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Tesis Doctoral

CHARACTERISATION, TYPIFICATION AND DYNAMICS OF MEAT SHEEP FARMS IN ARAGON (SPAIN)

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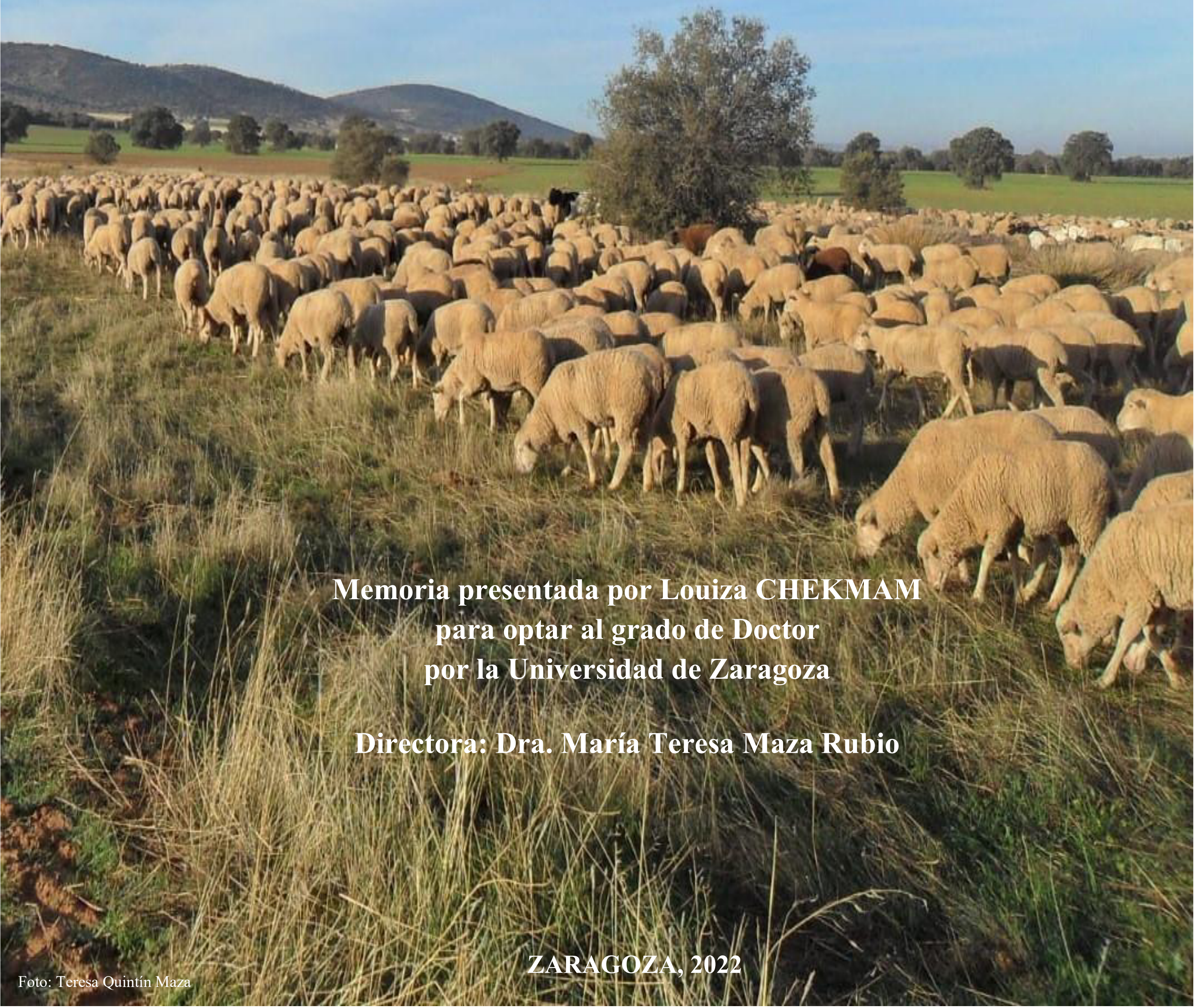
DEPARTAMENTO DE CIENCIAS AGRARIAS Y
DEL MEDIO NATURAL

CHARACTERISATION, TYPIFICATION AND DYNAMICS OF MEAT SHEEP FARMS IN ARAGON (SPAIN)



Memoria presentada por Louiza CHEKMAM
para optar al grado de Doctor
por la Universidad de Zaragoza

Directora: Dra. María Teresa Maza Rubio

ZARAGOZA, 2022

Foto: Teresa Quintín Maza

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La Dra. **MARÍA TERESA MAZA RUBIO**, Profesora titular de Universidad del Departamento de Ciencias Agrarias y del Medio Natural de la Facultad de Veterinaria,

CERTIFICA

Que la Tesis Doctoral titulada “*Characterisation, typification and dynamics of meat sheep farms in Aragon (Spain)*”, elaborada por la Licenciada **LOUIZA CHEKMAM**, ha sido realizada bajo su dirección, se ajusta al proyecto de Tesis aprobado el 1 de noviembre de 2015, y cumple con las condiciones exigidas para optar al grado de Doctor por la Universidad de Zaragoza.

Para que conste, firma la presente en Zaragoza, 12 de septiembre de 2022

Fdo. María Teresa Maza Rubio

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Al alma de mi madre que era y será para siempre mi

luz para guiarme y seguir adelante.

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RESUMEN

El sector del ovino de carne está experimentando un fuerte declive en España y en la Unión Europea. La viabilidad y la continuidad de estos sistemas ganaderos extensivos ha sido un problema real en las últimas décadas. Es un tipo de ganado muy diversificado que juega un papel importante en las zonas desfavorecidas por su contribución a la sostenibilidad económica, social y ambiental, siendo importante garantizar su viabilidad económica en un contexto incierto de ayudas de la PAC. El objetivo principal de la presente tesis doctoral es la caracterización y tipificación de explotaciones ovinas de carne de una región española desde diferentes puntos de vista, estructural, técnico y económico. Esto se justifica por dos motivos: el primero porque, como se ha mencionado, existe una gran diversidad de explotaciones y mediante la tipificación es posible averiguar su heterogeneidad. El segundo porque la caracterización de los diferentes tipos de explotaciones nos permite conocer los factores o indicadores que determinan sus resultados. Los resultados económicos han sido estudiados a lo largo del proceso de caracterización y tipificación, por lo que podemos afirmar que es en la sostenibilidad económica en lo que ha profundizado el estudio. Además, dado el amplio periodo de tiempo del que tenemos información de las explotaciones (1993-2016) se han podido estudiar las trayectorias seguidas por las mismas y los cambios que se han producido en los diferentes indicadores (estructurales, técnicos y económicos), con el fin de identificar cuál ha sido su dinámica y predecir la adaptabilidad a futuros escenarios y su resiliencia a los cambios ocurridos en el tiempo. Se ha utilizado una muestra de 128 explotaciones ovinas localizadas en la Comunidad Autónoma de Aragón (España) con registros de datos en un largo periodo de tiempo como se ha mencionado. Mediante el uso de diferentes metodologías estadísticas, principalmente de tipo multivariante, se ha obtenido lo siguiente: 1) Los indicadores estructurales, técnicos y económicos evaluados tienen un impacto real en los resultados económicos de las explotaciones ovinas de carne, tanto si se tienen en cuenta o no la mano de obra familiar o las subvenciones. 2) La optimización del número de ovejas por unidad de trabajo y por hectárea de superficie agrícola útil son aspectos importantes para mejorar la rentabilidad de las explotaciones ovinas de carne. 3) Un buen manejo reproductivo con mejoras en la productividad predice un buen desempeño económico al reducir el impacto de las subvenciones. La mano de obra principalmente familiar y su intensificación, el número de corderos vendidos por oveja, la prolificidad y el número de partos por oveja, la correcta tasa anual de reposición de

ovejas y el número de ovejas por semental son importantes para mejorar los resultados económicos. 4) La carga ganadera y la tasa de mortalidad de los corderos tiene un poder de predicción negativo sobre los resultados económicos. 5) Con respecto a los costes, los de alimentación representan casi el 70 % de los costes totales, minimizar este porcentaje podría mejorar los resultados económicos. Esto podría ser posible con una mayor autonomía alimenticia basada principalmente en el aprovechamiento de pastos naturales. 6) Los resultados muestran cuatro tipos de trayectorias de las explotaciones caracterizadas por una mayor o menor estabilidad tanto a corto como a largo plazo. Vuelve a ser evidente que, a largo plazo, mejorar la autosuficiencia alimentaria y la productividad de las ovejas es importante para mejorar la rentabilidad de las explotaciones de ovino de carne, reduciendo su dependencia de las subvenciones y mejorando su viabilidad. También se ha puesto de manifiesto que existen limitaciones en algunos grupos de explotaciones que condicionan la flexibilidad y adaptación a los cambios que introducen las medidas de la PAC. Probablemente, será interesante tener en cuenta esta diversidad para aplicar políticas más específicas. Así, estos sistemas podrían ser más sostenibles y resilientes y aumentar su flexibilidad y adaptabilidad a los continuos cambios en las políticas de ayudas y al cambio climático.

ABSTRACT

The sheep meat sector is experiencing a strong decline in Spain and in the European Union. The viability and continuity of this extensive farming systems have been a real issue in the last decades. It is a very diversified type of livestock that plays an important role in less favoured areas due to its contribution to economic, social and environmental sustainability, being important to guarantee its economic viability in an uncertain CAP aids context. The main objective of the present PhD thesis is the characterisation and typification of meat sheep farms in a Spanish region from different points of view, structural, technical and economic. This latter is justified by two reasons: the first because, as it has been mentioned, there is a great diversity of farms and by typification it is possible to figure out their heterogeneity. The second because characterizing the different types of farms allows us to figure out the factors or indicators that determine their results. The economic results have been studied throughout the characterisation and typification process, so we can affirm that it is the economic sustainability that the study has deepened into. Moreover, given the long period of time for which we have information on the farms (1993-2016), it has been possible to study the trajectories followed by them and the changes occurred in the different indicators (structural, technical and economic) in order to identify the drivers of change which affect the dynamics of these farms and predict their adaptability to future scenarios and their resilience to changes occurred over time. A sample of 128 sheep farms from Aragon region (Spain) with data records on a long time period as it has been mentioned previously. By using different statistical methodologies, mainly multivariate analyses, it has been resulted the following: 1) The assessed structural, technical and economic indicators have a real impact in improving the economic results of the meat sheep farms in both cases with or without taking into account family labour or subsidies. 2) The optimisation of the number of sheep per labour unit and per hectare of useful agricultural are aspects to be taken into account when it comes to improving the profitability and viability of meat sheep farms. 3) Good reproductive management with improvements in productivity predict good economic performance by reducing the impact of subsidies. Labour mainly family labour and labour intensification, number of sold lambs per ewe, prolificacy and number of lambings per ewe, the right annual ewe replacement rate and number of ewes per stud are important in improving the economic results. 4) Stocking rate and lambs' mortality rate has a negative predictive power on the economic results. 5)

With respect to costs, feeding costs represent almost 70 % of the total costs, reducing this percentage could improve the economic results. This could be possible with more feed autonomy based mainly on naturel grazing resources. 6) The results show four types of trajectories of the farms characterised by greater or lesser stability in both the short and long term. It again becomes evident that, in the long term, improving feed self-sufficiency and productivity of sheep is important to improve the profitability of meat sheep farms, reducing their dependency on subsidies and improving their viability. Furthermore, it has been shown that there are limitations in some groups that condition the flexibility and adaptation to the changes introduced by the CAP measures. Probably, it will be interesting to take into account this diversity for more targeted policies mechanisms. Thus, these systems could be more sustainable and resilient and could increase their flexibility and adaptation to the continuous changes in the policy aids as well as the climate change.

GENERAL INDEX

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AR: Autonomic Region.

CAE: Cooperativas agroalimentarias de España

EU: European Union

FAO: Food Agricultural Organisation

INE: Instituto Nacional de Estadísticas.

MAGRAMA: Ministerio de Agricultura, Alimentación y Medio Ambiente.

MAPA: Ministerio de Agricultura, Pesca y Alimentación.

SEOC: Sociedad Española de Ovinotecnia y Caprinotecnia.

USDA: United States Department of Agriculture.

INTRODUCTION AND JUSTIFICATION

1- INTRODUCTION AND JUSTIFICATION

1-1. Features and functions of the extensive sheep farming

The sheep activity in Spain is almost localised in less favoured areas, where 80 % of the census is localised in areas with specific difficulties (MAGRAMA, 2013; Toro-Mujica et al., 2015; Betolozzi-Caredio et al., 2021). Sheep farming, in fact, is likely to be practiced in those regions where other productive activities would be unfeasible (de Rancourt et al., 2006). They are mostly characterised by extensive and semi-extensive systems the result of the spread of autochthonous breeds and their exceptional adaptation to extreme environmental conditions, generally accompanied by grazing land, as well as different forage species and rainfed cereal crops (Pardos et al., 2008). However, the adopted systems vary according to the areas, farm size and the livestock production orientation (Esteban et al., 1997; Pardos et al., 2008). Aragón is one of the important ovine regions in Spain which counts about (10.25 %) the total national ovine flock (MAPA, 2022). The sheep farming in Aragon is oriented toward meat production. The model employed is associated with grazing chiefly on areas over to cereal crops, taking advantage of stubble and fallow fields (Pardos et al., 2008).

Sheep extensive farming systems are multifunctional, it can be illustrated by the important role in forest fires prevention. In Spain, grassland has decreased by 15% in 2000s, leading to an increase in abandoned shrub and forest areas (Betolozzi-Caredio et al., 2021; Porqueddu et al., 2016) which increases the risk of forest fires. The second role is rural population fixation in very disadvantaged areas for other activities. They are a source of employment in disadvantaged agricultural areas a high-quality traditional product they yield are broadly recognised as the result of a sustainable and multifunctional form of agriculture that contributes to preserve the environment and social cohesion in rural areas (Kramer, Groen and Van Wieren, 2003; Plieninger, Hochtl and Spek, 2006; Rodríguez, 2010; Ruiz-Mirazo, Robles and Gonzales-Rebollar, 2011; Ripoll-Bosch, 2013; Rossi, 2017). Batalla et al. (2015) have highlighted the climate mitigation potential of the grazing systems. González, Garcia and Garcia Arias (2014) have classified the factors which affect evolution and changes in agrarian farms in four groups: macroeconomics factors, public policies, localisation and characteristics of the farm.

During the last decades, sheep sector is going through a very difficult situation. The EU sheep and goat sector has been experiencing economic and structural difficulties in recent decades, mainly involving a consistent decrease in livestock numbers, following outbreaks of contagious diseases and policy changes in public funding schemes. With a population of about 98 million animals and a production that accounts for a small share of the total EU livestock output, the sheep and goat sector does not ensure self-sufficiency. That is why the EU is among the world's main importers of sheep and goats, mainly from New Zealand and Australia. Moreover, as sheep and goat farming are among the less remunerative agricultural activities, it does not encourage investments or new entrants from younger generations of farmers (Rossi, 2017). Spain with the largest sheep flock in EU knows the same downward trend in sheep heads number which decreased about 30 % from 2007 to 2020 for the total ovine flock and 37.6 % for meat sheep flock. Aragon region, our case study, has recorded a decrease of 40.32 % for its total sheep flock (MAPA, 2022). The consumption records a downward trend too, it decreased for the same period with about (–57 %). The consumption per capita decreased from 2.7 kg in 2007 to 1.17 kg in 2021 which confirms the decreasing trend recorded these last years (MAPA, 2022).

The diversity of sheep farming is one of the issues which make difficult implementing new adequate management programs or more adaptative policies measures to support the viability of these extensive sheep farming systems which is really threatened. Extensive sheep farming systems are characterized by unique and intrinsic features, which make them diverse with respect to other livestock sectors, and more difficult to support and restructure (Betolozzi-Caredio, 2021). In sheep farming there is great variability and heterogeneity in the farming systems due to the limitations that the farms have in terms of labour, land, animal breeds, feeding systems, knowledge of management, etc. (Pardos et al., 2008; Benoit et al., 2019 and 2020).

1-2. Justification

Therefore, the urgent need for the extensive sheep farming systems to adapt sustainable management systems to be able to remain insuring their critical and irreplaceable role in the overall economic, environmental and social sustainability, was the main motivation of the present PhD thesis. The critical situation of the extensive sheep farming in marginal areas in general and in Spain in particular motivates us to plan for the present PhD thesis, which aims to study the economic sustainability of the studied sample given its importance in the overall sustainability. As these systems are generally dependent on

Common Agricultural Policy (CAP) measures mainly those related to subsidies (Milán, Arnalte and Caja, 2003; Weltin, Zasada and Piorr, 2016; Soriano, Bertolozzi-Caredio and Bardaji, 2018; Benoit et al., 2020) the farms with good economic results will be more resilient and more flexible to the changes in the CAP subsidies. These farms will be economically independent and develop more viable management systems.

2- RESEARCH OBJECTIVES

2-1. General objective

As it has previously mentioned in the motivation part, the nucleus of the present PhD was born from the observation of the current situation of decline of the extensive sheep farming systems which threaten the viability and the continuity of a very important and vital sector in less favoured areas. Thus, identifying the main factors or drivers of change, which could reverse this situation and give more opportunities of viability to this important, diversified and vulnerable sector, is a real emergency.

Therefore, the main objective of this PhD thesis is the characterisation and typification of meat sheep farms from different points of view, structural, technical and economic. This is for two reasons: the first because, as it has been mentioned, there is a great diversity of farms and by typification it is possible to figure out their heterogeneity. The second because characterising the different types of farms allows us to figure out the factors or indicators that determine their results. Their economic results have been studied throughout the characterisation and typification process, so we can affirm that it is the economic sustainability that the study has deepened into. Moreover, in this PhD thesis it will be used the approach of studying the farms trajectories and the dynamics of change which have occurred in the different indicators (structural, technical and economic) in order to identify the drivers of change which affect the dynamics of these farms and predict their adaptability to future scenarios and their resilience to the tremendous changes occurred over time.

To this end it has been focused on the case study of the extensive sheep farms in Aragon region in Northeast Spain. This analysis would give us a holistic view for the extensive sheep sector in Spain.

2-2. Specific objectives

1- What are the relevant structural indicators that could influence greater in the economic profitability of meat sheep farms?

   The objective is to identify the main structural indicators and their use that increase or decrease the economic profit for each specific group of farms with assessing the family labour contribution in the gross margin per labour unit.

2- What are the technical indicators that could influence greater the economic profitability of meat sheep farms?

   The objective is to identify the main technical indicators and their management that increase or decrease the economic profit for each specific group of farms with assessing the subsidies' contribution in the gross margin per labour unit.

3- What is the combination of the structural, technical and economic indicators which could influence significantly the economic profitability of meat sheep farms?

   The objective is to identify the main structural, technical and economic indicators that increase or decrease the economic profit for each specific group of farms with assessing the subsidies' contribution in the gross margin per labour unit. And figure out the main interactions between these three types of indicators.

4- What are the trajectories of evolution of the studied meat sheep farms and what are the main drivers of change on the short and long term. And the impact of the CAP measures on the dynamics of each group of these farms?

The objective is to figure out the main trajectories of change for a constant sample on the short and long term and the main drivers of change for each trajectory. Furthermore, how sensitive was each resulted trajectory of farms to the changes of the CAP measures.

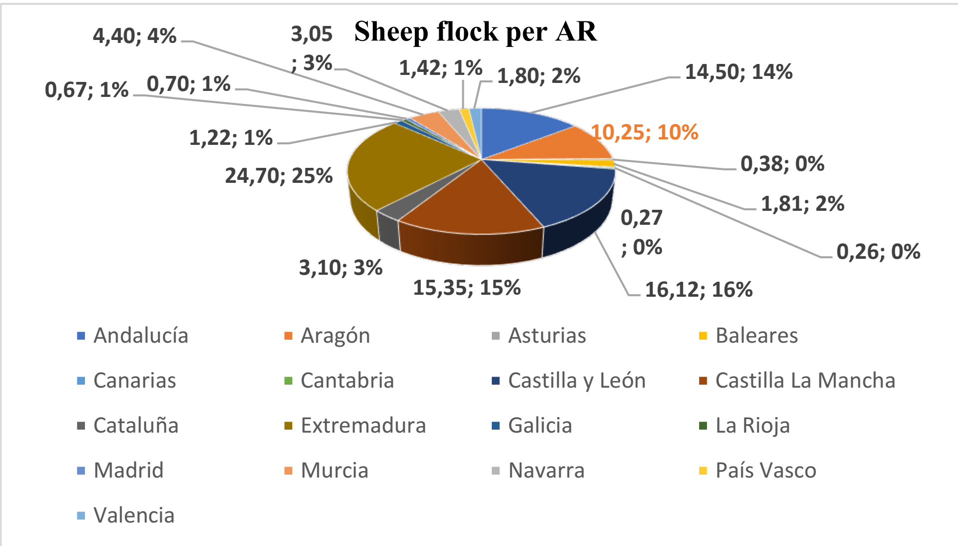
BIBLIOGRAPHIC ANTECEDENTS AND STATE OF THE QUESTION

3- BIBLIOGRAPHIC ANTECEDENTS AND STATE OF THE QUESTION

3-1. Key statistical data of meat sheep sector in Spain

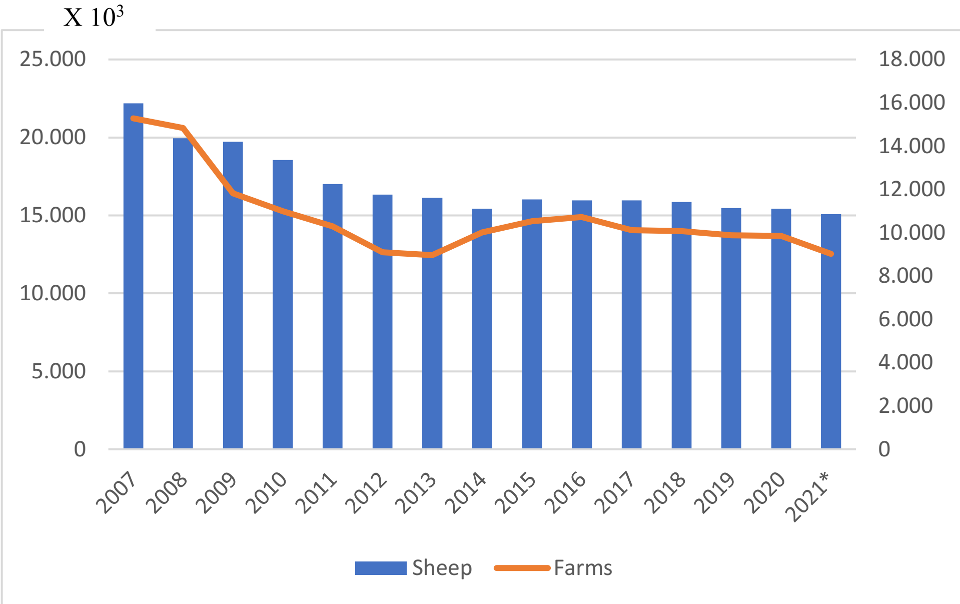
After BREXIT the sheep flock in Spain in 2021 has reached almost 26 % of the total of the EU-27, which allows to Spain to convert to the first country with more sheep in the European union (MAPA, 2022). Figure 1 shows the distribution of sheep flock in Spain per autonomic region (AR). As it can be seen, Aragon region represents (10.25 %) of the total national flock. It is classified as the 5th autonomic region with more sheep heads. In figure 2, it has been shown the trend of the sheep farms in Spain from 2007 to 2022. The number of sheep farms has suffered a decrease of (-13 %) from 2007 to 2012. Despite the rebound in the number of the farms after 2012 until 2015, the trend got back to decrease and it has recorded a more or less stability than the first period. For the same period the number of sheep has decreased (-32 %) for total flock size, and it has been recorded a decrease of (-39 %) of meat sheep while the decrease in milk sheep has been (- 19,6 %). Figure 3 shows the evolution of meat sheep consumption. It has been recorded a decrease of (-57 %) from 2007 to 2021 in meat consumption per capita (MAPA, 2022). It is a high rate of decrease. Finally, we can say that despite the importance of sheep sector in maintaining the overall sustainability of the society in marginal regions, the trend of the different parameters tends to decrease.

Figure 1: Distribution of the sheep flock in Spain per Autonomic Region (November, 2021)



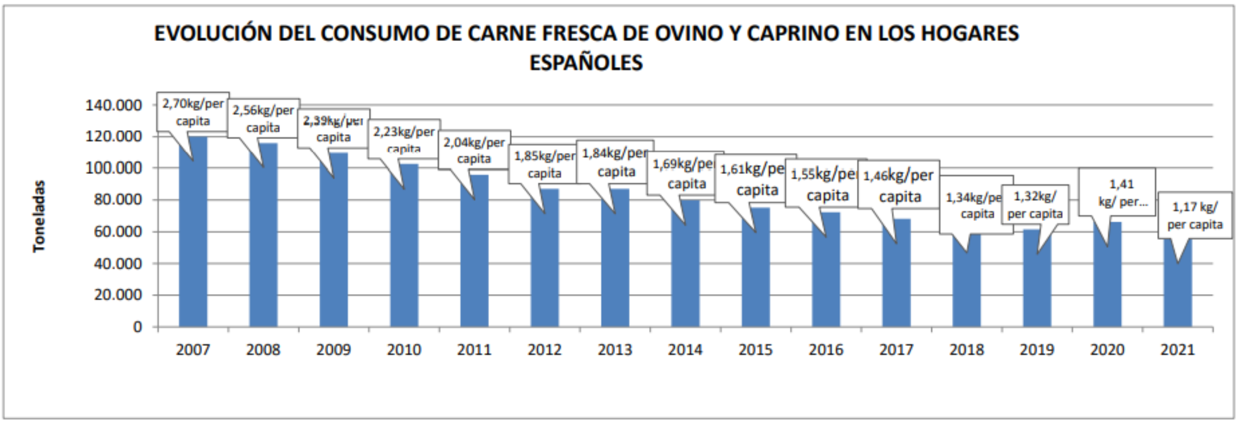
Source: Statistics. MAPA, 2022. Graphic. Own elaboration

Figure2. Evolution of sheep heads and farms in Spain from 2007-2021



Source: Statistics. MAPA, 2022. Graphic: own elaboration
*November, 2021

Figure 3. Evolution of the fresh meat sheep consumption in Spain from 2007-2021



Source: MAPA, 2022

3-2. Bibliographic antecedents

As it was previously mentioned in the introduction that sheep sector in Spain is experiencing a difficult episode in its existence, there were numerous research studies which have been conducted to identify the responsible factors on the actual situation. Moreover, attempt to propose viable solutions in order to contribute to improve the viability chance for these farming systems.

