.60	
Size of the farm (heads)	58.08±43.89	
The production system is backyard (% yes)		79.00%
The production system is specialized in fattening (% yes)		96.00%
The sale of animals is for the barbacoa market (%)		87.50%
The Hampshire breed is used in fattening (% yes)		61.00%
The production system is based on grazing for feeding (%)		85.00%
The system does not hire workforce (%)		91.00%

¥The average values are presented with standard deviation when appropriate.

a minimum percentage for self-supply (2%). This result exceeds the mean reported for similar small-scale sheep production systems (Serrano *et al.,* 2022; Pérez *et al.,* 2011). With this scenario and the proximity with the central state of Mexico, characterized by its high consumption of sheep meat (Rodríguez-Licea *et al.,* 2016), trade through a safe market has been benefitted, which guarantees the production units assessed with the exit of their product at competitive prices, thus becoming an attractive current business option and for new generations of producers, which could confer successive continuity.

The dominating production system observed is the backyard system, which favors fattening of sheep breeds such as Hampshire, fed primarily by grazing. The data are similar to those reported by Salinas-Martínez *et al.* (2022) and Vélez *et al.* (2016). These authors have documented that sheep production in Hidalgo is developed under the intensive, semi-extensive and backyard production system, with the latter being the one that is mostly based on the exploitation of grazing lands and family workforce. Thus, there is cost reduction and greater economic benefits for the sheep breeder. These characteristics can be explained because 85% of the sheep farms in Singuilucan base their productive system on grazing (Table 3).

The production systems presented low technological adoption in sectors such as: balancing feeds, artificial insemination, records, among others, as reported in similar systems (Barrón-González *et al.,* 2022; Hernández-Marín *et al.,* 2017), phenomenon possibly explained by the high age average (58 years) observed for this study, although it was similar to other national and international values (Galván-Antonio *et al.,* 2020; Voors and Haese, 2010). Authors such as Zenda and Malanen (2021), report that there is a correlation between level of schooling and technological adoption. These results allow inferring that the decision of producers to adopt new forms of production depends on various factors, among which the following stand out: age, schooling and knowledge used in the productive process. The latter is of great value since, despite the low technological level found, the farms produce traditionally using mainly family workforce (Hernández *et al.,* 2022; Vieyra *et al.,* 2020), and they depend on knowledge that are passed from generation to generation, in addition to presenting a low level of schooling and greater age (58 years) in the owners of the farms (Table 3).

Countable analysis of the production cost

The highest production cost was purchasing sheep and feed both for the simulated scenario and for the real scenario for production. Similar results were reported by Martínez-Martínez *et al.* (2022) and Adams *et al.* (2021), who also mention that the exploitation of locally available supplies, such as grazing and corn stubble, significantly reduce the production cost. This is how farms from the real scenario do it, where the intensive use of grazing, complemented with the efficient exploitation of harvest residues, decreased the cost by 32%, compared to the simulated scenario (Table 4).

The workforce represented the highest cost in the two scenarios analyzed for production factors; however, for the simulated scenario, the cost was 48% higher than the real scenario,

Table 4. Average production cost (pesos by farm).

Concept	‡Simulated scenario		‡Real scenario	
	($)	(%)	($)	(%)
Tradable inputs	45,268.63	38.63	31,474.45	31.76
Feed	43,500.00	37.12	29,705.82	29.97
Health (medications)	1,521.30	1.30	1,521.30	1.54
Implements (depreciation)	247.33	0.21	247.33	0.25
Indirectly tradable inputs	58,244.74	49.70	58,244.74	58.77
Sheep purchase (cost/head)	58,000.00	49.49	58,000.00	58.53
Infrastructure (depreciation)	244.74	0.21	244.74	0.25
Production factors	13,679.00	11.67	9,383.00	9.47
Land	215.00	0.18	215.00	0.22
Workforce	9,000.00	7.68	4,704.00	4.75
Utilities (payment for water and electricity)	4,464.00	3.81	4,464.00	4.50
Total costs	117,192.37		99,102.19	
Incomes from the activity				
Sale of animals to the barbacoa market	145,000.00	95.23	145,000.00	100.00
ϒManure sale	7,260.00	4.77	0.00	0.00
Total income	152,260.00		145,000.00	
Return	35,067.63		45,897.81	