For the reason of the multifunctionality of ovine sector previously commented, there are authors who studied the viability of sheep farms with respect to their three dimensions as Batalla, Pinto and del Hierro (2014) who find that the holistic view of farms and figuring out correlations between social, economic and environmental aptitudes improve the viability options for survival of farms. Pardos et al. (2008) confirm that the importance of sheep meat sector goes beyond the strictly economic, covering also important environmental and social aspects in the territories which support this livestock. Pardos and Fantova (2007) studied the influence of the different productive factors in the economic results, and within the main findings was the necessity to have a technical economic control of the farm and the use of new reproductive techniques.

As the extensive sheep farming systems are heterogeneous and diverse, it has been studied this diversity to understand better the management systems at farm groups level. It has been used the typification or classification as a methodological method to figure out the different existing farming systems. Some studies have been cited previously. The conclusion from these studies that focused on one indicator and data in a single point of time or a very short period (Hamrouni, 1993; Manrique et al., 1994; Manrique et al., 1999; Paz et al., 2003; Milán, Arnalte and Caja, 2003; Milán et al., 2006; Chertouh, 2005; Pardos et al., 2008; Pardos, 2014; Ripoll-Bosch, Joy and Bernués, 2014; Mena et al., 2016). In the present Phd thesis we will attempt to prepare a robust analysis of characterisation and trajectories for Aragonese meat sheep farms which would be representative of the whole extensive sheep farms in Spain. The available data along 24 years would allow us to study the trajectories' dynamics of these farms with more precision and more realism. Thus, assess the previous results in this same area.

It has been deduced that the main condition to reach the economic efficiency is the necessity to get the reliable technical economic information at the accurate time. Sierra (2002) has mentioned in his study that a high livestock company benefit depends on the right management. In the purpose to know deeply the company characteristics and its management, it is necessary to develop technical economic studies. They are developed in three steps as following: the first step is about data collection, the second one is the data analysis, elaboration and the establishment of the right conclusions. The last one is the diffusion of the results for the livestock sector which can improve the sector management.

Other research studies have studied deeply one type of indicators, technical economic or structural factors or indicators influencing the viability and profitability of farms. Ripoll-Bosch et al. (2012) deduced that the economic efficiency of farming was mainly explained by high animal productivity as well as high forage and feed self-sufficiency in the meat system. A clear trade off was observed between economic and environmental indicators, the higher the economic sustainability the lower the environmental one. According to Benoit et al. (2019) low-productivity but fully self-sufficient fodder livestock systems can achieve excellent economic performance, but require both specific skills and marketing adequacy.

Pardos et al. (2008) studied the diversity of sheep production systems in Aragón. They found four groups of farms, the typologies obtained show the relationship in the sheep studied production systems, between production intensification, feeding costs and labour productivity. Numerous studies have studied feeding costs and it has been concluded that is a main concern in extensive sheep farming systems and it is classified as the leading risk factor for the viability of these systems (Bertolozzi-Caredio et al., 2021; Benoit et al., 2019 and 2020).

From his side, Raineri, Stivari and Gameiro (2015) have found that the analysis of elasticity clearly shows that the biggest obstacle to the economic viability of lamb production, under the observed conditions, is the low technical level of the activity. High production costs are often more related to inadequate zoo technical indicators, than actually to high expenses. Others like Ameen, Manrique and Olaizola (2009) have found that significant structural changes (growth in livestock unit, reduction in labour, etc.) have not resulted in appreciable gains in livestock productivity. They were linked mainly to a favourable evolution in the price ratios than to technical improvements.

At present it is making great efforts in improving the automation and productivity of meat sheep farms, trying to optimize the feeding, increase the number of sold lambs per ewe, adjust the number of sheep to the available labour and increase training level for farmers (Pardos et al., 2009). Olaizola, Chertouh and Manrique (2008) have concluded that the adoption of the new feeding technology led to positive changes in farm structure, particularly in terms of flock size, and could contribute to the social sustainability of sheep farms in the region. The economic interest of adopting this feeding system depended largely on the expected improvements of technical results and on the increase of feeding costs that new feeding technology involved.

Pardos (1994) have deduced that the economic results of livestock farms, its evolution and the influence on them of temporary, structural and spatial factors, is necessary to the right and efficient management of these farms (knowing the inefficiency reasons leads to propose suitable solutions), in the application of agricultural policy, and for studies related to the changing processes in the farm and its origin.

With respect to studies on farms trajectories, Iraizoz, Gorton and Davidova (2007) studied the trajectories of agricultural farms in Navarra region in Spain, they concluded that high levels of direct payments dampen pressures for restructuring rather than stimulating improvements in productivity. Farms in the most marginal areas benefited relatively little from the switch to more direct forms of farm support and their continued existence depends on farmers accepting returns below their opportunity costs for own land and labour (self-exploitation). González, Garcia and Garcia Arias (2014) have studied the trajectories of growth of agrarian farms in the Cantabria coast; they concluded that the pathways were affected by the location and intrinsic farms factors. However, studies about sheep trajectories in particular are very scarce, the only one we could find is the research paper of Benoit and Laignel (2011) where they studied the trajectories of meat sheep farms on a long term period in France.

With respect to public policies, it will be interesting and very important to study the effect of the CAP reforms on the evolution of these farms. The survival of ovine sector is very dependent on CAP subsidies than production and economic benefit. Gaspar et al. (2008) found that 29 % of the total farm income is depending on livestock subsidies and any changes in the PAC affect these farms. The majority of studies on this aspect are unanimous that the PAC reforms have caused adjustments on farms' structure and strategies of management. For example, the total decoupling of aids led to the decreasing in the size of herds. So, sheep farms are affected by these direct aids. The PAC subsidies represent a real network of insurance which avoid the disappearance of this sector (MAGRAMA, 2013; CAE, 2012; AND international and European Commission, 2011). Pardos et al (2008) found that the flexible adaptability to change contexts in agricultural policy is also an important factor which affects the survival of meat sheep farms.

It was highlighted a real interest to investigate on the farm systems, where it was created different management groups in different departments in Spain. Within the most important programmes the National Farm Accountancy Network (RECAN). It was initiated since 1972, provides economic and financial information of the farms and their evolution, from the following variables: production value, sales and purchases of livestock and crops, production costs, finance charges and interest, assets, liabilities, fees, grants and subsidies, etc. Moreover, assesses objectively the impact exerted by agricultural policy measures´ on the evolution of agricultural enterprises. The ‘RECAN‘data base is often used by researchers to study the agrarian sector. With respect to the ovine sector, there are other programmes from which we can cite “Management programme of Latxo ovine in Pais Vasco” oriented to milk production, developed from 1988. The differences noticed between theses management programmes are mainly oriented to the global analysis of the farm or the separation of the analysis of different productive speculations and the calculation method of the results and the assessment th used criteri, especially the estimated costs.

In the case of Aragon different programmes were developed to manage the information in the farm. One of these programmes is headed by Cooperativa Oviaragon grupo pastores, with collaboration with the Superior Polytechnic School in Huesca, University of Zaragoza. The data in the present PhD thesis have been collected through the programme called (GTE1).

MATERIAL AND METHODS

4- MATERIAL AND METHODS

4-1 Literature review

To collect secondary data, a literature search related to previous studies about issues related to our topic is planned. The principal topics which have been investigated were related to sheep production, consumption and trade in Spain and in worldwide, as well as all literature about technical economic management in sheep sector in Spain and outside. Likewise, search studies investigated trajectories and dynamics of ovine systems in Spain and in Aragon specially.

To perform the literature search, it has been used the major databases which collect the most prestigious journals in different scientific fields as Science-direct, Web of Science and Web of Knowledge. It has been used the search engine "Google", "Google Scholar". Furthermore, various official statistics sources have been used such as Food Agricultural Organisation (FAO) and the United States Department of Agriculture (USDA) websites. Statistical annual reports from the Spanish Ministry of Agriculture, fisheries and food (MAGRAMA or MAPA) have been used to collect data about sheep sector in Spain. Likewise, it has been searched informative reviews and journals which gather data and news on ovine sector in Spain.

4-2 Primary data

a- Sample

In our study the sample size is made up of 128 meat sheep farms which belong to Cooperativa Oviaragon. These farms are selected from a larger sample with 233 sheep farms those participated in the Technical Economic Management Programme 1 (GTE1) headed and developed by Cooperativa Oviaragon grupo pastores, with collaboration with the Superior Polytechnic School in Huesca, University of Zaragoza. The criterion of selection which used to select the 128 farms was the number of years of participation of every farm in the GTE1. It was selected those participated in this programme with an average period of 5 years or more. It is supposed that 5 years period is sufficient to study farms evolution or dynamic which is one of the important objectives of the present research (examples of studies: 1- Pardos et al. (2008): Sheep farms characterisation and typification in Aragon. The data used were for a period of 5 years. 2- Garcia Martinez, (2007): The recent dynamic of bovine system in the central Pyrenees. The data used refers to 15 years. 3- Pardos et al. (2014): A technical economic study of meat sheep farms in Aragon along of 5 years. 4- A report of Spanish agricultural ministry where it was analysed the impact of CAP reforms on the sheep sector along 7 years period. With a sample which counts with longer period of data collection from 5 years to 24 years, the authenticity of the present PhD thesis results and the representativeness of the sample in this type of studies will be better comparing to smaller samples and short study periods. Given that the technical-economic program which recorded all the data used in the present study began in the decade of the 90s and the continuity of many of the farms, in some cases we used data averages of 24 years that range from 1993 to 2016. For each farm the mean data of each variable corresponds to the average of the years for which there were records or registers. The length of the study period made it necessary for those variables expressed in monetary units to be converted to constant euros of 2016.

b- Study area

The farms are located in Aragon region (Spain). Aragon is an autonomous region in north-eastern Spain. The Aragonese autonomous region comprises three provinces (from north to south): Huesca, Zaragoza, and Teruel. Its capital is Zaragoza. The sample of farms is distributed on the three provinces which characterised by extensive sheep farming system with meat production orientation.

c- Data collection

To achieve this project, as we previously mentioned that the 128 meat sheep farms are integrated in the technical economic management programme network (GTE1) belonging to Oviaragon Cooperativa and the Polytechnic School of Huesca (University of Zaragoza). The data have been collected through the GTE1 programme since 1993 until 2016. Given the long period of the study the monetary data have been converted to constant euros of 2016. The Data have been processed according to the objectives of the present PhD thesis.

d- Data analysis

d-1 Descriptive analysis for the sample

Farms' structure

To analyse the farms' structure, it was analysed the structural indicators which have been recorded. The most interesting indicators are about the cattle size (number of ewes), number of studs present and the labour or work units available (Chertouh, 2005; Pardos, 1994; SEOC, 2014). Added to the structural indicators previously cited it was described the following: the annual ewe replacement rate and the annual stud replacement rate, % of studs by 100 ewes, ratios related to total man labour units, family labour units and number of ewes per labour unit, the total useful agricultural area, irrigated and non-irrigated useful agricultural area, rented grazing land, hectares used for sheep, stubble follow land and hills hectares, and ratios related to (% forage UAA, % owned UAA, % rented UAA per useful agricultural area). The information about the agricultural land is available for just some years.

For Labour Unit, within the different definitions it has been opted for the definition proposed by the National Institute of Statistics (INE) One (1) ALU (Annual Labour Unit) is equivalent to the labour realised by one person at full time during one year (1826 hours/year or more) (SEOC, 2014). In the case of family labour, one person can never exceed the labour unit equivalent, even if his effective labour time is above the regional norm and the relative farm type (Regulation CE 868/2008 of the commission)

Handling and production indicators

To analyse this part, it was taken into account indicators related to the number of lambings/present ewe per year, the medium interval between births (days), prolificacy, % twin births, % births with more than two lambs, born lambs/present ewe, % abortions, % lambs' mortality, number of sold lambs/present ewe and number of ewes/stud.

Revenues' structure

To describe the revenues, it was studied the following parameters: average lamb price, revenues per ewe and farm, subsidies and sold lambs revenues, inventory difference and other revenues.

Costs' structure

Costs' structure includes a large list of indicators related to feed, rented land, salaried and family labour, social security, sanitary costs, animal purchase, financial costs and other costs. To analyse deeply these costs, it was described cost per farm and per ewe. The following are cost indicators which were described: total feed cost, purchased feed cost, rented grazing land cost, auto consumption cost, salaried man labour units cost, social security family man labour units cost, health and reproduction cost, purchase of breeding stock cost, financial and general costs. Furthermore, it was analysed ratios related to the importance of costs components by farms' flock size and land size stratum.

Economic results structure

It has been done a descriptive analysis for the gross margin per ewe and per farm and per total man labour unit. The gross margin was the economic indicator used to describe the economic results. The gross margin is calculated as revenues minus the costs per sheep, with the income being all those derived from sheep activity and the costs being all less amortizations (for family labour, it is considered the cost of social security). It has been performed an analysis of frequencies to describe the sample which was divided to 6 flock size dimension stratum and 5 total useful agricultural area (TUAA) dimension stratum.

d-2 Farms' typification

It has been used the multivariate analysis: the Principal Component Analysis (PCA) method and the Cluster Analysis to identify the different homogenous groups of the studied farms. It has been chosen a set of variables of each single performed typification in the present study.

Principal Component Analysis

It has been used the Principal Component Analysis (PCA) in order to reduce the variables used in our analysis**.** The objective of PCA is the data reduction, replace original variables with fewer factors for subsequent analyses and identify the dimensions of an original set of variables such as a scale. In the present case the purpose is to reduce the variables related to the structural, technical economic management in the ovine sector to fewer factors in order to facilitate the analysis. To confirm the data are correlated it is used the 'KMO 'index and Bartlett's (Chi-square) test for Sphericity. The 'KMO'index value has to be near of one to confirm the existence of the correlation between variables Bartlett's (Chi-square) test for Sphericity is the statistical test used to confirm correlation between variables in the factor analysis. The nil hypothesis no correlation between variables is rejected at $p < 5$ % (Ness, 2014).

The next step is to analyse the communalities which are the proportion of variance of a specific variable explained by all the derived factors. The higher the value of the communality the higher is the variance explained by the extracted factors. To interpret the explained variance analysis and the extraction of factors, it was taken in account: the Eigen value criterion, derive factors as long as the Eigen value is at least one, the screen test: plot of Eigen value against the factor number, look for elbow shaped kink in the plot and the variance criterion which compares percentage of variance explained with the percentage of variance of previous factor and cumulative variance of factors derived up to that point. The explained variance must be more than 60 %. The factors rotation uses the Varimax rotation with Kaiser Normalization. This treatment is performed to characterize the factors. Finally, it was selected the strongly correlated variables.

Cluster analysis

Cluster analysis is a multivariate analysis. Cluster analysis can complete the factor analysis by using the factor scores. The objective of cluster analysis is to group objects (e.g. people, products)**.** The similarity within the group must be as big as possible, and the variance must be as small as possible, and it's vice versa between groups. With cluster analysis it will be used the factor scores to identify the clusters through the principal components method and it will be created groups of similar individuals. The proportions of the clusters were defined with the variable «cluster membership». It is often used (ANOVA) to test the difference between groups with respect to each factor (Ness, 2014).

d-3 Multiple linear regression

In the multiple linear regression analysis, the predictor variables were the chosen structural, technical and/or economic variables which have been used to carry out the factor analysis, and the dependent variable was the gross margin per labour unit (GM/LU) with and without taking into account subsidies for research papers 2 and 3, and the gross margin per labour unit with and without taking into account the cost of family labour for research paper 3. It has been performed a multiple linear regression for the whole sample and for each group resulted from the cluster analysis. To perform the multiple linear regression analysis, it was used the stepwise method to keep only the significant independent variables in the resulting models.

The linear generic model was formulated as follows:

$$(GM/LU) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ...\beta_n X_n + e$$

Where GM/LU (Gross margin per labour unit) with subsidies, without subsidies, with family labour cost and without family labour cost) is the dependent variable, $\beta 0$ is the regression constant, and β_1, β_2, β_3 ... β_n are coefficients to be estimated, X_1, X_2, X_3 .. X_n were the used structural, technical and economic variables (depends on each research paper) and (e) is the error of the regression model. Regression coefficients were checked using the t-test. The coefficient of determination (R2) was used as a predictive criterion for the regression model (Draper and Smith, 1998; Sakar et al., 2011). Furthermore, the robustness of each of the models was validated as follows: the absence of multicollinearity was verified using the tolerance index and the variance inflation factor (VIF). According to Pérez (2005), a large VIF and a small tolerance index may indicate the possible presence of collinearity. A VIF < 10 is acceptable to conclude that there is no multicollinearity problem (Marcoulides and Raykov, 2019). To verify the serial correlation of the residuals, the Durbin Watson test was applied, which establishes that a value close to 2 indicates that there are no autocorrelation problems. It is usually considered that between 1.5 and 2.5 there should be independence between the residuals (Pineda Jaimes et al., 2011). For the model goodness of fit, from the model summary, the explained variance can be assessed from the adjusted R2. On the other hand, from the ANOVA summary, the F statistic allows us to assess whether there is a significant linear relationship between the dependent variable and the set of independent variables of the model. Especially, with the significance level, it can be assessed if this relationship is significant (lower than 0.05) (Vilá, Torrado and Reguant, 2018).

d-4 Analysis of trajectories evolution

The sample used for the analysis of the farms trajectories is made up of 23 meat sheep farms, selected from the original sample of 128 provided by the GTE1. Only 23 sheep farms have been selected since a constant sample is needed for the study of trajectories on long time period. The selection of these 23 farms has been mainly based on the number of years that each farm spent in the technical-economic management program. After consulting studies related to farms typologies or trajectories of change, it has been chosen farms that have been participated 18 years and more in this data collecting program (it has been collecting data from 1993 until 2016), it has been considered that 18 years is a strongly sufficient time period to study a farm trajectory. A serie of variables has been selected based on previous studies (Hamrouni, 1993; Chertouh, 2005; Pardos et al., 2008; López-i-Gelats, Milán and Bartolomé, 2011; Benoit and Laignel, 2011). It has been used 14 different types of variables mainly structural, technical and economic (See research paper 4). To analyse the trajectories first we carried out a principal component analysis (PCA) based on the 14 variables previously commented. In this study the 23 farms represent 497 years-farm (number of individuals), which means each farm has been represented by the number of the years spent in the recording data programme; remember that there are 18 years or more for each farm. For this long-time study period, the annual data (14 variables) per farm has been projected on the plan defined by the two first factors resulted from the PCA. The years' dots have been connected as curves that represent the trajectories. In graphic representation the big dot represents the first year of data recording and the arrow represents the last year of data recording for each farm (see research paper 4). It has been used two types of criteria to study the evolution of each farm. The present methodology has been used by Benoit and Laignel (2011):

1/ Variability between successive years: it shows the stability or the instability of the technical itineraries and performances. This variability has been figured out by calculating the mean distance per farm between successive years (MDF) for each variable. This distance has been calculated using the coordinates of each year-farm of the 14 factors defined by the principal component analysis.

2/ Distance between the year of the start and the end of data recording for each farm in the management programme. This criterion gives us an idea on the changes occurred in farms' structure and the different modes of using farm land. It has been calculated with the same formula used in the calculation of (MDF) but using just two points: the beginning year and the ending year for the farm studying period.

The formula to define the mean distance between successive years (MDF) is the following:

$$MDF = \frac{\sum_{i=1}^{n-1} [\sum_{j=1}^{14} (x_{i+1}^{j} - x_{i}^{j})^2]^{1/2}}{n-1}$$

Where:

i: years (n is the available years for the farm)

j: the studied factor or variable

xji = the value of the factor j for the year i

The SPSS version 26 statistical software package has been used to carry out the statistical analyses.

RESULTS AND DISCUSSION

5-RESULTS AND DISCUSSION

5.1- Description of the studied sample

a. Structural description of the sample per number of ewes' strata

The information corresponding to structural data per ewes' flock size groups is illustrated in table 1. The results show that stratum of the smallest and largest farms flock size represent almost the same percentage (13.3 %) and (12.5 %), respectively, with respect to the total sample size. Almost 1/2 of the sample (47.7 %) are farms with sizes oscillating between (300 and 600) ewes, small and average farms. The rest of farms (26.5 %) are represented by farms with sizes varying from (600 to 1000) ewes, fairly medium and quite large farms. The average number of ewes (age more than one year) is (605 ewes).

It is recorded that the average annual ewe replacement rate is (14 %). It's noticed that this percentage did not vary significantly comparing to the different stratum where the highest percentages (13.2; 15; 14.2; 13.7; 13.5 and 14.3 %) are recorded with strata representing by farms with (300-450), (>1000), (450-600), (800-1000) and (600-800) ewes respectively, and the lowest percentage (13.2 %) is recorded for the smallest farms size strata.

With respect to the number of studs for each group. it can be seen that the number is positively proportional to farms' size. The number of studs per 100 ewes is approximately the same varying between (2.64 %) for the smallest group to (2.27 %) for the largest group (>1000) ewes. The average percentage of studs for the whole sample is (2.4 %), which considered lower than the recommended zoo technical parameter norm to obtain the adequate fertility (4%) (Hamrouni. 1993).

Regarding to total man labour units (TMLU), it is increasing with increase in flock size from the smallest group with (0.8) to the largest group with (2.20). It is recorded an average TMLU per farm and per year of (1.3). It coincides with the results of Chertouh (2005) (1.33). The family labour units predominate the total man labour units for the whole sample, the average recorded has been (90%). The largest group with (> 1000) ewes is the group which hire more salaried man labour units (24.1 % of the TMLU), with less proportions for the third (451-600) ewes and the fourth group (601-800) ewes with respectively (12%) and (15.9 %).

With respect to labour intensification, the indicator number of ewes per man labour unit (NE/LU) is the most used index in this purpose. In the case of the studied sample, for the two first groups with small flock sizes, about 45 farms for which the number of ewes per man labour unit is considered to be quite small (< 400), which increase the costs. For other groups it is considered quite good (400-600), according to Pardos and Fantova (2007) that the best economic results are obtained with farms which handle (400-600) ewes per man labour unit.

Table 1. Structural description by flock size groups

Structural data	Strata by number of ewes						
	< 300	300-450	451-600	601-800	801-1000	> 1000	Total
Number of farms	17	28	33	20	14	16	128
Number of ewes (NE)	173.4	330.6	476.2	644.5	818.8	1162.6	605
Annual ewe replacement rate (% FRep)	13.2	15	14.2	13.7	13.5	14.3	14.0
Number of studs (NS)	5.8	9.0	12.6	16.7	20.5	27.5	15.4
Number of studs/ 100 ewes	2.64	2.38	2.41	2.41	2.37	2.27	2.4
Number of males for replacement	0.9	1.3	2.0	2.3	2.9	4.6	2.4
Tota man labour unit (TMLU)	0.8	1.1	1.2	1.4	1.6	2.2	1.3
% of family (% FLU)	96.9	95.8	90.4	86.2	91.6	76.8	90
% of salaried MLU/TMLU	6.2	5.9	12	15.9	10.2	24.1	12.4
Number of ewes per labour unit (NE/LU)	311.4	379.9	448.2	519.5	548.9	571.7	463.3

b. Structural description of the sample by total useful agricultural area (TUAA) strata

By dividing the sample into stratum land size (table 2), it is recorded that 10 farms have less than 10 hectares, where three (03) of them don't have land. In the other extremity, there are 12 farms with more than 200 hectares. Approximately (58.59 %) of the whole sample is represented by farms which have from 11 to 100 hectares. The rest of the farms (31) have from 101 to 200 hectares. Approximately the same proportions were found by Pardos (1994).

It is recorded that farms with less land have low number of ewes and low number of total man labour units; however, they have high percentage of family labour units. Added to that, it is registered more hectares by man work unit in farms with large flock size.

The average of TUAA is 96 hectares, from which (90.74 %) is non-irrigated area (dry land) and (9.26 %) is irrigated area. With respect to land possession, the average land in property is about (68.8 %) and the average rented TUAA is (31.4 %).

Regarding to the area used for forage, it is recorded an average of (32.1 %). It decreases with the increase of the dimension of farms from (55.9 %) to (8.6 %). These results are consistent with those found by Pardos (1994) (32.9%). It could be explained by the intensification for farms with less land, thus these farms intensify its use. The second hypothesis could be that farms with more land use it for other crops like cereals. Farmers tend to rent grazing land. The results show that the average area of the rented grazing land is about (464) hectares. About only (20.32 %) of farms don't rent or rent a surface less than their TUAA, thus the majority of farms rent more hectares than what they own. The average stocking density is about (17.5) ewes/ha of TUAA, which is approximately consistent with Pardos (1994). (22 ewes /ha of TUAA)

With respect to hectares used for sheep, the average recorded is 587.1 hectares. Groups with large land sizes (101-200 ha) and (>200 ha) use more land for sheep because they rent more grazing land specially for the group with (101-200 ha). Groups with less land sizes between (0-10 ha) and (51-100 ha) use less hectares for sheep. In the case of the second group (11-50 ha) farmers rent less grazing land thus they use fewer hectares for sheep. For the smallest group (0-10ha) they use more hectares for sheep than the second and the third group because they rent more grazing land.

The results show that the largest and the smallest farms counts with more owned useful agricultural area. With respect to the rest of the groups they own little more than the ½ of their TUAA. Farms with more TUAA count with a greater number of total men work units.

Table 2. Structural description by TUAA groups

Structural data	0-10 ha	11-50 ha	51-100 ha	101-200 ha	> 200 ha	Total
Number of farms	10	37	38	31	12	128
Number of ewes (NE)	387.6	518.9	600.8	704.6	772.6	605
Number of total Men Labour Units (TMLU)	1.09	1.19	1.31	1.42	1.70	1.3
% Family labour unit (%FLU)	96.0	92.7	90.9	90.4	75.1	90.0
Total useful agricultural area TUAA (ha)	3.3	11.2	51.4	129.2	283.7	95.76
Non irrigated TUAA (ha)	1.2	21.7	56.6	127.8	296.2	100.7
Irrigated TUAA (ha)	2.1	8.6	13.8	20.4	6.5	10.3
Number of ewes/TUAA	116.4	17.2	8.5	4.8	2.6	17.5
Rented grazing land (RGL)	435,9	363,7	472,4	547	486,4	461
Hectares used for sheep	454.2	408.9	557.9	710.2	804.2	587.1
Stubble. fallow land. hills (ha)	208.2	450.0	269.9	694.7	745.8	473.7
% Forage UAA/ TUAA (%FA/TUAA)	43.5	55.9	30.9	21.5	8.6	32.1
% Owned UAA/TUAA	100.0	67.3	52.6	53.1	70.2	68.6
UAA/number of TMLU	3.1	25.4	53.7	104.1	178.0	72.9

c. Technical description of the sample

With respect to the technical indicators, the average number of lambings by present ewe and year (NL/PE) recorded for the whole sample is (1.12). There are not significant differences between groups. The recorded medium intervals between births have more or less the same trend as the number of births per present ewe. The average medium interval of births is about 342 days, oscillating between 332 days for the largest group and 345 days for the medium group with (450-600) ewes and the smallest group with (< 300) ewes.

Regarding to the prolificacy, the average recorded number is (1.34). This result is consistent with the result found by Pardos et al. (2008) (1.35). Prolificacy for different groups is varying from (1.32) to (1.37). Farms with the smallest flock size (< 300) and with (600-800) have the lower prolificacy comparing to other groups.

The average percentage of twin births for the whole sample is (31.0 %). The highest one is recorded for farms with (800-1000) ewes which is (32.3 %). The average percentage births more than two lambs is about (1.5 %). The highest percentage is registered for farms with (450-600) ewes.

Regarding to born lambs per ewe, the average registered was 1.51. The result is almost the same found by Pardos et al. (2008) (1.61).

The average of lambs' mortality rate is (10.66 %). This result is consistent with Pardos et al. (2008) (10.50). It is varying between (10.1 %) and (11.5 %). The highest percentage is recorded for farms with the largest flock size (11.5 %). It could be explained by the labour intensification as we have already seen that more than 500 ewes are handled by one man labour unit.

The recorded average of sold lamb per ewe is 1.18. This result consists also with results found by Pardos et al. (2008) (1.28). It oscillates between (1.16) and (1.21). The highest percentages are recorded for farms with highest flock sizes (800-1000 ewes) and (> 1000) ewes with (1.21) and (1.19) respectively.

Regarding to reproduction ratios, the average number of ewes per stud is (45.6). It is varying between (42.7) and (51.4). The number of ewes per ram is considered high which could be influence negatively the fertility.

Table 3. Technical indicators description of the sample

Technical indices	Strata by number of ewes						
	< 300	300-450	450-600	600-800	800-1000	> 1000	Total
Number of farms	17	28	33	20	14	16	128
Number of lambings by present ewe and year (NL/PE)	1.12	1.12	1.11	1.12	1.12	1.13	1.12
Medium interval between births (days)	345.1	342.7	345.2	338.8	343.6	332.3	341.28
Prolificacy (Pr)	1.32	1.34	1.37	1.33	1.35	1.34	1.34
% Twin births	29.0	30.5	32.2	30.6	32.3	31.6	31.04
% Births with more than two lambs	1.55	1.57	2.08	1.16	1.18	1.40	1.49
Born lambs/present ewe	1.49	1.50	1.53	1.50	1.51	1.53	1.51
% Abortions (Ab)	3.45	2.40	2.65	2.55	2.13	2.03	2.53
% Lambs' mortality (%Mr)	10.5	10.1	10.8	10.8	10.2	11.5	10.66
Sold lambs/present ewe (NSL/PE)	1.16	1.17	1.16	1.18	1.21	1.19	1.18
Number of ewes/Stud (NE/S)	42.7	44.9	45.1	45.2	44.9	51.4	45.6

d. Revenues per farm and ewe description

It has been analysed the revenues structure per farm and per ewe. It was registered an average total revenue per farm of about (89036.33 €) varying between (32138.7 €) and (164734.1 €). As it can be noticed, total revenues as well as subsidies are positively proportional to flock size. However, this trend is not maintained at unit level. The average revenue per ewe is about (141.33 €), varying between (137.8 €) and (147 €). Groups with low number of ewes have registered the highest revenues per ewe which are superior or equal to the mean, mainly groups one and three with (147 € and 145.5 €) respectively. Nevertheless, groups with big flock sizes have registered lower unit revenues, particularly the group with (800-1000) ewes have the lower unit revenue (137.8 €). These results are consistent with those found by Chertouh (2005).

Revenues coming from lambs' sale represent the highest proportion for all cases for revenues per ewe. The mean value registered was (91.81 €) per ewe. It was recorded the highest unit value for the smallest group with respect to the flock size which is (94.5 €). The group with (800-1000) ewes has registered a high a value for sold lambs' revenues about (92.1 €). For other groups there were not important differences and the values were slightly lower than the mean value per ewe for the whole sample.

With respect to revenues coming from subsidies at unit level, it is recorded a mean value of (43.13 €) per ewe. It can be observed that groups with small farm sizes have the highest values of subsidies' revenues per ewe, except the smallest one with (< 300) ewes. Groups with bigger flock sizes have smaller values of subsidies' revenues comparing to the mean

value and to other smaller groups except the smallest one (<300 ewes) as it was previously mentioned. This variation could be explained by the number of ewes which receives the ewe compensatory premium in each farm. The number of these ewes is normally high in small flock sizes farms except the first group in our case; this result is supported by the results of Chertouh (2005).
With respect to factors which can influence the total revenues per ewe, it can be observed that added to subsidies and sold lamb price, the number of sold lambs by ewe influence the total revenues per ewe (Table 3 and Table 4).

Regarding to sold lambs prices, it is recorded an average of (77.91 €), oscillating between (75.9 €) and (80.6 €). It can be noticed that there is not a big difference between prices inter group farms, thus, sold lamb price is independent from the flock size. It could be explained the fact that as all farms are belonging to Oviaragon cooperative, thus there is not a big difference in sold lamb prices between farms. As it is demonstrated in table 4 the highest sold lamb price is registered for the smallest group and lower prices are registered for the two larger groups with (800-1000) and (> 1000) ewes which are (76.3 €) and (75.9 €) respectively.
As a conclusion for this part, it is clearly presented in table 4 that sold lamb revenues contribute with the highest percentage in the total farm revenues with an average of about (65.10 %) for the whole sample. The highest proportion is recorded for group farms with (800-1000) ewes with (67.05 %). And the lowest percentage is registered for the smallest flock size group with (63.78 %). Regarding to subsidies contribution in farm total revenues, the average is (30.77 %), oscillating between (29.58 %) for the smallest flock size group and (31.81 %) registered for farm group with (450-600) ewes.

Table 4. Revenues per farm and per ewe (€)

Revenues	Strata per number of ewes						
	< 300	300-450	450-600	600-800	800-1000	> 1000	Total
Number of farms (NE)	17	28	33	20	14	16	128
Average lamb price (LP)	80.6	77.8	79.4	77.5	76.3	75.9	77.91
Subsidies' revenues (SR)	9507.5	16640.5	24027.0	29291.4	33884.1	51437.6	27464.69
Sold lambs revenues (SLR)	20499.4	34183.6	48343.7	62778.1	76339.4	107427.4	58261.92
Inventory difference and other revenues (IDOR)	1543.2	814.7	1119.3	612.2	1470.5	2586.6	1357.75
Total revenues	32138.7	53070.0	75527.0	94891.0	113857.2	164734.1	89036.33
% Sold lambs revenues (%SLR/TR)	63.78	64.41	64.01	66.16	67.05	65.21	65.10
% Subsidies' revenues (% SR/TR)	29.58	31.36	31.81	30.87	29.76	31.22	30.77
% Inventory difference and other revenues	4.8	1.5	1.5	0.6	1.3	1.6	1.5
Revenues per ewe							
Sold lambs revenues	94.5	90.8	91.8	91.6	92.1	90.1	91.81
Subsidies	42.4	44.0	46.6	42.5	40.8	42.6	43.13
Inventory difference and other revenues	7.5	2.7	3.3	1.1	2.3	2.5	3.24
Total revenues per ewe	147.0	141.3	145.5	138.5	137.8	137.9	141.33

e. Costs structure

e.1 Costs structure per farm

In this part it has been analysed farm costs structure. The main components of farm costs are illustrated in table 5. First it can be noticed that costs are positively proportional to the flock sizes. This trend characterises all cost components. The average farm total cost is 54887.6 €, it oscillates between 19950.6 and 102351.2 €. Feed total cost is varying between 13541.1 and 66739.8 € according to farms' flock sizes. It can be noticed that feed is the component which costs more for farmers. More details about the importance of the different cost components will be discussed in the next section.

Table 5. Costs structure per farm (€)

Costs per farm	< 300	300-450	450-600	600-800	800-1000	> 1000	Total
Number of farms	17	28	33	20	14	16	128
Feed total cost (FC)	13541.1	21118.9	31785.5	39793.6	51860.5	66739.8	37473.2
Purchased feed cost (PFC)	8119.1	13126.3	21428.3	27218.9	38 846.6	44686.8	25571.0
Rented grazing land cost (RGLC)	714.8	1332.0	2193.3	4560.2	5411.0	8003.6	3702.5
Auto consumption (AC)	5422.0	8055.4	10357.2	12574.7	13013.9	22053.0	11912.7
Salaried Men Labour Unit cost (SMLUC)	831.3	1025.4	2573.2	4420.0	4117.2	9831.3	3799.7
Social security family Labour unit cost (SSFLUC)	1392.6	2008.6	2504.2	2538.9	3319.3	4 574.4	2723.0
Health cost (HC)	891.7	1338.4	1914.2	2464.0	3078.0	4 249.2	2322.6
Reproduction cost (RC)	54.3	154.1	290.7	335.1	446.4	600.3	313.5
Purchase of breeding stock cost	1746.8	806.2	1945.3	1883.9	967.0	3 598.1	1824.6
Financial cost	145.6	450.9	698.5	623.7	943.4	1 177.4	673.3
General costs**	1347.1	2705.6	4723.0	6040.0	8224.5	11 580.8	5770.2
Farm total costs	19950.6	29533.9	46434.5	58099.1	72956.4	102 351.2	54887.6

e.2 Costs structure per ewe

Results in table 6 show the cost components by ewe. At unit level, it can be noticed that the total costs per ewe have not the same trend as farm total costs. The average total cost per ewe is 86.4 € oscillating between 78.5 € for group farm with (300-450) ewes and 91.6 € for the smallest group farms. It can be deduced that at unit level, total cost is independent from the flock size. Regarding to feed cost, it remains the component which costs more for farmers. particularly purchased feed cost.

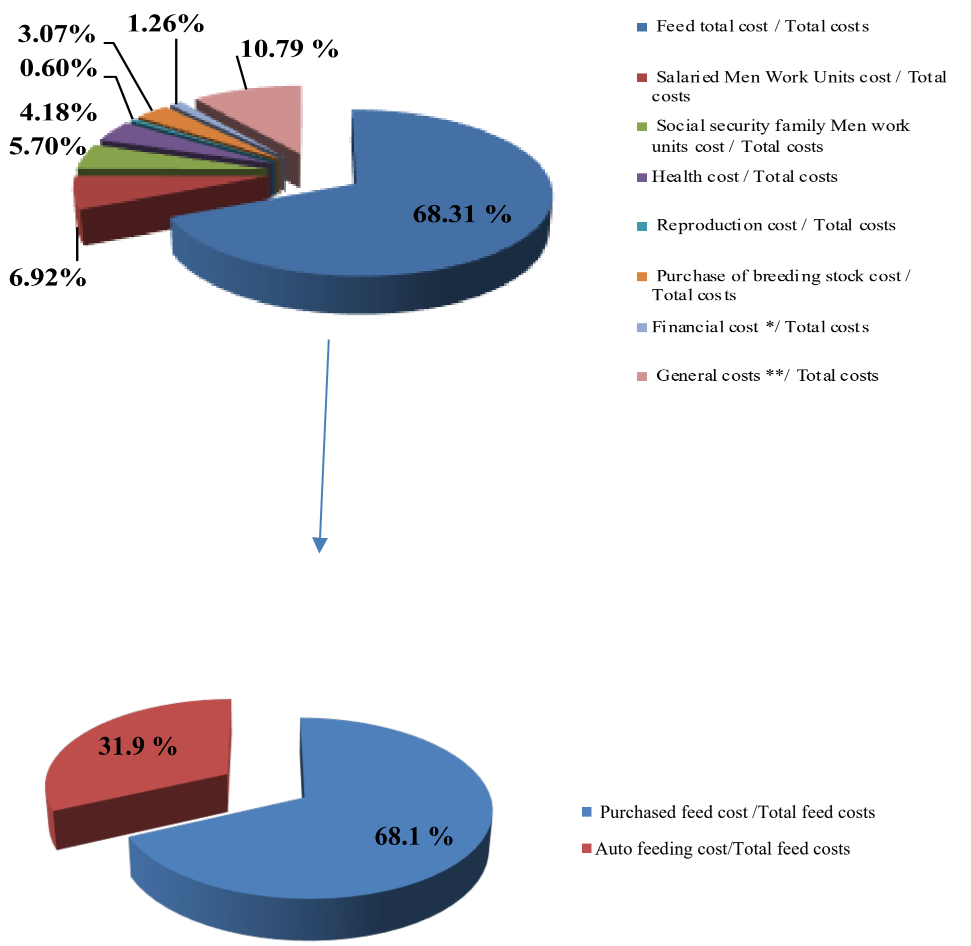
Table 6. Costs structure per ewe (€)

Costs per ewe	< 300	300-450	450-600	600-800	800-1000	> 1000	Total
Number of farms	17	28	33	20	14	16	128
Feed total cost	63.3	56.2	61.1	57.6	62.9	55.9	59.5
Purchased feed cost	36.0	34.6	40.9	39.4	47.1	37.5	39.3
Rented grazing land cost	2.9	3.7	4.2	6.7	6.1	7.0	5.1
Auto feeding cost	27.3	21.8	20.2	18.2	15.8	18.3	20.3
Salaried Men Work Units cost	3.2	2.2	4.9	6.2	5.8	8.0	5.1
Social security family Men work unit cost	6.4	5.6	4.9	3.8	4.0	3.9	4.8
Health cost	4.2	3.5	3.7	3.6	3.8	3.6	3.7
Reproduction cost	0.2	0.4	0.5	0.5	0.5	0.5	0.4
Purchase of breeding stock cost	7.9	2.4	4.3	2.9	1.2	3.0	3.6
Financial cost	0.6	1.2	1.4	0.9	1.1	1.1	1.1
General costs	5.8	7.0	9.1	8.7	9.6	9.6	8.3
Ewe total costs	91.6	78.5	90.0	84.1	88.9	85.6	86.4

e.3 Relative importance of cost components with respect to the total cost per farm (%)

The relative importance of the total cost components is represented in figure 4. Feed total cost represents (68.31 %) of the total costs. Thus, feed is the input which costs the most for the farmers. Regarding to the nature of feeding costs, they are divided into two components: purchased feed cost which is the most important with (68.1 %) of feed cost, and auto feeding cost with (31.9 %). In the second position with lower percentage (10.79 %), it is recorded the general costs. In the third position it is recorded the salaried man labour units with a proportion of (6.92%). Other costs are representing with lower proportions in the total cost, oscillating between (0.60 %) and (4.70 %).

Figure 4. Relative importance of total costs components %



In table 7 it can be understood the relative importance of different cost components by farms flock size groups. It was recorded the highest percentages (71.51 %) and (71.08 %) for feed total cost in the total cost for farm groups with (300-450) ewes and (800-1000) ewes respectively. For the groups with (450-600) and (600-800) they have almost the same percentage (68.45 %) and (68.49 %) respectively. It was recorded the smallest percentages for the smallest group (< 300) and the largest group (> 1000) with (67.87 %) and (65.21%) respectively.

Regarding to the proportion of purchased feed cost in the total feed cost, the average recorded is (69.42%). This index is positively proportional to the flock size except for the largest group with (> 1000) ewes. It could be explained by using more proper crops. It is oscillating between (59.95 %) for the smallest group with (<300) ewes and (74.91 %) for the group with (800-1000) ewes. It is noticed that the trend of the purchased feed cost in the total cost has the same trend as the purchased feed in the feed total cost.

The group with (800-1000) ewes purchase more feed; it could be explained by purchasing more concentrate feed than other groups. However, the largest group with (> 1000) ewes purchase less feed than the first cited because it rents more grazing land (7.82 %). The smallest groups with (< 300) and (300-450) had highest percentages of auto feeding cost (27.18%) and (27.27%).

With respect to salaried labour, it is registered an average of (6.92 %) with a highest proportion for the largest farm flock size group with (9.61 %). For the social security family labour cost, it is registered a mean of (4.70 %) with a highest percentage for the smallest group (6.98 %).

For the general costs, the average registered is (10.79%). This cost is positively proportional to the flock size. It oscillates between (6.75 %) for the smallest group and (11.31 %) for the highest group.

Health cost is represented with an average of 4.18 %. Although there is not a notable variation between groups but higher percentages are registered in smaller flock size groups. The lower percentage is recorded for the largest group (4.15%). Reproduction costs are very low; the average recorded is (0.60 %) varying between (0.27%) and (0.63) (Table 7).

With respect to financial costs, their incidence is very low on total costs. The average recorded is about (1.26%) oscillating between (0.73%) and (1.53 %).

Finally, purchase of breeding stock cost has an average of (3.07 %). It is varying between (1.33%) and (8.76 %). It is noted that the highest proportion is attributed to the smallest flock size group.

Table 7. Relative importance of total costs components per farms flock sizes %

Data per farm	Number of ewes						
	< 300	300-450	450-600	600-800	800-1000	> 1000	Total
% Purchased feed cost /Total costs	40.70	44.44	46.15	46.85	53.25	43.66	47.48
% Auto feeding cost/Total costs	27.18	27.27	22.31	21.64	17.84	21.55	20.83
% Rented grazing land cost/Total cost	3.58	4.51	4.72	7.85	7.42	7.82	6.95
% Feed total cost / Total costs	67.87	71.51	68.45	68.49	71.08	65.21	68.31
% Salaried Men Work Units cost / Total costs	4.17	3.47	5.54	7.61	5.64	9.61	6.92
% Social security family Man work unit cost / Total costs	6.98	6.80	5.39	4.37	4.55	4.47	4.70
% Health cost / Total costs	4.47	4.53	4.12	4.24	4.22	4.15	4.18
% Reproduction cost / Total costs	0.27	0.52	0.63	0.58	0.61	0.59	0.60
% Purchase of breeding stock cost / Total costs	8.76	2.73	4.19	3.24	1.33	3.52	3.07
% Financial cost / Total costs	0.73	1.53	1.50	1.07	1.29	1.15	1.26
% General costs / Total costs	6.75	9.16	10.17	10.40	11.27	11.31	10.79
% Purchased feed cost / Feed total cost	59.96	62.15	67.42	68.40	74.91	66.96	68.1

In table 8 it is presented the incidence of the different studied costs on the total cost by useful agricultural area farm groups. The results show that the average cost for purchased food is about ½ of the total cost. Farms with less UAA purchase more feed. The incidence of purchased feed in total cost is higher in small UAA farms (0-10 ha) and (11-50 ha) with (59.58%) and (50.23%). And the incidence of the purchase feed cost in the feed total cost is recorded an average of (69.85%). It has almost the same trend of the purchased feed percentage in the total cost, it oscillates between (59.77%) and (89.83%). Regarding to auto feeding costs, are higher in group farms with more UAA hectares mainly for the farm group with (101-200 ha) where it is registered the highest proportion (27.80 %). For renting grazing land, small UAA farms rent more with a percentage of (11.77 %). The proportion of the incidence of feed total cost in the total cost is approximately the same for all farm groups varying between (66.19%) and (69.10%).

Table 8. Relative importance of total costs components per farms' land size (%)

Data per farm	TUAA size					
	0-10 ha	11-50 ha	51-100 ha	101-200 ha	> 200 ha	Total
% Purchased feed cost /Total costs	59.58	50.23	45.17	41.30	47.20	47.41
% Auto feeding cost/Total costs	7.04	17.14	24.80	27.80	18.99	20.49
% Rented grazing land cost / Total costs	11.77	6.46	5.52	6.82	5.24	6.68
% Salaried Men Work Units cost / Total costs	3.89	5.61	6.49	5.20	13.41	7.52
% Social security family Man work unit cost / Total costs	6.34	5.58	4.94	5.19	3.86	5.00
% feed total cost / total cost	66.62	67.37	69.88	69.10	66.19	67.88
% Purchased feed cost/feed total cost	89.43	74.56	64.64	59.77	71.30	69.85

f. Economic results

After describing costs and revenue's structure, in this part it has been described the economic results. The criterion used to quantify the economic results in our case is the gross margin.

Results in table 9 show that the average gross margin obtained per farm was 34 138.7 euros. oscillating between 12188.1 € for the smallest farm group (<300) ewes and 62382.9 € for the largest farm group (>1000) ewes.
Regarding to the gross margin per ewe, it is recorded an average of 54.9 €. It is noticed that the unit gross margin has not the same trend as the gross margin per farm. Thus, values of gross margin are negatively proportional to the flock size except for farm group with (300-450) ewes which has registered the highest gross margin value per ewe (63.2 €). Otherwise, the smallest group with (<300) ewes has registered a gross margin value of about 55.4 euros per ewe and the largest group (>1000) ewes has registered a gross margin value of 52.3 €. For the gross margin per total man labour unit, it was registered an average of 25205.2 €. In this case it is positively proportional to the farm flock size.

Table 9. Economic results per farms flock size groups (€)

Economic results	< 300	300-450	450-600	600-800	800-1000	> 1000	Total
Gross margin per ewe (GM/E)	55.4	63.2	55.5	54.4	48.8	52.3	54.9
Gross margin per farm (GM/F)	12 188.1	23 475.8	29 092.5	36 791.9	40 900.9	62 382.9	34 138.7
Gross margin per TMLU (GM/LU)	18 402.8	24 447.2	24 993.3	27 250.5	26 866.3	29 271.3	25 205.2

Table 10 shows the economic results by farms land size. The highest value of gross margin per ewe recorded for the smallest farm land size group (0-10 ha) with 60.3 € followed by farms' groups with more land (101- 200 ha) and (> 200 ha) with 58.8 €and 55.6 € respectively. It has been recorded a gross margin per ewe of 54.3 € per ewe for the medium group with (51-100 ha). For the group with (11-50 ha) it has been recorded 53.9 € per ewe, the lowest gross margin per ewe.

Regarding to the gross margin per farm, the values are proportional to the farm land size from (20451.7 €/farm) for the smallest group (0-10 ha) to (41592.7 €/farm) for the largest group (>200 ha).

Finally, for gross margin per total man labour unit it is recorded the highest values for groups with (101-200 ha) and (>200 ha) respectively (30539.1€ and 24350.9 € per TMLU). For other groups it was recorded values from (19354.2 € /TMLU) for the smallest group to 23861.1 € for the group with (11-50 ha).

Table 10. Economic results per farms' land size (€)

	0-10 ha	11-50 ha	51-100 ha	101-200 ha	> 200 ha	Total
Number of farms	11	39	35	28	14	127
Gross margin per ewe (GM/E)	60.3	53.9	54.3	58.8	55.6	56.6
Gross margin per farm (GM/F)	20 451.7	27 208.1	30 452.9	40 761.7	41 592.7	32 093.4
Gross margin per TMLU (GM/LU)	19 354.2	23 861.1	23 586.9	30 539.1	24 350.9	24 338.5

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RESEARCH PAPER 1

Tipificación estructural y rentabilidad de explotaciones ovinas de carne

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Tipificación estructural y rentabilidad de explotaciones ovinas de carne

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Resumen

El sector ovino de carne está experimentando un fuerte retroceso en España y en la Unión Europea. Se trata de un tipo de ganadería que desempeña un importante papel en zonas desfavorecidas por su contribución a la sostenibilidad económica, social y medioambiental, siendo importante garantizar su viabilidad económica. El objetivo genérico del presente trabajo ha sido analizar las posibles relaciones entre los resultados económicos de una muestra de explotaciones de ovino de carne ubicadas en Aragón (España) y determinados indicadores estructurales. Previamente se realizó una tipificación para estudiar su variabilidad. La muestra la componen 126 ganaderías aragonesas de ovino de carne. Se utilizan las medias de las variables durante un período que oscila entre 5 y 24 años dentro del periodo 1993-2016. Se realizó un análisis factorial sobre diez variables estructurales y se identificaron cuatro factores a partir de los cuáles se obtuvieron dos grupos significativamente diferentes en cuanto a sus características estructurales. Se eligió la renta disponible por unidad de trabajo como indicador del resultado económico de las explotaciones, y se calculó teniendo en cuenta o no la retribución de la mano de obra familiar. Mediante una regresión lineal múltiple se estableció su dependencia con las variables estructurales previamente analizadas. Se puede concluir que la optimización del número de ovejas por unidad de mano de obra y por hectárea de la superficie agrícola útil, son aspectos a tener en cuenta a la hora de mejorar la rentabilidad y la viabilidad de las explotaciones ovinas de carne.

Palabras clave: Ovino de carne, estructura explotación, resultados económicos.

Structrural tipyfication and profitability of sheep meat farms

Abstract

The sheep meat sector is experiencing a strong recoil in Spain and in the European Union. It is a type of livestock that plays an important role in disadvantaged areas for its contribution to economic, social and environmental sustainability, being important to ensure its economic viability. The generic objective of this work has been to analyze the possible relationship between the economic results of a sample of sheep meat farms located in Aragon (Spain) and certain structural indicators. Previously a typification was done to study their variability. The sample is made up of 126 Aragonese meat sheep

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farms. The variables' means are used during a period that varies between 5 and 24 years within the 1993-2016 period. A factor analysis was performed on ten structural variables and four factors were identified from which two significantly different groups of farms were obtained in terms of their structural characteristics. The gross margin per total labor unit was chosen as an indicator of the economic result of farms, and was calculated considering or not the remuneration of family labor. By means of a multiple linear regression the dependence of this economic result on structural variables previously analyzed was established. It can be concluded that the optimization of the number of ewes per total labor unit and per hectare of the used agricultural area, are aspects to be considered when improving the profitability and viability of sheep meat farms.

Keywords: Meat sheep, farm structure, economic results.

Introducción

A pesar del reconocimiento que la Política Agraria Común (PAC) otorga al sector ovino por su contribución a la sostenibilidad social, económica y medioambiental (MAGRAMA, 2016), el censo de ganado ovino ha experimentado un claro retroceso en los últimos años tanto en España como en los países de nuestro entorno. En el periodo 2008-2018 el número de cabezas de ganado ovino disminuyó un 26,2 % en España (MAPA, 2019), y un 7,5 % en el conjunto de la Unión Europea (EUROSTAT, 2019). El descenso fue más acusado hasta 2013, observándose después una estabilización del censo.

Distintos factores han contribuido a que el sector ovino de carne se encuentre en una situación crítica: el aumento constante de los costes de producción, el estancamiento de los precios de venta del producto, la tendencia a la baja en el consumo de carne de cordero y la concurrencia internacional de distintos países productores (Bernués y Olaizola, 2012; Marín-Bernal y Navarro-Ríos, 2014; Olaizola *et al.*, 2014; Rodríguez-Ortega *et al.*, 2018a), entre otros. En este contexto pueden adoptarse diferentes medidas que palíen al menos de forma parcial el paulatino declive del sector. Entre ellas pueden destacarse el fomento y la promoción del consumo de carne de ovino, el aumento de la rentabilidad de las explotaciones o la adopción de diferentes políticas que regulen los mercados y aumenten las ayudas a las explotaciones sobre todo aquellas relacionadas con los servicios ecosistémicos que prestan (Olaizola *et al.*, 2008; Rodríguez-Ortega *et al.*, 2018a,b).