‡The simulated and real scenarios were adjusted to a production of 58 heads of sheep, finalized in the fattening stage; for the simulated scenario, a productive cycle of three months was considered, while the real scenario has a productive cycle of approximately four months.
ϒThe real scenario did not take into account the cost for manure, since under the extensive system, the animals that are found most of the time in the open field during the finalization stage, and manure and urine are dispersed by the animals themselves to fertilize the pasturelands.

and this is explained mainly because the family workforce is a cost of opportunity that producers do not include in the accounting of exits and returns (however, in this study a cost based on payment per workday in the region for this aspect was counted; Vázquez-Martínez *et al.,* 2018). However, the workforce was the aspect with the highest expenditure in the productive factors (Table 4), which is why its importance in the economic balance and in the financial leverage of the farms is relevant to maintain an economic equilibrium. In the case of the real scenario, the utility was $10,830 pesos higher for each productive cycle of four months compared to that of the simulated scenario (Table 4). Given this behavior, the sheep producers from Singuilucan, with an approximate herd of 58 heads, based on the regional advantages of grazing and family workforce (real scenario), can cover the annual value of the food basket for 3.7 people, according to estimations by CONEVAL (2023).

This council establishes a rural poverty line of $3,102.31 (which is why the profit from the real scenario divides the 4 months of fattening by the amount of the poverty line (45,897.81/4)/3,102.31=3.7 people), economic value that in presence of the employment opportunities (Garmendia *et al.,* 2022) in rural zones, such as the study region, contribute to the food security of the families (Vázquez-Martínez *et al.,* 2018), given the competitive income shown by the small-scale sheep production system.

Private profitability and competitiveness

Sheep production for the real scenario, for each peso invested, obtains 53% more profit than production under the simulated scenario (Table 5). However, Díaz-Sánchez *et al.* (2018) found that fattening sheep with commercial feed was more profitable than the production based on grazing and stubble. This is in contrast with the results of this study, where the expenditure for grazing and workforce are the main advantages of the sheep system since they decrease the production cost (Salinas-Martínez *et al.,* 2022). Daniele *et al.* (2021) and Nyam *et al.* (2022) report similar results, by highlighting that one of the most important threats for sheep farms in terms of profitability are the high costs associated to the purchase of commercial feed. These characteristics show that there is the possibility that only the farms which adopt the following innovative solutions will remain in the business: increasing the number of finalized sheep to use economies of scale, managing the use of grazing and strategies for commercialization (Theodoridis *et al.,* 2021). These results are consistent with those of this study, since a higher profitability is seen when the farms take advantage efficiently of grazing and family workforce (real scenario; Hernández *et al.,* 2022).

The sheep farms, under both scenarios of production, were competitive since they presented values lower than 1. However, the conditions of the real scenario generate greater competitiveness. This capacity is founded on a productive system based on grazing and an intensive use of family workforce. Similar results were reported by Nyam *et al.* (2022), who concluded that the competitiveness of small-scale sheep production systems is limited by the commercialization and high costs of the commercial feed. Although the commercialization was one of the main strengths found in this study, a loss of competitiveness of 62% was observed in the simulated scenario as a result of hiring workforce and purchasing feed. This can gradually exert pressure if the producers modify their production to a more intensive system (simulated scenario), since the volatility in the feed price could increase the breach of competitiveness between the real and the simulated

Table 5. Indicators of private profitability and competitiveness of the small-scale sheep production system in Singuilucan, Hidalgo.