De todas estas medidas el aumento de la rentabilidad ha sido citada por algunos autores (Benoit y Laignel, 2011; Olaizola *et al.*, 2014) como una medida fundamental para disminuir la dependencia de las explotaciones de las actuales ayudas, cuya continuidad se ve amenazada en las sucesivas revisiones que va sufriendo la Política Agraria Común. Además de la rentabilidad, Pardos *et al.* (2008) han señalado que una mayor flexibilidad que permita la adaptación a los cambios de la política agraria afectará también positivamente a la supervivencia de las explotaciones ovinas de carne.

Sin embargo, la heterogeneidad existente en las explotaciones ovinas de carne motivada en parte por su dependencia del medio donde se ubican, con una disponibilidad de recursos muy variada, dificulta el que puedan diseñarse medidas que consigan el mismo efecto en el conjunto de las explotaciones. Una de las fuentes de heterogeneidad de las explotaciones son sus características estructurales determinadas por la disponibilidad y el uso de los diferentes factores de producción. El grado de aplicación de un factor en relación a otro permite calificar a las explotaciones como más o menos intensivas en su utilización. De forma que en los procesos de intensificación se combina una unidad del factor limitante con cantidades crecientes de otros factores, mientras que se habla de extensificación con relación al factor relativamente más abundante, cuando éste se combina con dosis decrecientes de los factores (Tirel, 1983).

La tipificación de las explotaciones ovinas se ha realizado con cierta frecuencia por distintos autores por su utilidad para comprender la diversidad del sector (Gaspar *et al.*, 2008; López-i-Gelats *et al.*, 2011; Gelasakis *et al.*, 2012). No ha tenido tanto la finalidad de poner en marcha diferentes políticas que tengan como objetivo la ayuda y promoción de las explotaciones; aunque como ha señalado Valerio Cabrera *et al.* (2014), los estudios de tipificación y caracterización permiten realizar mejores planes y distribución de los recursos destinados a gestionar los factores determinantes que rodean a las explotaciones. Las medidas que apoyen a las explotaciones ovinas de carne son necesarias por cuanto, tanto en España como en otros países, la mayoría están localizadas en áreas desfavorecidas, de hecho en nuestro país el 80 % del censo se ubica en áreas con dificultades específicas (Andersen *et al.*, 2007; Ruiz-Mirazo *et al.*, 2011; Toro-Mujica *et al.*, 2015). Además se trata de un sector multifuncional cuyas explotaciones practican sistemas de explotación extensivos o semi-extensivos, con utilización de razas autóctonas adaptadas a las condiciones ambientales y con un importante papel en la prevención de incendios forestales, la fijación de población rural en áreas muy desfavorecidas para otras actividades, la protección y conservación de prados y la posibilidad de ofrecer productos diferenciados con valor añadido (Ruiz-Mirazo *et al.*, 2011; Vázquez *et al.*, 2014; Mena *et al.*, 2014). La multifuncionalidad de los sistemas de ovino de carne les convierte en un elemento vital para el equilibrio medio ambiental en las zonas donde se localizan, existiendo una interacción mutua entre la viabilidad de los sistemas y la protección de la biodiversidad de los ecosistemas (Olaizola *et al.*, 2014; Dubeuf *et al.*, 2016; Bernués *et al.*, 2018; Rodríguez-Ortega, 2018a,b).

El objetivo del presente trabajo es caracterizar un grupo de explotaciones ovinas en función de sus características estructurales e identificar diferentes tipos de explotación. Para ello se tendrán en cuenta los principales factores de producción y la combinación de los mismos que las define como más o menos intensivas en su uso. Finalmente se analizará su posible relación con los resultados económicos alcanzados. Un mejor conocimiento de los resultados económicos obtenidos por los distintos tipos de explotación puede ayudar a detectar cuáles son más vulnerables y por tanto tener un mayor riesgo de desaparición.

Material y métodos

Para la realización del presente trabajo se contó con una muestra de 126 explotaciones ovinas de carne localizadas en Aragón (España). Estas explotaciones se distribuyen a través de sus tres provincias: Zaragoza, Huesca y Teruel, y siguen un programa de gestión técnico-económica utilizado por una importante cooperativa ubicada en esta región (Oviaragón-Grupo Pastores). Dada la antigüedad del programa que comenzó en la década de los 90 y la continuidad de muchas de las explotaciones, los datos que utilizamos son en algunos casos las medias de los 24 años que van desde 1993 a 2016. Para cada explotación el dato medio de cada variable corresponde a la media de los años de los que se tienen registros. Lo prolongado del periodo estudiado hizo necesario que aquellas variables expresadas en unidades monetarias fueran convertidas a euros constantes del 2016.

Se seleccionaron una serie de variables estructurales basándonos en estudios de explotaciones ovinas llevados a cabo anteriormente por distintos autores (Hamrouni 1993; Chertouh, 2005; Maza *et al.*, 2008; Pardos *et al.*, 2008; López-i-Gelats *et al.*, 2011). Tras un análisis detallado de las variables más frecuentemente utilizadas, se seleccionaron 10 variables estructurales referidas a la superficie y su uso, a la mano de obra y al tamaño del rebaño (Tabla 1). Relacionadas con el factor tierra se incluyeron la superficie agrícola útil total (SAUT), el porcentaje que supone el regadío (% Reg/SAUT), las hectáreas de arrendamientos forrajeros aprovechados a diente (AF), las hectáreas de cultivos forrajeros (HCF) y la relación de la superficie con la mano de obra (SAUT/UTAT). Asimismo, se incluyeron la variable número de ovejas (NO), y su relación con la superficie (NO/SAUT) y la mano de obra (NO/UTAT). Por último, se consideró el número de unidades de trabajo anual total (UTAT) y el porcentaje de trabajo familiar (% UTF).

Para lograr el objetivo de la presente investigación se utilizaron análisis univariantes y multivariantes. El análisis univariante permitió realizar una descripción general de la muestra. Los análisis multivariantes fueron el análisis de componentes principales (ACP) para reducir el número de variables y facilitar el análisis posterior de los resultados, el análisis clúster bietápico para la obtención de grupos de explotaciones, y la regresión lineal múltiple para establecer relaciones de dependencia (Hair *et al.*, 2014).

El análisis clúster permite la obtención de grupos de explotaciones lo más homogéneas posible dentro de cada grupo y lo más heterogéneas entre grupos. Se tuvieron en cuenta las puntuaciones factoriales de los individuos para realizar el análisis clúster. Con la variable de «pertenencia al clúster» se definieron las proporciones de los clústeres.

En el análisis de regresión lineal múltiple las variables predictoras fueron las diez variables estructurales utilizadas para realizar el análisis factorial, y como variable dependiente se

Tabla 1. Descripción de la muestra[(1)] por las variables estructurales.
Table 1. Description of the sample by structural variables.

Datos estructurales	Media	Deviación estándar
Número de Ovejas (NO)	605,6	304
Número de Unidades de Trabajo Anual Total (UTAT)	1,32	0,49
% Unidades de Trabajo Familiar (% UTF)	90	18,0
Número de Ovejas por Unidad de Trabajo Total (NO/UTAT)	463,2	143,7
Número de Ovejas por hectárea de Superficie Agrícola Útil Total (NO/SAUT)	17,5	59
Superficie Agrícola Útil por unidad de Trabajo Total (SAUT/UTAT)	74,6	61,4
Superficie Agrícola Útil Total (SAUT)	95,7	87,8
% Regadío sobre Superficie Agrícola Útil Total (% Reg/SAUT)	22,2	32,3
Arrendamiento forrajero (AF)	461,3	791
Hectáreas de cultivos forrajeros (HCF)	21	22,7

[(1)] Muestra total de 126 explotaciones ovinas de carne en Aragón.

consideró la renta disponible por unidad de trabajo total (RDPUTAT). La renta disponible por unidad de trabajo puede considerarse como la medida más significativa de los resultados económicos obtenidos y un indicador de la posible continuidad de las explotaciones al incluir la productividad por oveja y el tamaño correcto del rebaño (Olaizola *et al.*, 1996). En su cálculo puede incluirse o no la retribución de la mano de obra familiar dado el carácter eminentemente familiar de las explotaciones ovinas. En el presente trabajo se ha calculado de ambas formas.

En el análisis de regresión lineal múltiple, se utilizó el método por pasos para retener solo las variables independientes significativas en los modelos resultantes. El modelo genérico lineal se formuló de la siguiente manera:

$$\text{RDPUTAT} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + + \ldots \beta_n X_n + \text{e}$$

Donde RDPUTAT (la renta disponible por unidad de trabajo anual total) es la variable dependiente, β_0 es la constante de regresión, y $\beta_1\ \beta_2\ \beta_3 \ldots \beta_n$ son coeficientes a estimar, X_1, X_2, $X_3 \ldots X_n$ son las variables estructurales utilizadas y (e) es el error del modelo de la regresión. Los coeficientes de regresión se comprobaron usando la prueba t. El coeficiente de determinación (R^2) se utilizó como criterio predictivo de éxito para el modelo de regresión (Drapper y Smith, 1998 citado por Sakar *et al.*, 2011). Se ha utilizado el paquete SPSS versión 26 para ejecutar los análisis estadísticos.

La robustez de cada uno de los modelos fue validada de la siguiente manera: la ausencia de multicolinearidad se verificó utilizando el índice de tolerancia y el factor de inflación (FIV). Según Pérez (2005) un FIV grande y un índice de tolerancia pequeño pueden indicar posible presencia de colinealidad. Para verificar la correlación serial de los residuos se aplicó la prueba de Durbin Watson, que establece que un valor cercano a 2 indica que no existen problemas de autocorrelación. Usualmente se considera que entre 1,5 y 2,5 debería existir independencia entre los residuos (Pineda Jaimes *et al.*, 2011).

Resultados y discusión

Descripción de la muestra

El tamaño promedio de las 126 explotaciones estudiadas es de 605,6 ovejas, manejadas por 1,32 unidades de mano de obra total (tabla 1). Esta última cifra coincide con la obtenida por Chertouh (2005) con 1,32 UTAT, en explotaciones de ovino de carne en Aragón. Las unidades de mano de obra familiar representan aproximadamente el 90 % del total de unidades de mano de obra, lo que significa que las explotaciones de la muestra son en su mayoría explotaciones familiares. Con respecto a la intensificación de la mano de obra, el número de ovejas por unidad del trabajo es el índice más utilizado. El número medio de ovejas por unidad del trabajo es de 463,2 ovejas/UTAT. En opinión de Pardos y Fantova (2007) los mejores resultados económicos se obtienen en explotaciones que manejan entre 400 y 600 ovejas por unidad de trabajo. La media de la superficie agrícola útil de estas explotaciones es de 95,7 ha, de las cuales el 22,2 % son de regadío. Los cultivos forrajeros suponen 21 ha de media y los arrendamientos forrajeros para pastoreo a diente 461,3 ha. Como medidas de intensificación la carga ganadera (NO/SAUT) se sitúa en 17,5 ovejas/ha, al tiempo que se registra una media de 74,6 ha de superficie agrícola útil por unidad de mano de obra (SAUT/UTAT).

Análisis de Componentes Principales

El análisis factorial parte de la matriz de correlación entre las variables que analiza. La mayoría de los coeficientes de correlación entre las variables son significativos ($p \leq 0{,}01$ o $p \leq 0{,}05$) (Complemento 1), por lo que puede realizarse el análisis (Sakar *et al.*, 2011).

Destaca la alta correlación positiva que presenta la variable número de ovejas (NO) con las variables número de unidades de trabajo total (UTAT), la intensificación de la mano de obra (NO/UTAT), las hectáreas de cultivos forrajeros (HCF), la superficie agrícola útil (SAUT) y el arrendamiento forrajero (AF). Por otro lado, el número de ovejas se correlaciona de forma significativa aunque con coeficiente negativo con el porcentaje de trabajo familiar (% UTF). Estos tres principales factores productivos (el capital vivo, la mano de obra y la superficie) están correlacionados, y este resultado es similar al encontrado por Hamrouni (1993), quien afirmó que estos factores productivos manifestaban una relación de dimensión. Por otro lado, el número de unidades de trabajo total (UTAT) presenta correlación negativa con el porcentaje de mano de otra familiar (% UTAF), y positiva con las variables de superficie SAUT, AF y HCF. Finalmente, la SAUT presenta una correlación positiva muy alta con SAUT/UTAT y negativa con el porcentaje de regadío.

Para reducir las dimensiones de los diez indicadores estructurales utilizados en esta sección, realizamos un análisis factorial que utilizó los componentes principales como método de extracción. Tanto el índice KMO = 0,465 como la prueba de esfericidad de Bartlett (Chi-cuadrado) fueron significativos ($p < 0,000$), lo que permitió seguir con la interpretación de los resultados. Las diez variables originales se sintetizaron en cuatro factores con valores propios superiores a 1 que explican el 71,78 % de la varianza total, lo cual se considera un buen porcentaje (Hair *et al.*, 2014). Realizamos el método Varimax para la rotación de factores; los resultados se muestran en la tabla 2.

El factor 1 explica el 28,45 % de la varianza. A este factor le caracterizan dos de las diez variables iniciales; estas variables son el tamaño de la superficie agrícola útil (SAUT) y las hectáreas de la superficie agrícola útil por unidad de la mano de obra total (SAUT/UTAT).

El factor 2 explica 19,75 % de la varianza. A este factor le caracterizan las unidades de la mano de obra total (UTAT) y el tamaño del rebaño (NO) y con signo negativo el porcentaje de unidades de trabajo familiar (%UTF). Esta relación negativa entre el porcentaje de trabajo familiar y el tamaño del rebaño ha sido señalada por otros autores (Hamrouni, 1993; Chertouh, 2005).

El factor 3 explica el 13,42 % de la varianza total. Al factor le caracterizan dos variables, hectáreas de cultivos forrajeros (HCF) y arrendamientos forrajeros (AF), por lo que una mayor superficie de cultivos forrajeros estaría asociada a un mayor arrendamiento de este tipo de aprovechamientos.

El factor 4 explica el 10,15 % de la varianza total. Le caracterizan las variables número de ovejas por unidad de mano de obra (NO/UTAT), la carga ganadera por hectárea de la SAUT (NO/SAUT) y el porcentaje del regadío sobre la SAUT (% Reg/SAUT). Este factor caracteriza pues a explotaciones más intensivas en el uso de la tierra y del trabajo con más proporción de superficie regada.

Análisis clúster

Se han obtenido dos grupos de explotaciones. El primero incluye 90 explotaciones y el segundo 36. Los tamaños de los clústeres no están equilibrados, pero la calidad del clúster se considera suficiente (figura 1).

La realización del ANOVA ($p < 0,0001$) permite demostrar que cada grupo está relacionado de manera diferente con respecto a cada factor.

Perfil de los grupos

La tabla 3 muestra el perfil de los grupos. El grupo 1 está correlacionado negativamente con los cuatro factores y el grupo 2 esta correlacionado positivamente con los cuatro factores.

Tabla 2. Matriz de componentes rotados a partir de variables estructurales.
Table 2. Matrix of rotated components from structural variables.

Indicadores estructurales	Factores				Comunalidades h^2
	Factor 1	Factor 2	Factor 3	Factor 4	
Superficie Agrícola Útil por unidad de Trabajo Total (SAUT/UTAT)	**0,922**(1)	–0,069	–0,054	–0,158	0,882
Superficie Agrícola Útil Total (SAUT)	**0,837**(1)	0,344	0,126	–0,201	0,875
Número de Unidades de Trabajo Anual Total (UTAT)	–0,028	**0,803**(2)	0,482	–0,024	0,879
% Unidades del Trabajo Familiar (% UTF)	–0,095	**–0,765**(2)	0,124	0,066	0,614
Numero de Ovejas (NO)	0,195	**0,634**(2)	0,609	0,319	0,913
Hectáreas de Cultivos Forrajeros (HCF)	0,158	–0,053	**0,761**(3)	0,031	0,607
Arrendamiento Forrajero (AF)	–0,285	0,267	**0,611**(3)	-0,186	0,561
Numero de Ovejas por hectárea de Superficie Agrícola Útil Total (NO/SAUT)	–0,238	0,204	-0,224	**0,695**(4)	0,631
% Regadío sobre Superficie Agrícola Útil Total (% Reg/SAUT)	–0,262	–0,188	0,028	**0,635**(4)	0,508
Numero de Ovejas por Unidad de Trabajo Total (NO/UTAT)	0,436	–0,039	0,368	**0,618**(4)	0,709
El valor propio	2,845	1,976	1,342	1,015	
% Varianza	28,45	19,75	13,42	10,15	
% Varianza cumulativa	28,45	48,21	61,63	71,78	

(1) (2) (3) (4) puntuaciones factoriales de las variables de los factores 1, 2, 3, 4 respectivamente.

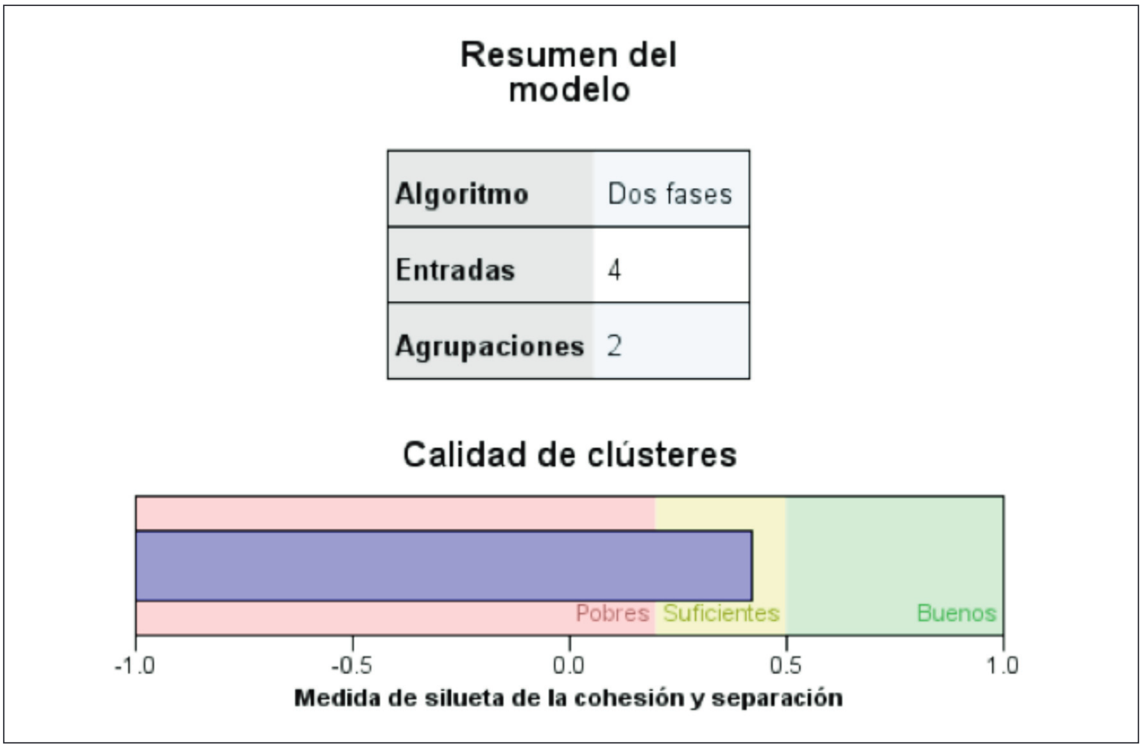

Figura 1. Calidad de los grupos.
Fuente: *Output* del análisis clúster.
Figure 1. Clusterts' quality.

Tabla 3. Perfiles de puntuaciones de los factores.
Table 3. Profiles of the factors' scores.

Factores	Grupo 1	Grupo 2
Factor 1	–0,1466566	0,3666416
Factor 2	–0,4538995	1,1347487
Factor 3	–0,1327536	0,3318841
Factor 4	–0,0706074	0,1765185

Para una descripción más detallada y una mejor caracterización de cada grupo, la variable «pertenencia a un grupo» se ha cruzado con las diez variables estructurales utilizadas en el presente trabajo. Los resultados se presentan en la tabla 4. Se han añadido también las variables indicativas de sus resultados económicos, que actuarán como variables dependientes en el análisis posterior. Como puede observarse, la mayoría de las variables permiten diferenciar los dos grupos de explotaciones, a excepción de las variables NO/SAUT y % Reg/SAUT. Los resultados económicos obtenidos por cada uno de los grupos no muestran diferencias significativas.

El grupo 1, que agrupa al 71,4 % de las explotaciones, está formado por explotaciones pequeñas o medianas con respecto a la dimensión del rebaño, a la superficie agrícola útil total, y a las unidades de la mano de obra total. Tiene más importancia la mano

Tabla 4. Descripción de los grupos.
Table 4. Clusters' description.

Variables	Grupo 1	D.E[3]	Grupo 2	D.E[3]	Nivel de Significancia
Número de explotaciones	90		36		
Número de Ovejas (NO)	487	199,1	903	319,7	0,000***
Número de Unidades de Trabajo Anual Total (UTAT)	1,13	0,3	1,81	0,4	0,000***
% Unidades de Trabajo Familiar (% UTF)	97,16	7,5	72,29	23,6	0,000***
Número de Ovejas por Unidad de Trabajo Total (NO/UTAT)	445	130,7	509	164,9	0,024**
Número de Ovejas por hectárea de Superficie Agrícola Útil Total (NO/SAUT)	13	14,4	29	107,8	N.S
% Regadío sobre Superficie Agrícola Útil Total (% Reg/SAUT)	23,05	33,8	19,91	28,5	N.S
Superficie Agrícola Útil Total/Unidad de Trabajo Anual Total (SAUT/UTAT)	67,25	51,0	93,04	79,4	0,033**
Superficie Agrícola Útil Total (SAUT)	71,33	51,6	156,50	124,2	0,000***
Arrendamiento Forrajero (AF)	308,26	361,9	844,03	1299,6	0,000***
Hectáreas de cultivos forrajeros (HCF)	18,28	15,7	28,02	33,7	0,029**
Renta Disponible por UTAT (RDUTAT)[1] (€)	25281,89	10072,1	24484,43	11019,7	N.S
Renta Disponible por UTAT con Mano de Obra Familiar (RDUTATCMOF)[2] (€)	12205,65	10210,6	14560,44	10005,6	N.S

[1] RDUTAT = Ingresos totales de la actividad productiva ovina - Costes totales objetivos de la actividad ovina "valorándose los reempleos e imputando los costes indirectos".

[2] RDUTATCMOF = Ingresos totales de la actividad productiva ovina - Costes totales objetivos de la actividad ovina (incluyendo el coste de la mano de obra familiar) "valorándose los reempleos e imputando los costes indirectos".

[3] D.E = Desviación estándar.

de obra familiar y son menos intensivas en el uso del trabajo al presentar menor número de ovejas y menor superficie agrícola útil por unidad de trabajo total. También son explotaciones con menor arrendamiento forrajero y menores hectáreas de cultivos forrajeros.

El grupo 2, por lo contrario es más reducido (28,6 % de las explotaciones) y a él pertenecen explotaciones más grandes en cuanto al tamaño del rebaño, a la superficie agrícola total y al número de unidades de trabajo total. También realizan mayor arrendamiento forrajero, con mayores hectáreas de cultivos forrajeros y son más intensivas en la utilización de la mano de obra con mayor número de ovejas y mayor superficie agrícola total por unidad de mano de obra.

Regresión lineal múltiple

Como se mencionó en el apartado de metodología, las variables estructurales utilizadas en el análisis factorial se utilizaron como variables predictoras y la variable renta disponible por unidad de trabajo total sin tener en cuenta la remuneración de la mano de obra familiar (RDUTAT) y teniéndola (RDUTATCMOF) se eligió como variable respuesta o variable dependiente. Se analizaron las relaciones en cada uno de los grupos obtenidos, y también se efectuó el análisis de regresión sobre la totalidad de la muestra.

Los resultados de las seis regresiones se muestran en las tablas 5, 6 y 7. Como se puede observar, todos los estadísticos de evaluación de los modelos referidos a las seis regresiones realizadas son significativos. Los resultados se presentan a continuación.

Para la totalidad de la muestra (tabla 5), el modelo de regresión 1 (RDUTAT), en el que no se ha tenido en cuenta la remuneración de la mano de obra familiar en el cálculo de la renta disponible por unidad de trabajo, los resultados indican que la intensificación del trabajo con respecto al tamaño del rebaño (NO/UTAT) y el porcentaje de la mano de obra familiar (% UTF) tienen un impacto positivo en los resultados alcanzados. En el modelo de regresión 2 (RDUTATCMOF) donde a diferencia del anterior se tiene en cuenta el coste de oportunidad de la mano de obra familiar, sólo la intensificación del trabajo con respecto al tamaño del rebaño (NO/UTAT) tiene un impacto positivo en la renta disponible por unidad total de mano de obra. En ambos modelos, la carga ganadera (NO/SAUT) influye negativamente en el resultado económico. Una posible explicación de este resultado reside en que las explotaciones con mayor carga ganadera tienen menos hectáreas para responder a las necesidades del rebaño; por lo que necesitan comprar más alimentos para ser suministrados en pesebre o recurrir al arrendamiento de pastos. Chabosseau *et al.* (2000) encontraron que la carga ganadera afecta negativamente los resultados económicos de las explotaciones estudiadas debido al incremento en la compra de inputs como fertilizantes y concentrado.

En el grupo de explotaciones pequeñas y medianas, grupo 1, la intensificación de la mano de obra (NO/UTAT) (tabla 6), sigue siendo la variable que en mayor medida explica los mejores resultados económicos. También explican estos resultados el mayor número de hectáreas de SAUT y cuando en el cálculo no se tiene en cuenta la remuneración del coste de oportunidad de la mano de obra familiar, el menor número de hectáreas de cultivos forrajeros. Por tanto, en las explotaciones de menor tamaño, donde predominan los sistemas mixtos que combinan ganado y cultivos comerciales (sobre todo cereales), la superficie puede ser un factor limitante. Una mayor superficie iría unida a una mayor autonomía alimenticia y unos mejores resultados económicos. La relación directa entre la mayor autonomía alimenticia de las explotaciones y la mejora de la rentabilidad ha sido puesta de manifiesto por diversos autores (Bernués *et al.*, 2011; Ryschawy *et al.*, 2013; Ripoll-Bosch *et al.*, 2014).

Tabla 5. Resultado de los modelos de regresiones lineales múltiples de la totalidad de la muestra.
Table 5. Results of the multiple linear regressions models for the whole simple.

	Parámetros	Coeficientes no estandarizados (β)	D.E[1]	Coeficientes estandarizados (β Std)[2]	T[3]	P[4]	R^2[5]	R^2 Ajustado	Durbin-Watson	FIV[6]
Regresión 1	Constante	–4856,800	4354,1		–1,115	0,267	0,395	**0,380**	**2,118**	
Renta Disponible por Unidad de Trabajo Total RDUTAT	Número de Ovejas por Unidad de Trabajo Total (NO/UTAT)	41,554	5,0	0,579	8,176	0,000***				1,010
	% Unidades de Trabajo Familiar (% UTF)	124,761	40,3	0,218	3,090	0,002**				1,004
	Número de Ovejas por hectárea de Superficie Agrícola Útil Total (NO/SAUT)	–32,560	12,4	–0,186	–2,620	0,010**				1,014
Regresión 2	Constante	–5836,250	2453,6		–2,379	0,019**	0,371	**0,361**	**2,122**	
Renta Disponible por Unidad de Trabajo Total con Mano de Obra Familiar RDUTATCMOF	Número de Ovejas por Unidad de Trabajo Total (NO/UTAT)	41,856	5,0	0,593	8,222	0,000***				1,010
	Número de Ovejas por hectárea de Superficie Agrícola Útil Total (NO/SAUT)	–36,477	12,4	–0,212	–2,937	0,004**				1,010

[1] (D.E) desviación estándar; [2] (β Std)β estandarizados;[3] (T) T-valor; [4] (P) P-valor; [5] (R^2) R cuadrado; [6] (FIV) factor de inflación de la varianza.

Tabla 6. Resultado de los modelos de regresiones lineales múltiples del grupo 1.
Table 6. The results of the multiple linear regressions models for cluster 1.

	Parámetros	Coeficientes no estandarizados (β)	D.E(1)	Coeficientes estandarizados (β Std)(2)	T(3)	P(4)	$R^{2(5)}$	R^2 Ajustado	Durbin-Watson	FIV(6)
Regresión 1	Constante	6141,779	3164,9		1,941	0,056	**0,374**	**0,352**	**1,745**	
Renta Disponible por Unidad de Trabajo Total RDUTAT	Número de Ovejas por Unidad de Trabajo Total (NO/UTAT)	40,343	6,7	0,524	6,004	0,000***				1,045
	Superficie Agrícola Útil Total (SAUT)	56,375	17,2	0,289	3,273	0,002**				1,071
	Hectáreas de cultivos forrajeros (HCF)	–154,843	56,863	–0,243	–2,723	0,008**				1,092
Regresión 2	Constante	–8531,790	3263,4		–2,614	0,011*	**0,343**	**0,327**	**1,865**	
Renta Disponible por Unidad de Trabajo Total con Mano de Obra Familiar	Número de Ovejas por Unidad de Trabajo Total (NO/UTAT)	38,728	6,8	0,498	5,647	0,000***				1,016
RDUTATCMOF	Superficie Agrícola Útil Total (SAUT)	50,117	17,4	0,253	2,874	0,005**				1,016

(1) (D.E) desviación estándar; (2) (β Std)β estandarizados; (3) (T) T-valor; (4) (P) P-valor; (5) (R^2) R cuadrado; (6) (FIV) factor de inflación de la varianza.

Tabla 7. Resultado de los modelos de regresiones lineales múltiples del grupo 2.
Table 7. The results of the multiple linear regressions models for cluster 2.

	Parámetros	Coeficientes no estandarizados (β)	D.E(1)	Coeficientes estandarizados (β Std)(2)	T(3)	P(4)	R^2(5)	R^2 Ajustado	Durbin-Watson	FIV(6)
Regresión 1	Constante	–7999,218	4193,3		–1,908	0,066	**0,707**	**0,669**	**1,877**	
Renta Disponible por Unidad de Trabajo Total RDUTAT	Número de Ovejas por Unidad de Trabajo Total (NO/UTAT)	40,214	7,2	0,602	5,564	0,000***				1,237
	Número de Ovejas por hectárea de Superficie Agrícola Útil Total (NO/SAUT)	–48,177	11,9	–0,472	–4,045	0,000***				1,437
	% Unidades de Trabajo Familiar (% UTF)	151,283	50,9	0,325	2,970	0,006**				1,266
	% Regadío sobre Superficie Agrícola Útil Total (% Reg/SAUT)	125,190	44,8	0,325	2,790	0,009**				1,430
Regresión 2	Constante	–7345,620	3406,8		–2,156	0,039*	**0,651**	**0,618**	**1,876**	
Renta Disponible por Unidad de Trabajo Total con Mano de Obra Familiar	Número de Ovejas por Unidad de Trabajo Total (NO/UTAT)	41,039	6,4	0,677	6,358	0,000***				1,039
RDUTATCMOF	Número de Ovejas por hectárea de Superficie Agrícola Útil Total (NO/SAUT)	–50,634	11,3	–0,546	–4,481	0,000***				1,362
	% Regadío sobre Superficie Agrícola Útil Total (% Reg/SAUT)	125,768	42,7	0,359	2,940	0,006**				1,369

(1) (D.E) desviación estándar; (2) (β Std)β estandarizados;(3) (T) T-valor; (4) (P) P-valor; (5) (R^2) R cuadrado; (6) (FIV) factor de inflación de la varianza.

En el grupo de explotaciones más grandes (tabla 7), el grupo 2, los resultados coinciden con los del total de la muestra, siendo la intensificación de la mano de obra (NO/UTAT) una variable explicativa de unos mejores resultados, mientras que el mayor número de ovejas por hectárea de SAUT, de nuevo vuelve a aparecer con signo negativo. Como diferencia con respecto a los resultados de la totalidad de la muestra podemos destacar que en este grupo de explotaciones grandes, la mayor proporción de regadío (% Reg/SAUT), se asocia también con unos mejores resultados económicos al permitir mejorar su autonomía alimenticia.

Los resultados del presente trabajo indican que la intensificación de la mano de obra está positivamente correlacionada con la renta disponible por unidad total de trabajo en todos los modelos analizados, por lo que se convierte en un instrumento importante para mejorar los resultados económicos por unidad de trabajo. De acuerdo con Pardos y Fantova (2007) las explotaciones con mejores resultados económicos son explotaciones con más ovejas por unidad de trabajo. Sin embargo, en opinión de algunos autores (Benoit y Laignel, 2011), la intensificación del trabajo no siempre lleva consigo más renta disponible por unidad total de trabajo, ya que no es fácil en esas circunstancias mantener el rendimiento zootécnico alto, por lo que es importante tener en cuenta el aspecto técnico cuando las explotaciones optan por la intensificación de la mano de obra. Además, el efecto positivo de la intensificación de la mano de obra sobre la renta disponible por unidad total del trabajo podría explicarse indirectamente por el tamaño del rebaño y las subvenciones de la PAC. De acuerdo con Lorent *et al.* (2009), las subvenciones acopladas estimulaban el crecimiento del tamaño del rebaño, por lo tanto, el número de ovejas por unidad total de mano de obra.

Con respecto a las unidades de trabajo familiar, éstas tienen un impacto positivo en la renta disponible por unidad de trabajo total solo cuando su coste no está incluido en la estimación del resultado económico. Este resultado se ha obtenido cuando se hizo el análisis de regresión sobre la totalidad de la muestra (tabla 5) y sobre el grupo 2 formado por las explotaciones más grandes (tabla 7). Este resultado es totalmente lógico e indica que solamente cuando no se retribuye la mano de obra familiar un mayor porcentaje de su utilización conlleva una mayor renta disponible. Coincide con lo señalado por otros autores Aggelopoulos *et al.* (2009) que han indicado la necesidad de reducir los costes de la mano de obra para la obtención de unos mejores resultados económicos. Esto no se observa en las explotaciones de menor tamaño donde la mayoría de la mano de obra es familiar. Por el contario estas explotaciones encuentran su limitación en las hectáreas de superficie útil disponible, por lo que una mayor disponibilidad explica unos mejores resultados.

Se puede señalar que según los resultados de la regresión del grupo 1, la variable SAUT está correlacionada positivamente con la RDUTAT con y sin tener en cuenta la mano de obra familiar. Mientras, la variable HCF tiene un poder negativo sobre la RDUTAT únicamente, cuando no se tiene en cuenta la mano de obra familiar, al incrementarse la importancia relativa del coste de alimentación en los costes totales. Como ya se ha indicado, este hecho podría tener su explicación en que estos sistemas, que suelen ser mixtos, intentan conseguir la autonomía forrajera sobre el aprovechamiento de los pastos naturales más que de los cultivos forrajeros, al orientar su SAU a la producción de cereales, tanto para la venta como para autoconsumo propio.

Conclusiones

La tipificación estructural realizada ha permitido la clasificación de las explotaciones en dos grupos distintos que se diferencian fundamentalmente por su tamaño. Las explotaciones más pequeñas utilizan mayor proporción de trabajo familiar y realizan menores arrendamientos de superficie forrajera, mientras que las de mayor tamaño, son más intensivas en el uso del factor trabajo. Sin embargo, estas diferencias estructurales no se traducen en unos resultados económicos distintos, no siendo por tanto el tamaño un determinante de su rentabilidad.

Al relacionar los resultados económicos con las variables estructurales se observa que éstos guardan relación con una mayor intensificación del factor trabajo con respecto al tamaño del rebaño. Un mayor porcentaje de utilización de mano de obra familiar contribuye a unos mejores resultados cuando ésta no se remunera tanto en el grupo de explotaciones grandes como para el conjunto de la muestra. En las explotaciones pequeñas los mejores resultados económicos se asocian a una mayor disponibilidad de superficie, al tratarse probablemente de un factor limitante. Por el contrario, una alta carga ganadera por hectárea de superficie agrícola útil se relaciona con peores resultados económicos. Si bien la intensificación del trabajo se ha relacionado en muchos trabajos con unos mejores resultados económicos, sería preciso profundizar en los aspectos técnicos relacionados con la utilización de recursos y el manejo de las explotaciones para una mejor comprensión de la repercusión negativa que una mayor carga ganadera tiene sobre los resultados.

Material complementario

El material complementario de este artículo se puede consultar en la URL https://doi.org/10.12706/itea.2020.023

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RESEARCH PAPER 2

Reproductive indicators as predictors of economic performance of sheep farms

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Reproductive indicators as predictors of economic performance of sheep farms

Los indicadores reproductivos como predictores de los resultados económicos en las explotaciones ovinas

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Summary

Sheep systems are very important to ensure the sustainability of Mediterranean regions. In Europe, the dependence of farms on EU subsidies makes them very sensitive to changes in the CAP, so it is very necessary to ensure their economic viability. It has been seen that the improvement of reproductive practices improves the economic performance of farms, so the aim of this work is to analyse the predictive role that reproductive variables have on the economic indicator Gross margin per annual labour work unit, in both cases when the subsidies have taken into account or not. A sample of 128 sheep farms from the Aragon region (Spain) with records on a long time period from 1993 to 2016 has been used. Six technical variables have been synthesized into two factors carrying out a PCA, and three groups of farms significantly different from each other in both their technical and economic performance have been established from the factors. Linear regression analysis allows us to observe that the technical variables have a predictive effect on economic performance. The results differ when referring to the whole sample as well as to the different groups, and depending on whether subsidies are taken into account or not. It has been concluded that good reproductive management with improvements in productivity predict good economic performance by reducing the impact of subsidies.

Resumen

Los sistemas ovinos son muy importantes para asegurar la sostenibilidad de las regiones mediterráneas. En Europa la dependencia de las explotaciones con respecto a las ayudas comunitarias las hace muy sensibles a los cambios de la PAC, por ello es muy necesario asegurar su viabilidad económica. Se sabe que buenas prácticas reproductivas mejoran los resultados económicos de las explotaciones, por lo que el objetivo de este trabajo es analizar el papel predictor que las variables reproductivas tienen sobre el indicador económico Margen bruto por unidad de trabajo anual, teniendo en cuenta o no las subvenciones. Se ha utilizado una muestra de 128 explotaciones ovinas de Aragón (Spain) con registros del periodo 1993 a 2016. Se han sintetizado seis variables técnicas en dos factores mediante un ACP, y se han establecido a partir de los factores tres grupos de explotaciones significativamente diferentes tanto en sus resultados técnicos como económicos. El análisis de regresión lineal permite observar que las variables técnicas tienen un efecto predictor en los resultados económicos. Éstos difieren cuando se refieren al conjunto de la muestra o a los diferentes grupos, y en función de si se consideran o no las subvenciones. Se concluye que un buen manejo reproductivo con mejoras en la productividad predice unos buenos resultados económicos reduciendo el impacto de las subvenciones.

Introduction

Animal production systems are complex and interlinked by biological, social, cultural, climatic, economic, and technological indicators (Freitas et al., 2021). Small ruminant systems of the Mediterranean basin have considerable economic, social and environmental importance. Their current organization and resource endowment are the result of long-term historical, geo-political and socio-economic changes (de Rancourt et al., 2006; Castel et al., 2011; Ryschawy et al., 2013, Toro-Mujica et al., 2015). Worldwide, sheep farming in semiarid regions is typically located in marginal areas, where other animal species with greater profitability, such as beef or dairy cattle, are not adapted to use the available pastoral resources (Toro-Mujica et al., 2019). In Spain, 82% of sheep farms are located in Extremadura, Andalusia, both Castillas and Aragon (MAPA, 2021). It is in the latter region where this work has been carried out and where sheep farming, although it can be considered in decline, continues to play an important role in the economic, social and environmental sustainability of many rural areas.

The sheep farming systems mainly the meat sheep farms has experienced a difficult period in the last decades, and their viability has been maintained at the majority thanks to subsidies (Milan et al., 2003; Weltin et al., 2016; Benoit et al., 2020, Soriano et al., 2018). But with the changes in the Common Agricultural Policy (CAP) regarding to the aids policy, the viability of these systems is threatened, because of their fragility and sensibility to every change. Improving technical indicators has been one of the solutions for these systems, mainly productivity is one of the solutions to alleviate the dependency of these farms to CAP subsidies (Benoit and Laignel, 2011). In the last decades, improving the reproductive management and practices of the meat sheep farms has been one of the solutions of the farms to improve their economic results. According to Pardos et al. (2008; 2014) in Aragon (Spain), the meat sheep farming systems have rapidly moved to intensive large flocks, focussed on lamb productivity and the use of the Rasa Aragonesa breed. In highly productive herds, the proportion of pregnant and lactating animals is greater, and these animals graze for shorter periods, as they are housed and fed more frequently (Bernués et al., 2011, Mena et al., 2016). According to Benoit and Laignel (2011) combine high animal productivity with increase of the use of fodder resources requires a certain technical know-how and an adaptation of farming systems, or even of the used genotypes.

In order to protect one of most important extensive systems, studying different farms indicators is a key to figure out the drivers of change in these systems and it could give to decision makers a clear insight on the dynamics of these farms. Though farm management indicators always aim to be simple statements of a complex reality, the assessment of a wide range of indicators can be quite complicated (Andersen et al., 2007). Studying the different indicators is generally related to the economic results. Improving the economic results of these farms has been the major preoccupation of farmers (Benoit and Laignel, 2008), because just with an economic autonomy the viability of these systems could be insured. Many studies have been carried out to figure out the influence of different technical variables on economic results.

The main objective of the present work is to figure out possible relationship between some selected technical indicators related to the reproductive management of the herds and the economic results. Given the existing heterogeneity of the farms in terms of this management and the obtained results, a previous typification of the farms will be made. This will make it possible to determine whether the technical variables associated with certain results differ according to the type of farm. From the management point of view, this will make it possible to make a greater effort to improve those parameters that have a more direct impact on results.

1. Material and Methods

It has been used a sample made up of 128 meat sheep farms which belong to a technical-economic recording data program of one of the most important sheep cooperatives located in Aragon (Oviaragón-Grupo Pastores). The farms are in the different three provinces (Zaragoza, Huesca and Teruel) of Aragon region (Spain). Given that the technical-economic program which recorded all the data used in this work began in the decade of the 90s and the continuity of many of the farms, in some cases we used data averages of 24 years that range from 1993 to 2016, for each farm the mean data of each variable corresponds to the average of the years for which there were records or registers. The length of the study period made it necessary for those variables expressed in monetary units to be converted to constant euros of 2016.

After consultation of various technical studies (Oliván and Pardos, 2000; Kleinhanß et al., 2007, Pardos et al., 2008; Olaizola et al, 2008; Benoit and Laignel, 2008; García Martínez, 2009; Ripoll-Bosch et al., 2014; Pardos, 2014; Earle et al., 2017; Bohan et al., 2018; Benoit et al., 2020; Gazzarin and El Benni, 2020; Bertolozzi-Caredio et al., 2021) it has been chosen six technical variables related to the reproductive management of herds to carry out the analyses of the present work. The chosen variables were Prolificacy (Pr), Number of lambings per present ewe and year (NL/PE), percentage of lambs' Mortality (% Mr), Number of ewes per stud (NE/S), Number of sold lambs per present ewe and year (NSL/PE) and the Annual ewe replacement rate (%FRep).

For economic results, the Gross margin per annual labour unit (GM/LU) was used. The gross margin per labour unit can be considered as the most significant measure of the obtained economic results and an indicator of the possible continuity of the farms by including the productivity per sheep and the correct size of the herd (Olaizola et al., 1996; Benoit and Laignel 2008; Charroin et al., 2012).

It has been used univariate analysis for the general description of the sample and the multivariate analysis for more deep analysis.

The multivariate analyses were factor analysis to reduce the number of variables and facilitate subsequent analysis of the results, two-step cluster analysis to obtain the homogeneous groups of farms, and multiple linear regression to establish dependency relationships (Hair et al., 2014).

Cluster analysis allows obtaining groups of farms that are as homogeneous as possible within each group and as heterogeneous between groups. The factorial scores of the individuals were taken into account to perform the cluster analysis. The proportions of the clusters were defined with the variable «cluster membership».

In the multiple linear regression analysis, the predictor variables were the six technical variables used to carry out the factor analysis, and the dependent variable was the Gross margin per labour unit with and without subsidies (GM/LUWS) and (GM/LUWTS), respectively. It has been performed a multiple linear regression for the whole sample and for each group resulted from the cluster analysis.

To perform the multiple linear regression analysis, it was used the stepwise method to keep only the significant independent variables in the resulting models. The linear generic model was formulated as follows:

$$(GM/LUWS) \text{ or } (GM/LUWTS) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ...\beta_n X_n + e$$

Where GM/LUWS (Gross margin per labour unit with subsidies) or GM/LUWTS (Gross margin per labour unit without subsidies) is the dependent variable, β_0 is the regression constant, and β_1 β_2 β_3 ... β_n are coefficients to be estimated, X_1, X_2, X_3 .. X_n were the used technical variables and (e) is the error of the regression model. Regression coefficients were checked using the t-test. The coefficient of determination (R^2) was used as a predictive criterion for the regression model (Draper and Smith, 1998, Sakar et al., 2011). The SPSS version 26 package has been used to carry out the statistical analyses.

2. Results

Sample description

As mentioned in the methodology section, the used sample was made up of 128 farms which belong to an important ovine technical economic management program in Aragon (Spain). Table 1 shows the sample description. The average ewes' number was (601) ewes handled by (1.32) total labour units. The average number of ewes per labour unit was (461) ewes. Regarding to the technical indicators, the average number of lambings per present ewe and year was (1.12), the average prolificacy recorded was (1.34) and the average percentage of lambs' mortality was (10.6 %). With respect to the annual ewe replacement rate was almost (14%), the average sold lambs per ewe and year was (1.17) and the average number of ewes per stud was (45 ewes). Regarding to economic variables, it has been recorded a mean of (25090 euros) for gross margin per labour unit with subsidies and (5272 euros) of the gross margin per labour unit without subsidies. With respect to the main sheep breed of the farms it is the "Rasa Aragonesa" breed where it has been recorded (107 farms) with this breed. Rasa Aragonesa is a rustic breed of meat aptitude located in the Northeast of Spain, with an average prolificacy of (1.30) (Alabart et al. (2016), and this breed can be exploited successfully with the system of 3 lambings in 2 years because it is a non-seasonal breed and because the lambs are weaned relatively early (at the age of six weeks), allowing the ewe to recover for the next mating (Folch et al., 2007). The rest of the farms has been distributed between (7) farms with "F1 prolifica", (7) farms with "Ojinegra", (3) farms with "Roya Bilbilitana", (2) farms with Lacaune, (1) farm with "Maellana" and (1) farm with "Segureña".

Factor analysis

In order to reduce dimensions of the technical indicators used in the present study, it has been performed a factor analysis with Principal Component Analysis (PCA) as an extraction method.

It has been recorded KMO index = 0.50, it is considered as low, but according to various authors it is an average value between 0.5 and 0.6 is acceptable for sample sizes between 100 and 200 (Guttman, 1954; Kaiser, 1970; Tabachnick, and Fidell, 2013; Shrestha,2021). The Bartlett's (Chi-square) test for Sphericity was very significant at $p < 0.0001$ which allow us to continue with the interpretation of factor analysis results. As it can be seen in table 2, the communalities of the used variables were high except for annual ewe replacement rate (%FRep) was (0.271). According to (Child, 2006; Samuels, 2017) it is advisable to remove just items with a communality score less than (0.200). Furthermore, it has been highlighted those communalities between 0.25 and 0.4 have been suggested as acceptable cut-off values, with ideal communalities being 0.7 or above (Beavers et al., 2013; Eaton al., 2019). The six original variables related to technical ratios were reduced to two factors which explain 65.59 % of the total variance which is considered quite significant rate for variance explanation (Table 2).

It has been performed the Varimax method for factors rotation; the results are reported as follows in table 2.

Factor 1 is highly and positively correlated with three of the sixth initial variables; these variables are related to the Numbers of sold lambs per ewe and year (NSL/PE) and Number of lambings by present ewe and year (NL/PE), Prolificacy (Pr) and moderately and positively correlated with Annual ewe replacement rate (%FRep). This factor can be characterized by *productivity and annual ewe replacement rate*

Factor 2 is correlated with two variables. This factor is positively correlated with the percentage of lambs' Mortality (% Mr) and negatively correlated with the Number of ewes per stud (NE/S). This factor can be characterized by *reproduction ratio and lambs' mortality.*

Cluster analysis

In order to gather the sample into homogeneous groups it has been performed a two-step cluster analysis. It has been used the factorial scores resulted from the factor analysis as continuous variables to perform the cluster analysis. It was created a new variable when computing data which named «cluster membership». It has been used to define clusters 'proportions. The quality of the resulted clusters is fair (Figure 1).

Statistics were significant for Variance ANOVA test at $p < 0{,}0001$. It has been demonstrated that each cluster is differently linked with respect to each factor.

The profiles reported in table 3 show that each cluster is correlated differently to each factor.

For farther description and more characterisation for each cluster, the variable « Cluster membership » has been crossed with the sixth initial technical variables used to perform factor analysis, the results are reported in the following table (Table 4).

Table 4 shows the description of the clusters. It has been used ANOVA to test the mean differences between groups. The mean differences for all the technical variables and the economic variables (gross margin per labour unit with or without subsidies) used in the present study were highly significant when the mean differences have been assessed between (C1, C2 and C3). When the mean differences were assessed between each two clusters, they kept the same trend and they were highly significant even there were some exceptions which were: the mean difference in prolificacy and the annual ewe replacement rate between cluster 2 and cluster 3 has been resulted not significant. The mean difference between the number of ewes per stud between cluster 1 and cluster 3 has been resulted not significant. And the mean difference in the number of lambings per present ewe and year has been resulted significant at 10% when comparing the means between cluster 2 and cluster 3. The mean differences for prolificacy and the annual ewe replacement rate have been resulted not significant too. The mean differences in the economic results between cluster 1 and cluster 2 has been resulted not significant. The description for each cluster is as follows:

Cluster 1- This group has been characterized more by factor 1 even if it is correlated positively with factor 2 but with lower importance. These farms have the highest means for the technical-economic variables characterising the factor 1: Prolificacy (Pr) (1.51), Number of lambings per present ewe and year (NL/PE) (1.28), Number of sold lambs per present ewe and year (NSL/PE) (1.50), Annual ewe replacement rate (% FRep) (16.76), Gross margin per labour unit with subsidies (GM/LUWS) (27209.00 €) and Gross margin per labour unit without subsidies (GM/LUWTS) (7166.6 €).

Where these farms have the lowest mean for the Number of ewes per stud (NE/S) (38.49) and the second mean for percentage of lambs' Mortality (% Mr) (10.98) comparing to other clusters resulting from this analysis. This group can be characterized as the group with the best technical productive indicators and best economic results.

Cluster 2- This group has been negatively correlated with both factors 1 and 2. This cluster presents the highest mean for the Number of ewes per stud (NE/S) (51.34 %) and the lowest mean for the percentage of lambs' Mortality (% Mr) (8.57 %). While it presents the second highest mean for the following variables: Prolificacy (Pr) (1.30), Number of lambings per present ewe and year (NL/PE) (1.08), Number of sold lambs per present ewe and year (NSL/PE) (1.11), and Annual ewe replacement rate (%FRep) (13 %). With respect to the economic results, it has recorded the second mean for the Gross margin per labour unit with subsidies (26668.17 €) and without subsidies (7142.12 €) respectively. This group does not have the high degree of reproductive intensification like cluster 1. This translates into lower lamb mortality, a lower replacement rate and a lower number of males per ewe. With a different reproductive strategy, they also achieve good economic results comparing to cluster 1, where the mean difference in the economic results has been resulted not significant between cluster 1 and cluster 2.

Cluster 3- This group has been negatively correlated with factor 1 and positively correlated with factor 2. It has been recorded the highest mean for lambs' Mortality (14.51 %) and the second highest mean record for the Number of ewes per stud (NE/S) (40.47). With respect to the rest of the used technical variables it has been recorded the lowest means: Prolificacy (1.26), Number of lambings per present ewe and year (NL/PE) (1.03), Number of sold lambs per present ewe and year (NSL/PE) (0.98), the average Annual ewe replacement rate (%FRep) (13.26). Regarding to the economic results it has been recorded the lowest means for the Gross margin per labour unit for both with subsidies GM/LUWS (19834.95 €) and without subsidies (GM/LUWTS) (-542.91 €). For this group, poor reproductive management translated into poorer economic results.

Linear regression analysis

It has been performed multiple linear regressions for the whole sample and by clusters as it has been commented previously in the methodological part. The dependent variables are the Gross margin with and without subsidies (GM/LUWS) and (GM/LUWTS) respectively. The independent variables were the six technical variables which have been used to perform the factor analysis in the present work.