Concept	Simulated scenario	Real scenario
Coefficient of private profitability (%/peso invested)	59.49	112.34
Rate of private cost	0.13	0.08
Added value at private prices (pesos)	106,991.37	113,525.55
Intermediate consumption in total income (%)	29.73	22.00
Added value in total income (%)	70.27	78.00

Source: prepared by the authors.

scenarios in the medium term (Table 5), and intensify the unsustainability of space and time, linked to more intensive sheep systems (real scenario; Dos Reis *et al.,* 2021). With these results, it is possible to determine that the sheep production system in the study region turned out to be not only profitable but also competitive when comparing it with other options of passive investment such as the annual CETES rate = 11.25% (CONDUSEF, 2023), which means that it is more profitable for producers to invest in the business of sheep breeding, since it generates twice the profits in the simulated scenario and it quadruples the profit of the annual CETES rate for the real scenario. These data reflect good competitiveness with low risks (Velázquez-Torres *et al.,* 2022), which proves why Singuilucan is the number one sheep meat producing region in Mexico.

Economic impact of the sheep system in the study region

The added value was $6,534 pesos higher in the real scenario. This difference is associated, primarily, with the payment of workforce counted in the simulated scenario, which decreases the private income of the farms, after having paid for the cost of the tradable inputs (Table 5). This result agrees with the reports by González-Garduño *et al.* (2013), when they found a better economic performance for the added value when the farms finalize the sheep, making use of the advantages of family workforce. This behavior was to be expected, since the sheep farms in the real scenario do not incur in expenses of hired workforce (although a cost based on the payment per workday in the region for this sector was estimated), allowing the reduction of the production cost (Calderón-Cabrera *et al.,* 2021). Although these results have been consistently reported in literature, always with characteristics that belong in each study region, conditions of feeding and technical management, the responses in financial terms of the use of family workforce, are not constant. However, it has been considered a key resource to improve the profitability of sheep farms (Calderón-Cabrera *et al.,* 2021; Hernández *et al.,* 2019).

Economically, the sheep production activity under the simulated and real scenarios of production contributes efficiently in the economic reactivation of region, by devoting 30 and 22% of each peso of income to paying the suppliers (Table 5). This suggests that the small-scale sheep production system is efficient, since it benefits the economy of the farms internally, and local and regional trade externally, through the purchase of inputs, medications and payment of services to suppliers. In this sense, González-Garduño *et al.* (2013) mention that the economic spill generated by the sheep system in Tabasco, Mexico, was higher for systems based on the purchase of commercial feed. This behavior is consistent, since the systems with greater intensification are more dependent on suppliers and services outside the farm. However, this characteristic has been reported with greater financial vulnerability (Adams *et al.,* 2021), since the farms are facing constant change in the price of inputs, which generates lower economic stability when compared to farms that take advantage of natural resources (real scenario).

The total income added value (TIAV) was similar for the simulated scenario and the real scenario of production, indicating that 70 and 78% of the incomes generated by the activity remain in the region (Table 5). This behavior shows that the small-scale sheep production system is a business that allows generating a profitable activity, where members of the family participate (wife, children, and elderly people), who would have access to a labor market with difficulty, although when they participate in this activity they are creators of economic value inside the family business, which should be counted as a production cost (Salinas-Martínez *et al.,* 2022; Calderón-Cabrera *et al.,* 2021).

CONCLUSIONS

Grazing, as a feeding basis instead of commercial feed, increases the profitability of the sheep production system (53%), which translates into a reduction in cost (32%) and an increase in return of $10,830 pesos for each productive cycle of four months. The high dependency on grazing and family workforce observed in the simulated scenario indicate that small-scale sheep production in Singuilucan could be vulnerable, if the micro-regional advantages that these factors contribute were lost, which would translate into a competitive reduction of approximately 62%. The behavior of the sheep production system in the real scenario can be reproduced only if the production unit has the family workforce that is devoted to this activity; otherwise, it would not be possible. Therefore, the families that do not have this human capital could or would be opting for the alternative scenario.

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