The results of the multiple linear regression analyses for the whole sample and for each cluster have been presented in tables 5 and 6. As it has been highlighted in the methodological part that R-Squared (R^2 or the coefficient of determination) is a statistical measure in a regression model that determines the proportion of variance in the dependent variable that can be explained by the independent variables. The recorded adjusted R^2 for the regressions were relatively low, but according to Falk and Miller (1992), they recommended that R^2 values should be equal to or greater than 0.10 to be considered. Its relevance has been supported by the T, Durbin-Watson, F and VIF values which were significant.

As it can be seen in table 5, related to the linear regressions for **the whole sample**, that the first model for regression 1 where it has been taken into account the subsidies in the Gross margin per labour unit (GM/LUWS), the Number of sold lambs per present ewe and year (NSL/PE) and the Number of ewes per stud (NE/S) had a positive power on the economic results. It could be explained that the correct number of ewes per stud could improve the economic results. However, percentage of lambs' Mortality (% Mr) had a negative power on the economic results.

The second model for regression 2 where the subsidies have not been taken into account showed that just the Number of sold lambs per present ewe and year (NSL/PE) had a positive impact on the economic results and the percentage of lambs' Mortality (% Mr) had a negative impact on the economic results. The explanation for the fact that the Number of ewes per stud does not appear as an explanatory figure when subsidies are not taken into account is due to subsidies. While the subsidies were totally or partially coupled, farmers increased the number of ewes or sheep culling was slowed down in order to receive more premiums, but not the number of studs. This is why, when subsidies are taken into account, the economic results are associated with a higher number of ewes per stud.

Lambs' mortality has been an issue for sheep meat farms because it causes the decrease of the sold lambs per ewe independently of the production system.

The results for **group 1** are presented in table 6. The first model for the regression 1 where subsidies have been taken into account has been recorded that the percentage of lambs' Mortality (% Mr) had a negative effect on the economic results and when subsidies have not been taken into account, the Annual ewe replacement rate (% FRep) had a negative power on the economic results. As this group had recorded the highest annual ewe replacement rate the farms couldn't support the additional cost without subsidies.

For **group 2**, the results showed in table 6 indicate that the Number of sold lambs per present ewe and year was the unique variable which had a positive power on the economic results in both cases when the subsidies were taken into account and when they weren't taken into account.

This group has recorded the lowest percentage of lambs' Mortality, it could be an explanation for the non-negative power of the percentage of lambs' Mortality on the economic results for this group.

The results (in table 6) for **group 3** showed that for regression 1 when subsidies have been taken into account, the Number of lambings per present ewe and year had the positive power on the economic results. The percentage of lambs' Mortality (% Mr) had a negative power on the economic results when the subsidies weren't taken into account. This group had recorded the highest lambs' mortality rate. For this group, the economic results could be improved with better lambing rate only with subsidies. In addition, to be more efficient, lambs' Mortality must be controlled to improve the economic results.

3. Discussion

From the results obtained we can deduce that the studied technical factors have a positive or a negative power on the economic results of meat sheep farms thus in their economic viability. Several studies agree that productivity is a main driver of economic success in the sheep business (Bohan et al., 2018; Harrison, 1980; Keady and Hanrahan, 2006; Morel et al., 2004). Productivity is influenced by the ewe genotype, herd management and feeding, and the intensity of supervision and care before and after lambing (Gazzarin and El Benni, 2020). Benoit et al. (2020) have showed that variations in technical variables have larger effects on income variability than variations in economic variables.

The prolificacy rate can vary significantly between herds (Amer et al., 1999), which is the case in our study, the difference in prolificacy rate between the resulted 3 groups has been very significant even if the main breed is the same Rasa Aragonesa. There are different factors on which the prolificacy depends which are mainly the individual variation (presence of major genes), age, season of year, climatology, ewes' feeding and flushing, use of hormonal treatments, number of lambings and health status of the ewe, etc. (Pardos, 2016). Increasing prolificacy reduces the production costs which leads to better production efficiency (Earle et al., 2017; Bohan et al. 2018; Gazzarin & El Benni 2020) and consequently the number of lambs produced per ewe can be a suitable indicator of productive efficiency (Bertolozzi-Caredio et al., 2021). Ólivan and Pardos (2000) have concluded that an increase in prolificacy of 9.2% above the mean (1.43 vs 1.31) causes an increase of 23.3% in the sheep activity margin per ewe per year. Thus, a higher prolificacy rate is a key to improve the economic results of meat sheep farms. Ripoll-Bosch et al. (2014) have concluded that a higher prolificacy could mitigate the relative importance of the coupled subventions to farms gross margin. And from his side Galanopoulos et al. (2011) argue that less efficient sheep farms are more dependent on aids.

The average sold lambs per ewe was 1.17 which is lower than the rates recorded by Pardos (2014 and 2016) as the samples and periods of study were different. The number of sold lambs is correlated with prolificacy and the number of lambings per ewe and per year. According to Riedel et al. (2007) the intensification of production in meat sheep systems leads to an increase in the number of sold lambs per ewe and year, which is the case of the group 1. In our results, it is showed that for the whole sample and for group 2 , the number of sold lambs has a positive power on the economic results.

This productive parameter is very important in improving the incomes of the farms. Cabrera (2009) found that greater number of sold lambs leads to more incomes for the farms. Gazzarin and El Benni (2020) have concluded that productivity, defined as the number of sold lambs per ewe and year, is strongly related to gross margin. According to Pardos (2014), those farms that have a greater productive intensification: greater number of lambings per present ewe per year, greater prolificacy, less lambs' mortality percentage and greater number of sold lambs per ewe, which leads to best economic results.

With respect to the number of lambings per ewe per year, in the literature, two systems are mainly discussed: 1) the 8-month system, applied more frequently, which corresponds to a lambing interval of 240 days or, what is the same, 3 lambings per ewe in 2 years (Fogarty et al., 1992; Speedy and FritzSimons, 1977) and 2) the "STAR" system, which corresponds to a lambing interval of 220 days or, what is the same to 5 lambings in 3 years (deNicolo et al., 2008 Lewis et al., 1996). Shortening the lambing interval to 240 days (3 lambings in 2 years), improving annual fertility, resulted in a substantial increase in gross margin (+44%), return on labour (+27%) and income per hectare (+57%) compared to the reference scenario (Gazzarin and El Benni, 2020). In mountain areas with one lambing per year, the increase in prolificacy also improved economic results (Gazzarin and El Benni, 2020).

In the case of our study, the mean lambing interval for the whole sample (342) days, and the lowest mean was for cluster 1 (293 days), which gives the possibility to improve this parameter to be more efficient. Cluster 3 has the highest mean lambing interval with (369 days), which means that the highest mortality rate for this group is due to other factors. The short pregnancy period gives the possibility to implement multiperiod lambing which can buffer the variability in technical performance and enhance the adaptive capability of the system for instance by moving empty ewes to a new batch and remating them. Lambing rate is one of the main drivers of flock technical performance on ewe fertility and breeding management (Benoit et al., 2020).

The other important technical factor which has been studied in this work, the impact of lambs' mortality rate on the economic results of the farms. An important factor in productivity per ewe is the mortality or loss of lambs after birth, including stillborn lambs (Gazzarin and El Benni, 2020). Lambs' mortality increased in recent years due, apart from births of old sheep, health problems and reproductive intensification, labour intensification more lambings to handle for the same number of workers, concentrated in time and sometimes with unfavourable weather, the impossibility on some occasions of continuous monitoring of the same and the incorrect feeding of the ewes at the end of gestation and first days of lactation. Added to that in some cases, having the same facilities with a larger number of ewes, without lambing boxes or enough space to separate them (Pardos, 2016).

Positive correlations have been recorded between litter size and mortality. This could be explained mainly by the higher frequency of triplets (Morris and Kenyon, 2014). According to Morel and Kenion (2006) higher prolificacy is associated with an increase in the percentage of double- or triple-lambings showing higher mortality rates than simple delivery.

Our results showed that cluster 3 had recorded the highest mortality rate and the worst economic results, which support the strong impact of mortality on the economic results. Added to that the regression analysis confirmed this trend by figuring out the negative impact of lambs' mortality in predicting the economic results. According to Delgado and Gutiérrez (2009) the lambs' mortality rate must not exceed 5 %. Shiels et al. (2022) have concluded that lambs' mortality could be reduced with on farm management practices thus improve the flock gross margin.

With respect to annual ewe replacement rate was almost 14%, this result coincides with the result of Marín-Bernal and Navarro-Rios (2014) but not with Garcia et al. (2005) 20%, and Pardos (2014) with a percentage of replacement oscillating between 15.9% and 17.2 %. For replacement rate Farrell et al. (2020) had concluded that larger increases in cash operating surplus (COS) occurred with a higher flock lambing rate and lower ewe replacement rate, which allowed for terminal sire use over a greater proportion of the flock. In our results even if the group 1 had the best economic results, but the replacement rate was higher, which means that the right replacement rate could improve the economic results by reducing the cost of unnecessary added cost for unproductive animals. According to Farrell et al. (2020) better economic results obtained with the lower annual ewe replacement rate combined with the higher flock lambing rate. Thus, the correct annual ewe replacement rate is important to avoid more additional unnecessary cost of non-productive animals.

The average number of ewes per stud was 45 ewes. It coincides more or less with the results recorded by Pardos et al. (2008). According to Delgado and Gutiérrez (2009) the right number of studs in a sheep herd is the 3% of the total number of ewes. Thus, in our case the number of ewes per stud for Cluster 1 could be considered as a good one, but for cluster 2 and cluster 3 it is high and could be adjusted to have the right effect of this parameter on the productivity of the farm.

The participation of farmers in research projects for the selection of breeds and management systems, as well as the technical support of cooperatives, appear as a promising way to increase the efficiency of farms and the prolificacy of sheep (Bertolozzi-Caredio et al., 2021).

Sheep farming must find solutions to a) increase production efficiency and profitability (Morgan-Davies et al., 2021) and b) accelerate the pace of technology development and adoption to successfully compete in the future (Montossi et al., 2013).

Conclusions

These results show that all the studied technical factors had a positive or a negative impact in predicting the economic results of meat sheep farms. The productive parameters as number of sold lambs has a real power in improving the economic results with and without taking into account subsidies. And the number of lambings per present ewe could be a solution to improve the economic results by shortening the lambings intervals. Finally, lambs' mortality percentage must be taken into account to improve the economic results of the meat sheep farms. Even if other productive parameters were performed, if the farm doesn't control lambs' mortality, it will record loss in the economic profit. As the values recorded were above 10%, thus there are possibilities to improve this aspect, both sanitary and handling. Added to that, and regarding to the reproductive aspect the use of the correct annual ewe replacement rate could help to improve the economic results by reducing the production costs, thus mitigating the impact of subventions in the economic efficiency and viability of meat sheep farms. Implementing new technologies and participating in research projects and benefit from the technical support of specialised cooperatives would be a real help to improve the technical efficiency of meat sheep farms.

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TableI. Sample description.

TablaI. Descripción de la muestra.

	Mean	Std. Deviation
Structural indicators		
Average number of ewes (NE)	601	303
Number of total labour units (TLU)	1.32	0.49
Number of ewes/Labour unit (NE/LU)	461	143
Technical indicators		
Number of lambings by present ewe and year (NL/PE)	1.12	0.13
Prolificacy (Pr)	1.34	0.134
Percentage of Lambs mortality (% Mr)	10.6	3.7
Annual ewe replacement rate (% FRep)	13.98	3.59
Number of sold lambs ewe and year- (NSL/PE)	1.17	0.25
Number of ewes per stud (NE/S)	45.5	12.1
Economic indicators		
Gross margin/Labour unit with subsidies (GM/LUWS)	25090.8	10238.2
Gross margin/Labour unit without subsidies (GM/LUWTS)	5272.2	9227.8

TableII. Components Rotated Matrix and Communalities for farms' technical variables.
TablaII. Matriz de Componentes rotados y Comunalidades de las variables técnicas.

Factors and variables	Factors		Communalities
	Factor 1	Factor 2	
Number of sold lambs per present ewe (NSL/PE)	**0.940**	-0.113	0.897
Number of lambings by present ewe (NL/PE)	**0.900**	0.013	0.811
Prolificacy (Pr)	**0.845**	0.102	0.724
Annual ewe replacement rate (%FRep)	**0.488**	0.182	0.271
Percentage of lambs' mortality (% Mr)	-0.131	**0.846**	0.732
Number of ewes per stud (NE/S)	-0.211	**-0.675**	0.500
Eigen value	2.714	1.222	
% Variance	45.230	20.359	
% Cumulative variance	45.230	65.589	

TableIII. Clusters' profile.

TablaIII. Perfil de los Clústeres.

Factors	Cluster 1	Cluster 2	Cluster 3
Number of farms	31	65	32
Factor 1	1.4028021	-0.3134774	-0.7222135
Factor 2	0.3679013	-0.6640958	0.9925402

TableIV. Clusters' description.

TablaIV. Descripción de los Clústeres.

Variables	Cluster 1		Cluster 2		Cluster 3		Significance level (C1,C2,C3)	Significance level C1, C2	Significance level C1, C3	Significance level C2, C3
	Mean	Std.D	Mean	Std. D	Mean	Std.D				
Prolificacy (Pr)	1.51	0.10	1.30	0.09	1.26	0.09	***	***	***	NS
Number of lambings per present ewe and year (NL/PE)	1.28	0.08	1.08	0.09	1.03	0.09	***	***	***	*
Percentage of lambs' mortality (%Mr)	10.98	2.83	8.57	2.29	14.51	3.81	***	***	***	***
Number of sold lambs per present ewe and year (NSL/PE)	1.50	0.19	1.11	0.16	0.98	0.15	***	***	***	***
Annual ewe replacement rate (% FRep)	16.76	2.99	13.00	3.05	13.26	3.82	***	***	***	NS
Number of ewes per stud (NE/S)	38.49	6.69	51.34	13.03	40.47	7.68	***	***	NS	***
Gross margin per labour unit with subsidies (GM/LUWS) (€)	27209.00	10476.20	26668.17	10170.97	19834.95	8451.30	***	NS	***	***
Gross margin per labour unit without subsidies (GM/LUWTS) (€)	7166.60	8609.54	7142.12	8421.59	-542.91	9273.12	***	NS	***	***

Significance level at: (***) p < 0,0001. (**) p < 0.05 (*) p < 0.1 NS: Not significant

TableV. Results of the multiple linear regression models for the whole sample.

TablaV. Resultados de los modelos de regresión lineal múltiple para el conjunto de la muestra.

	Parameters	Unstandardised coefficients (β)	Sd.D(1)	Standardised coefficient (β Std)	T(2)	P(3)	R^2 % (4)	Adjusted R^2 %	Durbin-Watson	VIF(5)
Regression 1 (GM/LUWS) (6)	Constant	3939.065	6617.663		0.595	0.553	24.1	22.2	1.823	
	Number of sold lambs per present ewe (NSL/PE)	14254.856	3238.342	0.360	4.402	0.000***				1.091
	Number of ewes per stud (NE/S)	213.018	69.153	0.252	3.080	0.003**				1.092
	Percentage of lambs' mortality (%Mr)	-495.854	224.353	-0.182	-2.210	0.029**				1.106
Regression 2 (GM/LUWTS)(7)	Constant	1954.694	4318.452		0.453	0.652	24.4	23.2	1.774	1.000
	Percentage of lambs' mortality (%Mr)	-841.325	195.315	-0.343	-4.308	0.000***				1.041
	Number of sold lambs per present ewe (NSL/PE)	10434.776	2834.851	0.293	3.681	0.000***				1.041

(1)(Sd D) Standard deviation; (2) (T) T-value; (3) (P) P-value; (4) (R^2 %) R squared; (5) (VIF) Variance Inflation Factor; (6) (GM/LUWS) Gross margin per labour unit with subsides; (7) (GM/LUWTS) Gross margin per labour unit without subsides. Significance level at: (***) $p < 0,0001$. (**) $p < 0.05$ (*) $p < 0.1$.

TableVI. Results of multiple linear regression models for the three clusters.

TablaVI. Resultados de los modelos de regresión lineal múltiple para los tres clústeres.

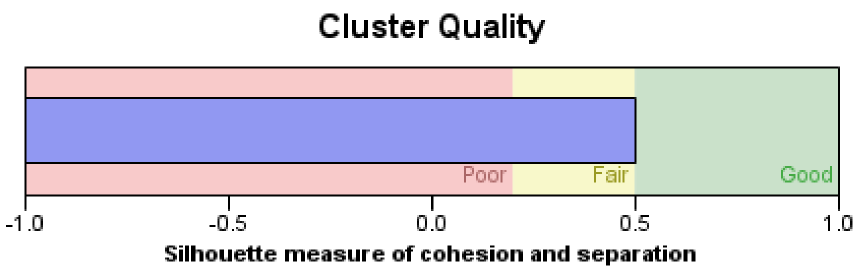
	Parameters	Unstandardised coefficients (β)	Sd.D(1)	Standardised coefficient (β Std)	T(2)	P(3)	R^2(4)	Adjusted R^2	Durbin-Watson	VIF (5)
Results of the multiple linear regression models for cluster 1										
Regression 1 (GM/LUWS)(6)	Constant	42848.640	7182.296		5.966	0.000***	**14.8**	**11.9**	2.031	1.00
	Percentage of lambs' mortality (%Mr)	-1424.512	634.100	-0385	-2.247	0.032**				
Regression 2 (GM/LUWTS)(7)	Constant	32326.988	7750.454		4.171	0.000***	**27.3**	**24.7**	2.000	1.00
	Annual ewe replacement rate (% FRep)	-1501.202	455.454	-0.522	-3.296	0.003**				
Results of the multiple linear regression models for cluster 2										
Regression 1 (GM/LUWS) (6)	Constant	562.247	7876.363		0,071	0,943	**15.1**	**13.8**	1.509	1.00
	Number of sold lambs per present ewe (NSL/PE)	23468.237	7001.810	0.389	3.352	0.001**				
Regression 2 (GM/LUWTS)(7)	Constant	-12843.096	6605.524		-1.944	0.056*	**12,9**	**11.6**	1.674	1.00
	Number of sold lambs per present ewe (NSL/PE)	17965.956	5872.079	0.360	3.060	0.003**				
Results of the multiple linear regression models for cluster 3										
Regression 1 (GM/LUWS)(6)	Constant	-26615.502	14879.840		-1.789	0.084*	**24.7**	**22.2**	1.683	1.00
	Number of lambings per present ewe (NL/PE)	44868.580	14316.597	0.497	3.134	0.004**				
Regression 2 (GM/LUWTS)(7)	Constant	13043.837	6171.695		2.113	0.043**	**15.1**	**12.2**	2.022	1.00
	Percentage of lambs' mortality (%Mr)	-932.848	409.973	-0.389	-2.275	0.030**				

(1)(Sd D) Standard deviation; (2) (T) T-value; (3) (P) P-value; (4) (R^2 %) R squared; (5) (VIF) Variance Inflation Factor; (6) (GM/LUWS) Gross margin per labour unit with subsides; (7) (GM/LUWTS) Gross margin per labour unit without subsides. Significance level at: (***) $p < 0,0001$. (**) $p < 0.05$ (*) $p < 0.1$.

Figure1. Cluster quality.
Figura1. Calidad del análisis Cluster.

Model Summary

Algorithm	TwoStep
Inputs	2
Clusters	3



RESEARCH PAPER 3

Predictive impact of different types of indicators on the economic results of meat sheep farms

L. Chekmam, M.T. Maza y. Pardos

PREDICTIVE IMPACT OF DIFFERENT TYPES OF INDICATORS ON THE ECONOMIC RESULTS OF MEAT SHEEP FARMS

ABSTRACT

Viability and continuity of extensive sheep farming has been a real issue in the last decades in Europe in general and in Spain in particular. Therefore, the main objective of the present research study has been figuring out the most important structural, technical, and economic aspects which could help to maintain this important and sustainable activity by using typification and multiple linear regression analyses. A sample of 126 sheep farms from the Aragon region (Spain) with records on a long time period from 1993 to 2016 has been used. 11 structural, technical and economic variables have been synthetised into four factors by carrying out a PCA analysis. It has resulted 3 significantly different groups of farms after performing the cluster analysis. It has been concluded that the structural, technical and economic assessed indicator labour mainly family labour, labour intensification, feed autonomy, number of sold lambs per ewe, prolificacy and number of lambings per ewe was important in improving the economic results. However, stocking rate, lambs' mortality rate has a negative power on the economic results. Finally, feed costs represent almost 70 % of the total costs, minimizing this percentage could improve the economic results. This could be possible with more feed autonomy based mainly on naturel grazing. Thus, these systems could accomplish their main task in maintaining their sustainability and become more resilient and at the same time more flexible and adaptative to the continuous changing in the policy aids as well as the climate change.

Key words: indicators, regression, typification, meat sheep, economic results.

1- INTRODUCTION AND OBJECTIVES

Spain has the largest sheep flock in Europe with 15.439.218 heads (MAPA, 2021) and the trend of evolution of the sheep flock continues to suffer from decline. It has registered a decrease of 30.4 % for the total flock and 37.6 % for meat sheep from 2007 to 2020, while the dairy flock has been more stable (-16.5 %) (MAPA, 2021). The main reasons for this decline are in part the low profitability of this farming systems, as they are located in general in disadvantageous areas (Pardos et al., 2008; Mujica et al., 2015) it is difficult to register high profits. Added to that the decline of demand on sheep meat and the rising of production costs mainly feeding and labour costs, and the international competition.

However, these extensive sheep farming systems, which are suffering from decline, are a multifunctional sector. It can be illustrated by their important role in forest fires prevention, rural population fixation in very disadvantaged areas for other activities, protection and conservation of meadows and the possibility to offer differentiated products with value added (Kramer Groen, and Van Wieren, 2003; de Rancourt et al., 2006; Plieninger, Hochtl, and Spek, 2006; Rodríguez, 2010; Ruiz-Mirazo, Robles and Gonzalez-Rebollar, 2011; de Rancourt and Carrère, 2011; Ripoll-Bosch, 2013; Toro-Mujica, 2015). Because of multifunctionality of extensive sheep farming and the emergency to maintain this strategic sector, the Common Agricultural Policy (CAP) has included in its aids scheme the disadvantageous areas in order to help them to maintain their economic, environmental and social sustainability. But the diversity of these systems makes it more difficult to address effective aids policies (Caballero, 2001).

Furthermore, the diversity of sheep farming systems and the need to identify them in order to contribute to their continuity and to attempt to fix the situation of decline from which it has been suffered and continue suffering, has encouraged investigators in this area to carry out typification studies to figure out the different management practices used in each homogeneous group systems. It has been a multitude of research on the typification of sheep farms and the following are some examples carried out in the region of Aragon (Pardos, 1994 and 2014; Pardos et al., 2008; Chertouh, 2005; Olaizola, Chertouh and Manrique, 2008; Traba and Perez-Granados, 2022).

Many of these studies have been carried out in Aragon, a region in the north-east of Spain which currently accounts for 10.5% of the total national flock (MAPA, 2021). The production system practised is mainly meat sheep farming, based on the "rasa aragonesa" breed, originally from this region and very well adapted to the territory, on which a process of genetic selection has been carried out, especially in the last decade, aimed mainly at increasing prolificacy and therefore the kilos of meat produced per ewe per year. In contrast to this apparent homogeneity of the production system, the different availability of resources on the farms determines a different use of production factors with a greater or lesser degree of intensification. This results in different management systems which hypothetically can lead to different economic results.

The main objective of this work is to carry out a typification of a sample of sheep meat farms, which will allow us to find out the existing heterogeneity from a structural, technical and economic point of view. Once the groups have been established, the next objective is to find out if the economic results obtained in each of the groups differ from each other, and if the predictor variables of these results are also different.

Thus, it is a mean to give more insight to decision makers mainly farmers regarding to the most profitable and adaptative management practices to apply at the farm level for better economic results, and for public policy makers to take into account the diversity of these systems to adapt better the design of their aids policies.

2- METHODOLOGY

It has been used a sample which was formed by 126 meat sheep farms which belong to a technical-economic recording data program of one of the most important sheep cooperatives located in Aragon (Oviaragón-Grupo Pastores). The farms were disturbed on the three provinces (Zaragoza, Huesca and Teruel) of the northern east region of Spain Aragon. It has been used the mean data for each variable for the years where the farm has participated in the technical-economic program, in some cases we used data averages of 24 years that range from 1993 to 2016. The variables in monetary units have been converted to constant euros of 2016 due to the length of the study period (the minimum years of participating in the technical economic program is 5 years and the maximum is 24 years).

The selection of the variables of this study has been based on the consultation of various structural, technical and economic studies (Hamrouni 1993; Oliván and Pardos, 2000; Chertouh, 2005; Kleinhanß et al. 2007; Pardos et al., 2008; Olaizola, Chertouh and Manrique, 2008; Benoit and Laignel, 2008; García-Martínez, Olaizola and Bernués, 2009; Ripoll-Bosch, Joy and Bernués, 2014; Pardos, 2014; Earle et al., 2017; Bohan et al. 2018; Benoit et al., 2020; Gazzarin and el Benni, 2020; Bertolozzi-Caredio et al., 2021). Furthermore, it has been summarised the most relevant variables resulted in our previous articles related to structural (Chekmam, Maza and Pardos, 2021), technical typification and the farms trajectories. It has been chosen eleven (11) variables related to the structural, technical and economic management of the farms to carry out the analyses of the present work. The chosen variables were 6 structural indicators: Total man labour units (TMLU), Percentage of family man labour units (%FLU), the stocking rate which has been expressed as the Number of ewes per hectare of total useful agricultural area (NE/TUAA), Total useful agricultural area (TUAA), labour intensification which has been expressed as the Number of ewes per man labour unit (NE/LU), Percentage of irrigated area on the total useful agricultural area (% IrrigA/TUAA). Four technical indicators it has been chosen: Percentage of lambs' mortality (% Mr), Number of lambings per present ewe and year (NL/PE), Prolificacy (Pr) and number of sold lambs per present ewe and year (NSL/PE). For the costs it has been used the feed costs per ewe and year (FC). It has been selected the feed cost precisely for its high impact in the total costs (it represents almost 70 % of the total costs in our case study) and it is considered as the leading risk in extensive sheep farming (Bertolozzi-Caredio et al., 2021). Furthermore, gross margin per labour unit with subsidies (GM/LUWS) and without subsidies (GM/LUWTS) have been used as the economic results to assess in the multiple linear regression analysis.

As we have already mentioned in our previous articles the gross margin per labour unit can be considered as the most significant measure of the obtained economic results and an indicator of the possible continuity of the farms by including the productivity per sheep and the correct size of the herd (Olaizola et al., 1996, Benoit and Laignel 2008, Charroin et al., 2012).

With the objective to figure out the relationship between the selected variables and the economic results which were in this case the gross margin per labour unit with and without subsidies, it has been used different types of statistical analyses, the univariate analysis for the general description of the sample, for further details it has been used the multivariate analyses which were factor analysis to reduce the number of variables and facilitate subsequent analysis of the results, two-step cluster analysis to obtain the homogeneous groups of farms, and multiple linear regression to establish dependency relationships (Hair et al., 2014; Shrestha, 2021).

Once the factor analysis has been carried out, the resulted factor scores have been used as continuous variables to perform the cluster analysis. The proportions of the clusters were defined with the variable «cluster membership».

In the multiple linear regression analysis, the predictor variables were the eleven structural, technical and economic variables which have been used to carry out the factor analysis, and the dependent variable was the gross margin per labour unit with and without subsidies (GM/LUWS) and (GM/LUWTS), respectively. It has been performed a multiple linear regression for the whole sample and for each group resulted from the cluster analysis. To perform the multiple linear regression analysis, it was used the stepwise method to keep only the significant independent variables in the resulting models. The linear generic model was formulated as follows:

$$(GM/LUWS) \text{ or } (GM/LUWTS) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots \beta_n X_n + e$$

Where GM/LUWS (Gross margin per labour unit with subsidies) or GM/LUWTS (Gross margin per labour unit without subsidies) is the dependent variable, β_0 is the regression constant, and β_1 β_2 β_3 ... β_n are coefficients to be estimated, X_1, X_2, X_3 .. X_n were the used structural, technical and cost variables and (e) is the error of the regression model. Regression coefficients were checked using the t-test. The coefficient of determination (R^2) was used as a predictive criterion for the regression model (Draper and Smith, 1998, Sakar et al., 2011). Furthermore, the robustness of each of the models was validated as follows: the absence of multicollinearity was verified using the tolerance index and the variance inflation factor (VIF). According to Pérez (2005), a large VIF and a small tolerance index may indicate the possible presence of collinearity. A $VIF < 10$ is acceptable to conclude that there is no multicollinearity problem (Marcoulides and Raykov, 2019). To verify the serial correlation of the residuals, the Durbin Watson test was applied, which establishes that a value close to 2 indicates that there are no autocorrelation problems. It is usually considered that between 1.5 and 2.5 there should be independence between the residuals (Pineda Jaimes et al., 2011). For the model goodness of fit, from the model summary, the explained variance can be assessed from the adjusted R^2. On the other hand, from the ANOVA summary, the F statistic allows us to assess whether there is a significant linear relationship between the dependent variable and the set of independent variables of the model. Especially, with the significance level, it can be assessed if this relationship is significant (lower than 0.05) (Vilá, Torrado and Reguant, 2018). The SPSS version 26 package has been used to carry out the statistical analyses.

3- RESULTS

Sample description

The sample used in the present work was made up of 126 farms which belong to an important ovine technical economic management program in Aragon (Spain) as it has been mentioned in the methodological part. The results descriptive analysis of the sample are shown in Table 1. First the structural indicators, the average number of ewes (NE) of the farms of this sample was 605 ewes handled by 1.32 total labour units from which 90 % was family labour. It has been recorded an average number of ewes per labour unit of about 463 ewes. This latter is considered as an indicator of labour intensification. With respect to land intensification, it is expressed in number of ewes per hectare of useful agricultural area or the stocking rate, it has been recorded an average of 17.53 ewes/TUAA. The average percentage of the irrigated area in the total useful agricultural area was 22.2 %. The average useful agricultural area for the farms of the sample was about 96 hectares. Regarding to the technical indicators, the average number of lambings per present ewe was 1.12, the average prolificacy recorded was 1.34 and the average percentage of lambs' mortality was 10.6 %. The average sold lambs per ewe was 1.17. Regarding to costs variables, it has been recorded an average feed costs per ewe of about 60 euros. For the economic variables it has been recorded 25.054 euros for gross margin per labour unit with subsidies and 5155 euros of the gross margin per labour unit without subsidies.

With respect to the main sheep breed of the used sample almost 84 % it is the "Rasa Aragonesa" breed. Rasa Aragonesa is a rustic breed of meat aptitude located in the Northeast of Spain, with an average prolificacy of 1.30 and with high maternal aptitudes (Alabart et al., 2016). And this breed can be exploited successfully with the system of 3 births in 2 years thanks because it is a non-seasonal breed and because the lambs are weaned relatively early (at the age of six weeks), allowing the ewe to recover for the next mating (Folch et al., 2007). Other registered breeds for this sample with very lower frequency were "F1 prolifica", "Roya Bilbilitana", "Lacaune", "Maellana" and "Segureña".

Factor analysis

Factor analysis has been performed to reduce dimensions of the eleven used variables in the present work. It has been chosen factor analysis with Principal Component Analysis (PCA) as an extraction method.

It has been recorded a KMO index = 0.604 it is considered acceptable. The Bartlett's (Chi-square) test for Sphericity was very significant at $p < 0,0001$ which allow us to continue with the interpretation of factor analysis results. As it can be seen in table 2, the communalities of the used variables were high except for lambs' mortality rate (0.378).

According to Child (2006) and Samuels (2017) it is advisable to remove just items with a communality score less than (0.200). The eleven original variables related to structural, technical and economic variables have been reduced to four factors which explain 67.31 % of the total variance which is considered quite significant rate for variance explanation. The data reduction rate has been quite important with about 55 % (Table 2).

It has been performed the Varimax method for factors rotation; the results are reported in table 2.

Factor 1 explains 28.55 % of the total variance. It is highly and positively correlated with four variables. These variables are related to the number of sold lambs per ewe and year (NSL/PE) and number of lambings by present ewe and year (NL/PE), prolificacy (Pr) and feed costs per ewe and year (FC). This factor can be characterized by *productivity and feed costs.*

Factor 2 explains 14.81 % of the total variance. It is correlated with two variables of the eleven initial variables. This factor is positively correlated with total man labour units (TMLU) and negatively correlated with the percentage of family man labour units (%FLU). This factor can be characterized by *labour force.*

Factor 3 explains 13.51 % of the total variance. It is correlated with three variables. It is positively correlated with two variables which were the percentage of irrigated area in the total useful agricultural area (% IrrigA/TUAA) and Number of ewes per hectare of total useful agricultural area (NE/TUAA), these two variables are considered as land intensification indicators. And it is correlated negatively with the variable total useful agricultural area (TUAA). This factor can be characterized by *stocking rate and land intensification*.

Factor 4 explains 10.43 % of the total variance. It is correlated with two variables. It is correlated positively with the indicator of labour intensification number of ewes per labour unit (NE/LU) and with the percentage of lambs' mortality (% Mr). This factor figures out that handling more ewes per labour unit leads to more lambs' mortality. It can be characterized as *labour intensification and lambs' mortality rate.*

Cluster analysis

A two-step cluster analysis has been performed to identify the homogeneous groups. It has been used the factorial scores resulted from the previous factor analysis as continuous variables to perform the cluster analysis. It was created a new variable when computing data which named «cluster membership». It has been used to define clusters' proportions. The quality of the resulted clusters is fair (Figure 1).

Statistics were significant for Variance ANOVA test at $p < 0{,}0001$. It has been demonstrated that each cluster is differently linked with respect to each factor.

The profiles reported in table 3 show that each cluster is correlated differently to each factor.

For further description and more characterisation for each cluster, the variable « Cluster membership » has been crossed with the eleven initial variables used to perform factor analysis, and the two variables which has been used as dependent variables in the multiple linear regression analysis. Furthermore, it has been added the number of ewes (NE) as an additional variable to figure out the differences in the flock size between clusters. The results are reported in table 4.

Table 4 shows the description of the clusters. It has been used ANOVA to test the mean differences between groups. The mean differences for all the used variables were significant or highly significant, except for stocking rate (NE/TUAA) which has not been resulted significant at all, when the mean differences have been assessed between (C1, C2, and C3) and multiple comparisons between clusters has been checked. The results per clusters are presented as follows.

Cluster 1- This group has been correlated with the four resulted factors, even if it is more positively characterised by factor 4 and factor 1 respectively, and negatively by factor 2. It is correlated with factor 3 with less score. It is made up of 48 farms with a mean number of ewes of about 604 ewes. It has recorded the highest means for all the descriptive used variables, comparing to other clusters, except for total man labour units (TMLU) for which it has recorded the lowest mean (1.14) and for total useful agricultural area (TUAA) for which has recorded the second highest mean almost (81ha). This cluster has recorded the highest mean for percentage of family labour (% FLU) almost 99 %. It is clear that these farms are family farms with almost family labour. It has recorded the highest mean for stocking rate (NE/TUAA) about (26 ewe/ha). For (TMLU), (%FLU), (TUAA) and (NE/TUAA) variables, there has no mean significance differences when comparing to cluster 3. Cluster 1 has recorded the highest mean for labour intensification (NE/LU) with significant mean differences when comparing to cluster 3 and with less significance when comparing to cluster 2. They count with greater hectares of irrigated area with almost 34 % irrigated area, with higher significance mean difference when comparing to cluster 3.

With respect to technical variables, this group has recorded the highest lambs' mortality rate (% Mr) (11.75 %), the highest lambings number per present ewe (NL/PE) (1.17), the highest number of sold lambs per ewe (NSL/PE) (1.29) and the highest prolificacy (Pr) (1.39). When comparing to cluster 2 the mean differences for these 4 technical variables have not been significant but when comparing to cluster 3 the mean differences have been highly significant. This group presents the highest mean feed costs per ewe (FC) (66.77 euros) with highly mean difference when comparing to cluster 3 and no mean difference when comparing to cluster 2. This group as well has recorded the highest mean for the gross margin per labour unit with (GM/LUWS) and without (GM/LUWTS) subsidies (29449.44 euros) and (7319.9 euros) respectively. The mean differences have been significant when comparing to cluster 2 for the gross margin per labour unit with and without subsidies. When comparing to cluster 3 the mean differences are highly significant for the gross margin per labour unit with subsidies, and not significant without subsidies. It can be concluded that this group has similarities with cluster 3 when comparing structural variables and similarities with cluster 2 when comparing technical and cost variables. This group gather semi-intensified medium sized family farms in irrigated areas.

Cluster 2- This group has been correlated positively more with factor 2 related to labour force, specially to total labour units and negatively with factor 3 and with less correlation score with factor 1 and factor 4. First for structural variables, this group has recorded significant means differences comparing to the other clusters. This group has gathered farms with large flock size with a mean of about (860) ewes, handled by 1.83 total man labour units (TMLU) from which 65.66 % were family labour units (%FLU). This group counts with large proportion of hired labour units comparing to the two other groups. The mean farms' land size (TUAA) for this group was the highest (182.46 ha), from which 16.90 % is irrigated. The mean difference for farm land size is highly significant when comparing this group to the other groups. For irrigated area (% IrrigA/TUAA) the mean differences with group 1 were weak and there has not been any significance difference when comparing to group 3. This group has recorded the second highest mean of number of ewes per labour unit (NE/LU) (467.37), the mean differences for labour intensification has been significant when comparing to group 1 and group 3. This group has recorded the lowest stocking rate about (10 ewes/TUAA), as it has been mentioned for the previous group, the mean differences for this indicator has not been significant. For technical variables, the trend is different comparing to structural variables. This group has recorded the second highest means for all the technical variables. It has recorded a mean lambs' mortality rate (% Mr) of 11.07 % and mean lambing rate (NL/PE) of 1.13. The recorded mean prolificacy (Pr) has been (1.38) and the mean of sold lambs per ewe (NSL/PE) was 1.23. The mean differences have not been significant for the technical variables when comparing to cluster 1 and they have been highly significant when comparing to cluster 3. This group has recorded the second highest mean for feed costs per ewe (FC) 59.27 euros. This latter had a weak mean difference comparing to cluster 1 and it has no mean difference significance comparing to cluster 3. This group has recorded the second highest mean for gross margin per labour unit with subsidies (GM/LUWS) 22893.15 euros, and the lowest gross margin per labour unit without subsidies (GM/LUWTS) 1941.54 euros, which has been significantly different comparing to cluster 1 and has not been significant comparing to cluster 3. They are extensive large sized farms in rainfed areas.

Cluster 3- This group has been negatively correlated with all the four resulted factors. It is more correlated with factor 4 and factor 1 and with less importance with factor 2 and factor 3. For structural variables, it has recorded the lowest number of ewes (456.40) which were handled by 1.22 labour units from which about 96 % were family labour units (%FLU). It has recorded the lowest mean for total useful agricultural area (TUAA) (59 ha). It has recorded the lowest means for labour intensification in number of ewes per labour unit about (377 ewes/LU). This group has recorded the second highest mean for the stocking rate expressed in number of ewes per hectare of useful agricultural area (NE/TUAA) about 14 ewes/ha. As it has been mentioned in the previous parts for structural variables, when comparing to cluster 1 the means differences has not been significant except for number of ewes (NE), labour intensification (NE/LU) and the percentage of irrigated area (%IrrigA/TUAA). This group has recorded the lowest means for technical variables. Comparing to group 1 and 2, the mean differences has been significant except for mortality lambs' rate (%Mr) which has recorded a non-significant mean difference when comparing to cluster 2. It has recorded a mean mortality lambs' rate of 9.35 %, a mean of number of lambings per ewe (NL/PE) of 1.05, a mean prolificacy (Pr) of 1.28 and a mean number of sold lambs per ewe (NSL/PE) of 1.03. It has recorded the lowest mean of feed costs per ewe (FC) 53.14. For the economic variables, it has recorded the lowest mean for gross margin per labour unit with subsidies (GM/LUWS), which has a significant difference when comparing to group 1 and has no mean significance difference when comparing to cluster 2. It has recorded the second highest mean for gross margin per labour unit without subsidies (GM/LUWTS) (4970.61 euros) which has no significant mean difference when comparing to the two other clusters. This group has recorded almost the same economic results as group 2. They are extensive small-medium sized family farms in rainfed areas.

Linear regression analysis

It has been performed multiple linear regressions for the whole sample and by clusters as it has been commented previously in the methodological part. The dependent variables were the gross margin per labour unit with and without subsidies (GM/LUWS) and (GM/LUWTS) respectively. The independent variables were the eleven structural, technical and cost variables which have been used to perform the factor analysis in the present work.

The results of the multiple lineal regression analyses for the whole sample and for each cluster have been presented in tables 5, 6, 7, and 8. As it has been highlighted in the methodological part that R-Squared (R^2 or the coefficient of determination) is a statistical measure in a regression model that determines the proportion of variance in the dependent variable that can be explained by the independent variables. The recorded adjusted R^2 for the whole regressions were high, they range from 54% to 80.9% and their relevance has been supported by the T, Durbin-Watson, F and VIF values which were significant.

As it can be seen in table 5, related to the linear regressions for the whole sample, that the first model for regression 1 where it has been taken into account the subsidies in the gross margin per labour unit (GM/LUWS), nine (9) of the eleven used independent variables had a significant impact power on the gross margin per labour unit with subsides (GM/LUWS). Feed costs per ewe (FC) had the highest negative power on predicting the gross margin per labour unit with subsidies (GM/LUWS), beside other variables with lower negative predictive power which were mortality lambs' rate (% Mr), the percentage of irrigated area (% IrrigA/TUAA), and total man labour units (TMLU). For the variables which had the highest positive power in predicting the economic results, the first one is labour intensification indicator expressed on number of ewes per total man labour unit (NE/LU) and the number of sold lambs per ewe (NSL/PE). Other variables with lower positive power were prolificacy (Pr), the percentage of family labour units (%FLU) and number of lambings per present ewe (NL/PE). All the coefficients of these variables were significant or highly significant.

The second model for regression 2 where the subsidies have not been taken into account in the gross margin per labour unit showed that just the number of sold lambs per present ewe (NSL/PE) had the highest positive predictive power on the economic results and the percentage of family labour units (% FLU) had a lower positive predictive power. From other side, the feed costs per ewe (FC) had the highest negative predictive power impact on the economic results beside the lamb' mortality rate (%Mr) with lower negative predictive power. All the coefficients of this regression model were significant or highly significant.

The results for **group 1** are presented in table 6. The first model for the regression 1 where subsidies have been taken into account in the gross margin per labour unit has recorded that feed costs per ewe (FC) had the highest negative predictive power on the economic results with high significance. The percentage of lambs' mortality (% Mr) and the percentage of irrigation area (%IrrigA/TUAA) have a negative power on the economic results with moderate significance. From other side, the number of sold lamb' per ewe (NSL/PE), number of ewes per man labour unit (NE/LU) and prolificacy (Pr) had positive effect on predicting the economic results with subsides. Labour intensification (NE/LU) had the highest significance, when the (NSL/PE) had a moderate significance predictive power and prolificacy had the lowest significance predictive power in predicting the economic results.

For model regression 2, when the subsidies have not been taken into account in the economic results, it has been recorded feed costs per ewe (FC) with the highest significant predictive negative power, beside lambs' mortality rate (Mr%) and the number of total man labour units (TMLU) with lower significant predictive negative power on the economic results without subsidies. While, the number of sold lamb' per present ewe (NSL/PE) had the highest predictive positive significant power on the economic results without subsidies.

The results showed in table 7 indicate that for **group 2** for the first model regression when the subsidies have been taken into account in the gross margin per labour unit, labour intensification (NE/LU) had the highest significant and positive predictive power on the economic results followed by the number of sold lambs per present ewe (NSL/PE) with moderate significance. The number of lambings per present ewe (NL/PE) and family man labour (%FLU) have the same positive predicting power, but the (NL/PE) is less significant. Feed costs per ewe (FC) has the highest negative predictive power which is highly significant followed by lambs' mortality rate (%Mr) with low predictive negative power and moderate significance.

For the second model regression when the subsidies have not been taken into account family labour (%FLU) and the percentage of irrigated area (%IrrigA/TUAA) had positive predictive power on economic results. Both coefficients for (%FLU) and (%IrrigA/TUAA) were highly significant. The lambs' mortality rate (% Mr) had a negative predictive power on economic results which was moderately significant.

The results for **group 3** showed that for the first model regression when subsidies have been taken into account, labour intensification (NE/LU) had the highest positive predictive power on economic results. Followed by the number of sold lambs per present ewe (NSL/PE) with positive power two. Both coefficients were highly significant. Feed costs per ewe has the highly significant negative predictive power on the economic results. Followed by the number of total man labour units (NMLU) with lower significant negative predictive power.

For the second model regression when the subsidies were not taken into account in the gross margin per labour unit, feed costs had the highest and significant negative predictive power on the economic results. Followed by the stocking rate indicator (NE/TUAA) with lower negative power and moderately significant. From the other side, the number of sold lambs per present ewe (NSL/PE) was the only variable which had the positive highly significant predictive power on the economic results for this group.

4- DISCUSSION

It has been resulted 4 factors from the factor analysis. These factors have figured out the relationship between the different structural, technical and costs indicators. The results have reflected that greater production intensification leads to higher feed costs per ewe as it has been pointed by Pardos et al. (2008). From other side, the variable total labour units was negatively related to family labour, which means that farms with more total labour are farms with greater hired labour than family farms. Production intensification was related to labour intensification which is not always a mean to increase the economic results (Benoit and Laignel, 2011). This latter tendency has been confirmed by the relationship highlighted by factor 4 between labour intensification and lambs' mortality rate, which means greater labour intensification could lead to greater lambs' mortality. According to Pardos et al. (2008) production intensification determines the nutritional requirements of the animals throughout the year; however, the way in which these nutritional requirements are satisfied depends to a great extent on the employed production system. Factor 3 has reflected the intensification use of land in small sized farms with greater percentage of irrigated area and greater stocking rate, which was negatively correlated with the total useful agricultural area. The maximum efficiency of use of these inputs is determined not so much by the production system as by the technical and economic management to accommodate the specific circumstances of each farm (Perez et al., 2007).

It can be concluded that group 1 and group 2 have adopted an intensified reproduction system with different strategies management for the structural indicators mainly in the feeding resources. Thus, they applied the theory which says that numeric productivity is a main driver of economic success in the sheep business (Morel, Kenyon and Morris, 2004; Bohan et al., 2018). For almost the same technical results from the point of view of reproduction and significant differences in the economic results, group 1 has opted to use its own labour family force with greater labour intensification for the reason that this group have fewer total labour units which is almost family labour. While group 2 has opted for greater hired labour units, it counts with larger sized farms from the point of view land and flock size, with more than twice of the total useful agricultural area in comparison to group 1 and the more than the third in comparison to group 3. So, group 2 has opted for the extensive use of its capital mainly land and labour. This group rent more grazing land than the two other groups (1 and 3) and depends more on subsidies than group 1. It counts with less irrigated area than group 1. After analysing with more details, the farms costs and incomes for group 1 and group 2 it has been figured out that for feed costs there has a low mean significance difference, even if group 1 rent less grazing land, it has less total useful agricultural area, with more irrigated area and more ewes handled by labour unit, and it depends less on subsidies. It seems that group 1 is less dependent on external resources as labour, subsidies and purchased feed. With the intensification of its own production factors mainly family labour and land and depending less on grazing land and feeding its herd with more fodder from the irrigated area, this group could get better economic results comparing to group 2 with almost the same reproduction intensification management. This result is partially consistent with the results of (Pardos et al., 2008), where they mentioned that farms which located in irrigated areas receive less aids and thus are less sensitive to the changes in the common agricultural policy. The production of small ruminants in Spain reveals a certain tendency to more forward more productive irrigated zones, which may indicate the possibility of employing more viable production systems in these areas (Pardos et al., 2008; Oregui and Falagán Prieto, 2006).

Group 3 has been formed by small to medium sized farms from the point of view of flock size and the total useful agricultural area. This group counts with almost the same patterns for structural variables than group 1, except for labour intensification and the percentage of irrigated area which were the lowest comparing to other two groups. It rents more grazing land than group 1 and have lower feed costs comparing to group 1. It depends more on subsidies comparing to group 1 and comparing to group 2 the differences were not significant. The feed costs for this group were not significantly different from group 2. Even if the number of sold lambs per ewe and year and prolificacy as well as number of lambings per present ewe and year for this group were significantly lower than group 2, the mean gross margin with and without subsides for these two groups have not been significantly different. Group 3 has recorded almost the same economic results than group 2 adopting lower reproduction intensification. According to Perez et al. (2007) and Pardos et al. (2008) the most inefficient farms are farms with lower reproduction intensification (number of ewes per labour unit) and the lowest intensification of reproduction. In our case even if group 3 seems to have these characteristics, it has recorded good economics results which were almost the same comparing to group 2 which includes extensive larger sized sheep farms. It could be explained that group 2 depends more than group 3 and group 1 on external feeding resources and on the hired labour, for this reason it couldn't get better economic results even if they have greater number of sheep. And for group 3 the family labour could compensate the loss in labour intensification. According to Pardos (1994), farms with greater total useful agricultural area are more oriented to commercialised agricultural products than forage crops which could be group 2 in our study, on the opposite smaller farms intensify their useful agricultural area for cultivating forage for their sheep which could be group 1.

The results of typification in general seems to be consistent with some results of Chertouh (2005). He concluded that farms with medium and small flock size with almost family labour, use their own fodder and forage resources and rent less grazing land record better results. Case of group 1 and with less consistency group 3. But for group 2, they could record better results if they could improve their labour intensification and reduce their feeding costs.

The results of the regressions for the whole sample have showed that labour intensification, family labour and reproduction intensification mainly the number of sold lambs were highly significant positive predictors for gross margin per labour units with subsidies. Numerous studies have pointed out that productivity is a main driver of economic success in the sheep business (Keady and Hanrahan, 2006; Morel, Kenyon and Morris, 2004; Bohan et al., 2018). And greater number of sold lambs leads to more incomes for the farms (Cabrera, 2009). For the negative predictors, feeding cost has been highly and negatively influenced the economic results of meat sheep farms as it has been pointed by various authors (Milan, Arnalte and Caja, 2003; Chertouh, 2005; Benoit and Laignel, 2009; Benoit et al., 2011, Benoit et al., 2020). Furthermore, lambs' mortality rate is a critical issue for meat sheep efficiency. Gazzarin and El Benni (2020) consider mortality or loss of lambs after birth, including stillbirths as an important driver of productivity per ewe. The percentage of irrigated area had a negative power on the economic results, it could be explained that this indicator is a limiting factor in this case. With more irrigated area, farms could have their own forage crops, thus improving the economic results by lowering feed costs and developing a certain feed autonomy. However, Rodriguez-Ortega et al. (2017) have concluded that sheep systems with lower intensity had higher sustainability than crops due to their higher capacity to use local and renewable natural resources. Furthermore, total man labour units which had a negative power on the economic results, which could be related to hired labour units.

When the subsides have not been taken into account, only the number of sold lambs per ewe and family labour had the positive power on the economic results, which supports the importance of these two indicators on improving the economic results of sheep meat farms. From other side, feed costs and lambs' mortality rate continue to be two of the most critical issues which affect directly the economic results. Bertolozzi-Caredio et al. (2021) have found that feeding costs are the leading risk factor in extensive sheep farming.

When moving to the results of the regressions for each group, when the subsidies has been taken into account the trend confirms that labour intensification and the number of sold lambs per ewe continue to have the same positive power on better economic results.

Furthermore, some additional variables to predict positively the economic results has been recorded in the regression models, like prolificacy for group 1 given this group had recorded one of the highest means for this important reproduction indicator. Some authors have highlighted the importance of prolificacy and its correlation with efficiency, and profitability (Ripoll-Bosch, Joy and Bernués, 2014; Bohan et al. 2018). For group 2 the number of lambing has been a positive indicator for economic results. This latter is studied by various authors and have identified the different lambings systems (3 lambs per ewe per 2 years or 5 lambing in 3 years) (Fogarty, Hall, and Atkinson, 1992; Lewis et al., 1996; Speedy and FritzSimons, 1977, deNicolo et al., 2008). According to Benoit et al. (2020) the most resilient systems, i.e. those with the lowest coefficient of variation of net income, are those that combine a low level of inputs with at least two lambing periods per year. Furthermore, family labour had a positive predictive power on the economic results for group 2, this group had the highest mean of hired labour, thus with more family labour its economic results would be better. From the other side, the negative predictive indicator had also the same trend, feed costs and lambs' mortality rate were the most indicators which explained the economic loss for group 1 and group 2. And for group 1 the percentage of the irrigated area predicts negatively the economic results. For group 3 the feed costs were accompanied by total man labour units as negative predicting factors, the hired labour will have a negative impact on these farms as they are small farms and they have the lowest labour intensification.

When the subsidies were not taken into account for group 1 the number of sold lambs per ewe is the only positive predicting indicator for the economic results. Feed costs, mortality and total labour units predicts negatively the economic results, this group has recorded the lowest total labour units. For group 2 family labour and percentage of irrigated area had the positive power in predicting the economic results without subsidies. Lambs' mortality rate continues to be an issue for sheep efficiency. For group 3 even if they have lower reproduction intensification, the number of sold lambs per ewe is the unique positive predicting indicator for the economic results without subsides. From the other side, feed costs influence negatively the meat sheep efficiency beside the stocking rate (number of ewes per hectare of total useful agricultural area). According to Chabosseau et al. (2000) stocking rate influences negatively the economic results because it leads to more external inputs.

The only variable which had not any impact on the economic results when performing regressions in the present study was the total useful agricultural area. This latter is consistent with the conclusion of Pardos (1994) that the size of total useful agricultural area didn't seem to have important correlation with economic results, showing that the size of the farm is not as important as the possibility of having rented pastures.

Thus, these results support the importance of family labour (Aggelopoulos et al., 2009) and labour productivity (Milán, Arnalte and Caja, 2003) in improving the economic results. Pérez, Gil and Sierra (2007) and Pardos et al. (2008) have concluded that the most inefficient farms have the lowest labour productivity (measured by the number of sheep per labour unit) and the lowest intensification of reproduction. Labour is increasingly becoming a central factor to understand the evolution of farming systems (Riedel, Casasus and Bernués, 2007). Regarding to the production intensification it has to be rational because inappropriate number of ewes per labour unit could deteriorate the zootechnical performance of sheep (Benoit and Laignel, 2011) especially the health state of the herd resulting in greater lambs' mortality. Furthermore, the feed autonomy or self-sufficiency mainly fodder is essential to ensure economic viability within the context of rising grain prices (Benoit and Laignel, 2009; Bernués et al., 2011; Ryschawy et al., 2013; Ripoll-Bosch, Joy and Bernués, 2014).

5- CONCLUSIONS

Viability and continuity of extensive sheep farming has been a real issue in the last decades in Europe in general and in Spain in particular. The present study has attempted to perform a typification of farms of the used sample to figure out the most important structural, technical, costs and economic aspects which could help to maintain this important and sustainable activity in the Spanish Northeast region Aragon. It has resulted 3 different management systems representing 3 groups of farms. The results have confirmed the diversity of the farming systems in Aragon. Furthermore, it has concluded that different farming management could lead to the same economic results. This latter point could be important in adjusting the inputs of some farming systems to improve their economic results and to be more sustainable by minimising gas emissions. After the typification of farms, it has been studied the relationship of the structural, technical and cost indicators with the economic results. It has been concluded that labour is very important component of the sheep farming mainly family labour. This latter has been one of the potential factors in maintaining the economic viability of the farms, in a context of high dependency to common agricultural policy subsides. Then, labour intensification has been a key element too in maximising labour productivity thus improve the economic results of the farms. With the condition to don't exceed the right number of ewes per labour unit, if not the zootechnical performance of sheep could be affected. Irrigated area has been an important indicator of fodder crops. This aspect would improve the feed autonomy of the farms even if an autonomy using naturel grazing land is more economically efficient and sustainable. Stocking rate has a negative power on the economic results, it could be explained by using more inputs. Moreover, rangeland degradation coupled with the high density of sheep flocks. Furthermore, and regarding to production intensification, the aspect on which all the studies agree that has a great importance in improving the economic results of farms. First, number of sold lambs per ewe and year have been the most important factor which could improve the economic results with and without subsides. The number of sold lambs per ewe and year is tightly linked to other aspects of reproduction intensification, which were prolificacy and number of lambings per ewe. These two indicators had a positive power in improving the economic results of the farms. It is possible to improve the prolificacy with rearing prolific autochthone breeds, and the number of lambings by reducing the number of days interval between births. However, one of major issues in sheep farming is lambs' mortality rate, this aspect must be taken seriously into account to be able to improve the economic results. Finally, the cost indicator which has been studied in this work was feed costs. Feed costs represents almost 70 % of the total costs, minimizing this percentage could improve the economic results. This will be possible with more feed autonomy based mainly on naturel grazing. Thus, these systems could accomplish their main task in maintaining their sustainability and become more resilient and at the same time more flexible and adaptative to the continuous changing in the policy aids as well as the climate change. New technologies, workshops organised by experts and integrating specialised cooperatives in sheep farming could help farmers to better decision making and improving the structural and technical aspects of their farms, thus alleviating the dependency to the common agricultural aids. Finally, an efficiency study is recommended for deeper understanding of the different studied management systems of meat sheep farming.

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Table 1. Sample description

	Mean	Sd. Deviation
Structural indicators		
Average number of ewes (NE)	605	304
Total man labour units (TMLU)	1.32	0.49
Percentage of family man labour units (%FLU)	90.05	18.02
Number of ewes per man labour unit (NE/LU)	463.16	143.62
Number of ewes per hectare of total useful agricultural area (NE/TUAA)	17.53	58.84
Percentage of irrigated area on the total useful agricultural area (% IrrigA/TUAA)	22.2	32.33
Total useful agricultural area (TUAA)	95.67	87.82
Technical indicators		
Number of lambings by present ewe (NL/PE)	1.12	0.13
Prolificacy (Pr)	1.34	0.13
Percentage of lambs' mortality (% Mr)	10.66	3.77
Number of sold lambs per present ewe (NSL/PE)	1.17	0.25
Economic indicator		
Feed costs per ewe (FC) (euros)	59.74	15.38
Economic result		
Gross margin per labour unit with subsidies (GM/LUWS) (euros)	25054.05	10313.30
Gross margin per labour unit without subsidies (GM/LUWTS) (euros)	5151.20	9251.43

Table 2. Components Rotated Matrix for farms' studied variables

Factors and variables	Factors				Communalities
	Factor 1	Factor 2	Factor 3	Factor 4	
Number of sold lambs per present ewe (NSL/PE)	**0.950**	0.082	-0.005	-0.094	0.917
Number of lambings by present ewe (NL/PE)	**0.862**	-0.032	-0.047	-0.007	0.746
Prolificacy (Pr)	**0.859**	0.131	-0.036	-0.018	0.756
Feed costs per ewe (FC) (euros)	**0.835**	-0.137	0.019	0.060	0.719
Total man labour units (TMLU)	-0.079	**0.836**	-0.042	0.073	0.713
Percentage of family man labour units (%FLU)	-0.077	**-0.795**	-0.017	0.087	0.646
Percentage of irrigated area in the total useful agricultural area (% IrrigA/TUAA)	0.088	-0.064	**0.784**	0.040	0.629
Number of ewes per hectare of total useful agricultural area (NE/TUAA)	-0.106	0.082	**0.740**	0.156	0.590
Total useful agricultural area (TUAA)	0.090	0.492	**-0.558**	0.289	0.645
Number of ewes per man labour unit (NE/LU)	0.106	-0.018	0.069	**0.806**	0.665
Percentage of lambs' mortality (% Mr)	-0.111	0.032	0.032	**0.603**	0.378
Eigen value	3.155	1.855	1.334	1.061	
% Variance	28.556	14.812	13.511	10.433	
% Cumulative variance	28.556	43.368	56.879	67.313	

Table 3. Clusters' profile

Factors	Cluster 1	Cluster 2	Cluster 3
Number of farms	48	29	49
Factor 1	0.4975363	0.1555669	-0.5794527
Factor 2	-0.5157093	0.4594782	-0.3585882
Factor 3	0.2600046	-0.2470641	-0.1084768
Factor 4	0.6129651	0.0927455	-0.6553458

Table 4. Clusters' description

Variables	Cluster 1		Cluster 2		Cluster 3		Significance level (C1, C2, C3)	Significance level C1, C2	Significance level C1, C3	Significance level C2, C3
	Mean	Std.D	Mean	Sd. D	Mean	Sd.D				
Number of ewes (NE)	603.83	276.38	860.55	344.53	456.40	186.13	***	***	**	***
Total man labour units (TMLU)	1.14	0.46	1.83	0.46	1.22	0.32	***	***	NS	***
Percentage of family man labour units (%FLU)	98.84	4.28	65.66	21.14	95.90	9.79	***	***	NS	***
Number of ewes per hectare of total useful agricultural area (NE/TUAA)	25.79	93.44	9.94	12.02	13.95	16.39	NS	NS	NS	NS
Total useful agricultural area (TUAA)	80.88	57.99	182.46	123.25	58.80	42.10	***	***	NS	***
Number of ewes per man labour unit (NE/LU)	548.19	146.25	467.37	115.83	377.37	100.97	***	**	***	***
Percentage of irrigated area in the total useful agricultural area (% IrrigA/TUAA)	33.95	39.58	16.90	26.24	13.71	23.63	***	*	***	NS
Percentage of lambs' mortality (% Mr)	11.75	4.03	11.07	3.74	9.35	3.15	***	NS	***	NS
Number of lambings by present ewe (NL/PE)	1.17	0.12	1.13	0.14	1.05	0.11	***	NS	***	**
Prolificacy (Pr)	1.39	0.13	1.38	0.14	1.28	0.11	***	NS	***	***
Number of sold lambs per present ewe (NSL/PE)	1.29	0.27	1.23	0.28	1.03	0.15	***	NS	***	***
Feed costs per ewe (FC) (euros)	66.77	14.63	59.27	16.44	53.14	12.45	***	*	***	NS
Gross margin per labour unit with subsidies (GM/LUWS) (€)	29449.44	9223.37	22893.15	9223.37	22027.25	7646.85	***	**	***	NS
Gross margin per labour unit without subsidies (GM/LUWTS) (€)	7319.90	9223.37	1941.54	9223.37	4970.61	5315.50	**	**	NS	NS

Significance level at: (***) p < 0,0001. (**) p < 0.05 (*) p < 0.1 NS: Not significant

Table 5. The results of the multiple linear regression models for the whole sample

	Parameters	Unstandardized coefficients (β)	Sd.D(1)	Standardized coefficient (β Std)	T(2)	P(3)	R^2 % (4)	Adjusted R^2 %	Durbin-Watson	VIF(5)
Regression 1 (6) (GM/LUWS)	Constant	-33571.033	7619.635		-4.406	0.000***	**81.8**	**80.4**	**2.199**	
	Number of ewes per man labour unit (NE/LU)	45.813	2.947	0.638	15.548	0.000***				1.074
	Percentage of lambs' mortality (% Mr)	-742.170	126.432	-0.271	-5.870	0.000***				1.364
	Number of sold lambs per present ewe (NSL/PE)	15720.204	4546.986	0.396	3.457	0.001**				4.356
	Feed costs per ewe (FC) (euros)	-499.183	40.038	-0.745	-12.468	0.000***				2.275
	Percentage of family man labour units (%FLU)	134.914	25.425	0.236	5.306	0.000***				1.259
	Percentage of irrigated area on the total useful agricultural area (% IrrigA/TUAA)	-55.203	13.019	-0.173	-4.240	0.000***				1.062
	Prolificacy (Pr)	21847.383	6375.265	0.287	3.427	0.001**				4.480
	Number of lambings by present ewe (NL/PE)	17144.519	5730.151	0.220	2.992	0.003**				3.460
	Total man labour units (TMLU)	-2081.202	947.393	-0.100	-2.197	0.030**				1.319
Regression 2 (7) (GM/LUWTS)	Constant	-15692.093	3963.986		-3.959	0.000***	**68.2**	**67.2**	**2.001**	
	Percentage of lambs' mortality (% Mr)	-533.770	130.723	-0.218	-4.083	0.000***				1.078
	Number of sold lambs per present ewe (NSL/PE)	32659.050	2623.560	0.920	12.448	0.000***				2.064
	Feed costs per ewe (FC) (euros)	-487.539	43.049	-0.813	-11.325	0.000***				1.949
	Percentage of family man labour units (%FLU)	192.313	26.687	0.376	7.206	0.000***				1.027

(1)(Sd D) Standard deviation; (2) (T) T-value; (3) (P) P-value; (4) (R^2 %) R squared; (5) (VIF) Variance Inflation Factor. (6) (GM/LUWS) Gross margin per labour unit with subsides; (7) (GM/LUWTS) Gross margin per labour unit without subsides. Significance level at: (***) $p < 0,0001$. (**) $p < 0.05$ (*) $p < 0.1$

Table 6. The results of the multiple linear regression models for cluster 1

	Parameters	Unstandardized coefficients (β)	Sd.D(1)	Standardized coefficient (β Std)	T(2)	P(3)	R^2 % (4)	Adjusted R^2 %	Durbin-Watson	VIF(5)
Regression 1 (6) (GM/LUWS)	Constant	-6165.273	12663.264		-0.487	0.629	**81.4**	**78.7**	**2.402**	
	Percentage of lambs' mortality (% Mr)	-820.276	278.267	-0.287	-2.948	0.005**				2.097
	Number of ewes per man labour unit (NE/LU)	36.972	5.816	0.470	6.357	0.000***				1.204
	Prolificacy (Pr)	22666.621	13078.368	0.264	1.733	0.091*				5.109
	Feed costs per ewe (FC) (euros)	-510.457	70.543	-0.649	-7.236	0.000***				1.773
	Percentage of irrigated area on the total useful agricultural area (% IrrigA/TUAA)	-68.234	19,946	-0.235	-3.421	0.001**				1.037
	Number of sold lambs per present ewe (NSL/PE)	23191.756	7693.774	0.538	3.014	0.004**				4.015
(GM/LUWTS) Regression 2 (7)	Constant	17939.305	8587.213		2.089	0.043**	**72.8**	**70.2**	**2.209**	
	Percentage of lambs' mortality (% Mr)	-825.659	294.356	-0.291	-2.805	0.008**				1.660
	Feed costs per ewe (FC) (euros)	-559.500	83.316	-0.707	-6.715	0.000***				1.716
	Number of sold lambs per present ewe (NSL/PE)	32074.189	5451.625	0.744	5.883	0.000***				2.476
	Total man labour units (TMLU)	-4235.611	2054.316	-0.169	-2.062	0.045**				1.039

(1)(Sd D) Standard deviation; (2) (T) T-value; (3) (P) P-value; (4) (R^2 %) R squared; (5) (VIF) Variance Inflation Factor. (6) (GM/LUWS) Gross margin per labour unit with subsides; (7) (GM/LUWTS) Gross margin per labour unit without subsides. Significance level at: (***) $p < 0,0001$. (**) $p < 0.05$ (*) $p < 0.1$

Table 7. The results of the multiple linear regression models for cluster 2

	Parameters	Unstandardized coefficients (β)	Sd.D(1)	Standardized coefficient (β Std)	T(2)	P(3)	R^2 % (4)	Adjusted R^2 %	Durbin-Watson	VIF(5)
Regression 1 (6) (GM/LUWS)	Constant	-32047.611	9125.635		-3.512	0.002**	**84.3**	**80.0**	**2.163**	
	Number of ewes per hectare of total useful agricultural area (NE/LU)	53.948	8.171	0.631	6.602	0.000***				1.276
	Number of lambings by present ewe (NL/PE)	24356.896	11177.258	0.358	2.179	0.040**				3.783
	Feed costs per ewe (FC) (euros)	-421.310	75.705	-0.699	-5.565	0.000***				2.208
	Percentage of family man labour units (%FLU)	167.178	43.095	0.357	3.879	0.001**				1.182
	Number of sold lambs per present ewe (NSL/PE)	17637.037	7059.249	0.496	2.498	0.020**				5.513
	Percentage of lambs' mortality (% Mr)	-506.331	230.968	-0.191	-2.192	0.039**				1.061
(GM/LUWTS) Regression 2 (7)	Constant	-9692.098	6158.921		-1.574	0.128	**59.0**	**54.0**	**1.711**	
	Percentage of family man labour units (%FLU)	266.872	61.534	0.588	4.337	0.000***				1.121
	Percentage of irrigated area on the total useful agricultural area (% IrrigA/TUAA)	192.072	49.915	0.526	3.848	0.001**				1.137
	Percentage of lambs' mortality (% Mr)	-825.298	332.880	-0.322	-2.479	0.020**				1.025

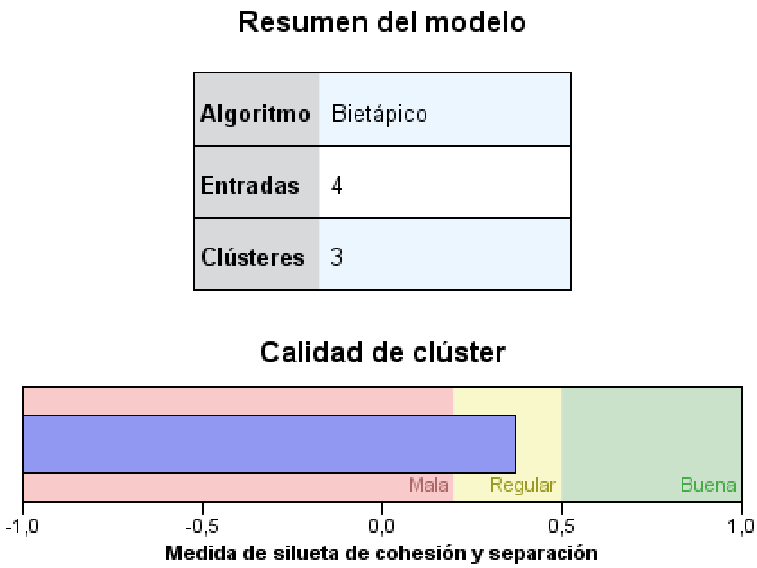
(1)(Sd D) Standard deviation; (2) (T) T-value; (3) (P) P-value; (4) (R^2 %) R squared; (5) (VIF) Variance Inflation Factor. (6) (GM/LUWS) Gross margin per labour unit with subsides; (7) (GM/LUWTS) Gross margin per labour unit without subsides. Significance level at: (***) $p < 0,0001$. (**) $p < 0.05$ (*) $p < 0.1$

Table 8. The results of the multiple linear regression model for cluster 3

	Parameters	Unstandardized coefficients (β)	Sd.D(1)	Standardized coefficient (β Std)	T(2)	P(3)	R^2 % (4)	Adjusted R^2 %	Durbin-Watson	VIF(5)
Regression 1 (6) (GM/LUWS)	Constant	-6336.039	3819.040		-1.659	0.104	**82.5**	**80.9**	**1.816**	
	Number of ewes per man labour unit (NE/LU)	56.340	4.903	0.744	11.490	0.000***				1.053
	Number of sold lambs per present ewe (NSL/PE)	27676.163	3976.186	0.562	6.960	0.000***				1.635
	Feed costs per ewe (FC) (euros)	-327.332	48.878	-0.533	-6.697	0.000***				1.590
	Total man labour units (TMLU)	-3281.199	1565.922	-0.139	-2.095	0.042**				1.105
(GM/LUWTS) Regression 2 (7)	Constant	1465.368	3482.099		0.421	0.676	**64.8**	**62.5**	**2.300**	
	Feed costs per ewe (FC) (euros)	-407.807	47.532	-0.955	-8.580	0.000***				1.586
	Number of sold lambs per present ewe (NSL/PE)	25523.863	3794.361	0.745	6.727	0.000***				1.570
	Number of ewes per hectare of total useful agricultural area (NE/TUAA)	-78.565	30.697	-0.241	-2.559	0,014**				1.136

(1)(Sd D) Standard deviation; (2) (T) T-value; (3) (P) P-value; (4) (R^2 %) R squared; (5) (VIF) Variance Inflation Factor. (6) (GM/LUWS) Gross margin per labour unit with subsides; (7) (GM/LUWTS) Gross margin per labour unit without subsides. Significance level at: (***) $p < 0,0001$. (**) $p < 0.05$ (*) $p < 0.1$

Figure 1. Cluster quality



RESEARCH PAPER 4

Trajectories of evolution of extensive sheep farms in Aragon (Spain).

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Abstract

Sheep farms have undergone important changes in the last decades motivated in part by the CAP, whose aids are essential for their survival. The objective is to analyze the evolution trajectories of a sample of sheep meat farms in northeastern Spain, representative of extensive production conditions in disadvantaged areas of Mediterranean regions. The sample is composed of 23 farms that have remained a minimum period of eighteen years (from 1993 to 2016) in a management program. A total of 14 indicators describes the sample from a structural, technical and economic point of view. Through a PCA, the information is reduced and the annual data of the farms are projected on the two planes defined by the first two factors. Two criteria are used to analyze the trajectory of each farm: the variability between successive years and the distance between the first year and the last year in which they remained in the program. The results show four types of trajectories characterized by greater or lesser stability in both the short and long term. It again becomes evident that, in the long term, improving food self-sufficiency and productivity of sheep is important to improve the profitability of sheep meat farms, reducing their dependency on subsidies and improving their viability. It has also been shown that there are limitations in some groups that condition the flexibility and adaptation to the changes introduced by the CAP measures. Probably, it will be interesting to take in account this diversity for more targeted policies mechanisms.

Additional key words

Ovine; trajectories; technical indicators; economic indicators; CAP.

Abreviations used

NE – Number of ewes

TMLU – Total man labour units

LU – Labour units

FLU – Family man labour units

TUAA – Total useful agricultural area

IrrigA – Irrigated area

RGL – Rented grazing area

FA – Forage area

FC – Food costs

PFC – Purchased feed costs

TC – Total costs

SR – Subsidies revenues

GM – Gross margin

NLB/PE – Number of lambs births/present ewe

Introduction

Spain is the first country with the largest sheep herd after the Brexit with almost 16 million heads, equivalent to 25 % of EU's total flock (MAPA, 2021). Meat sheep production is generally located in marginal areas where semi-arid conditions constrain agricultural and animal production.

Sheep production systems have been developed over time as extensive grazing systems with natural vegetation as the main feed source. Native grasslands predominate and their use has been mainly restricted to very extensive systems or to limited periods of the year during in which animals have low nutrient requirements (Jouven *et al.,* 2010; Toro-Mujica *et al.,* 2015). Their current organization and resource endowment are the result of long-term historical, geo-political and socio-economic changes (de Rancourt *et al.*, 2006; Castel *et al.*, 2011; Ryschawy *et al.*, 2013). Additionally, variable ecosystems and socio-cultural contexts have given rise to highly variable production systems (Robinson *et al.*, 2011; Toro-Mujica *et al.,* 2015).

Though sheep meat sector has a very important role in the economic, social and environmental equilibrium through the provision of several ecosystem services and the maintenance of the rural population, as well as acting as a barrier against the abandonment of otherwise unusable land (Rossi, 2017; Rodríguez-Ortega *et al.,* 2018; Bertolozzi-Caredio *et al.,* 2021), it is experimenting drastic changes in the last two decades.

Farming systems are diverse and dynamic; thus, the agricultural land use is constantly changing in response to biophysical and socio-economic drivers (Mottet *et al.,* 2006; Garcia-Martinez *et al.,* 2009). A variety of driving forces have shaped the livestock sector of EU countries during recent decades. Structural changes and direct decision making of farmers largely depend on internal and external influencing factors. Evaluation of the expert consultation showed that on national and European levels regulatory environment, technological change and progress in animal genetics during the last decades, as well as inputs and farm gate prices were assessed as having the largest influence. In contrast to this on the global scale, economic development and population dynamics were rated as the major driving forces that have led to the current status quo of the livestock sector (F.O.A.F, 2019).

With respect to public policies, it will be interesting and very important to study the effect of the Common Agricultural Policy (CAP) reforms on the evolution of these farms.

The survival of ovine sector depends to a large extent on the CAP subsidies. Gaspar *et al.* (2008) found that 29 % of the total farm income is depending on livestock subsidies and any changes in the CAP affect these farms. In Paas *et al.* (2021) the participants pointed out that if basic payments would be lower than the current level, the gross margin would be null or negative. The majority of studies on this aspect are unanimous that the CAP reforms have caused adjustments on farms' structure and strategies of management. For example, the total decoupling of aids led to the decreasing in the size of herds. So, sheep farms are affected by these direct aids. The CAP subsidies represent a real network of insurance which avoid the disappearance of this sector (MAGRAMA, 2013; CAE, 2012, AND international and European Comission, 2011). Pardos *et al.* (2008) and Soriano *et al.* (2018) found that the flexible adaptability to change contexts in agricultural policy is also an important factor which affects the survival of sheep meat farms.

To understand the dynamics of change of livestock systems, a multitude of studies have been performed. However, these studies have been studying the typology of farms or classifications, categorising the state of subsets of farms and using this as a basis for predicting future changes (Daskalopoulou & Petrou, 2002; Shucksmith & Herrmann, 2002; Iraizoz *et al.,* 2007). These studies often have been using data for a single year or a mean of data for some years, which gives to the majority of these studies an exploratory static aspect rather than capturing the changes occurred over time. On the other hand, there are studies that have been looking for farm's trajectories, but very few refer to sheep farms. The following are some studies which have attempted to study the trajectories of these systems: García-Martínez *et al.* (2009) studied the trajectories of evolution and drivers of change in European mountain cattle farming systems, explained as a strategy of adaptation the three groups of factors used by farmers: (1) The socio-economic environment, predominantly influenced by agricultural policies; (2) specific local/regional factors relative to farm location, which determine production potential, access to inputs and outputs markets, etc.; and (3) internal characteristics of the household, including structural, economic and sociological ones (García-Martínez *et al.,* 2009). Iraizoz *et al.* (2007) studied the trajectories of agricultural farms in Navarra region in Spain, they concluded that high levels of direct payments dampen pressures for restructuring rather than stimulating improvements in productivity. Farms in the most marginal areas benefited relatively little from the switch to more direct forms of farm support and their continued existence depends on farmers accepting returns below their opportunity costs for own land and labour (self-exploitation). González *et al.* (2014) have studied the trajectories of growth of agrarian farms in the Cantabria coast; they concluded that the pathways were affected by the location and farms' internal factors.

In order to contribute to more understanding of the dynamics of sheep meat farms, we defined the objective of our present work as studying the long-term trajectories of these farms throughout a long time period. We commented previously some studies about agrarian trajectories in general; however, studies about sheep trajectories in particular are very scarce and we have not found any for sheep meat farms. This latter is one of the motivations to choose the objective of the present work. We illustrate the usefulness of the approach with an application to the extensive sheep farming system in Aragon, in north-eastern Spain. The sector within our empirical context is characterized by a declining socio-economic trend, which is in line with overall tendencies documented for extensive sheep farming in marginal and less-favoured areas of the EU Mediterranean regions. In fact, a sample of sheep farms in this region has been the subject of analysis in recent studies (Bertolozzi-Caredio *et al.,* 2021; Paas *et al.,* 2021). Indeed, studying the change on a long time period could give us more insight on the drivers of change which helps to propose some recommendations both to farms managers and policies makers.

Material and methods

The sample used for the analysis of the farms trajectories is made up of 23 meat sheep farms, selected from the original sample of 126 provided by the technical-economic management program used by an important sheep cooperative located in Aragon, Spain. Only 23 sheep farms have been selected since a constant sample is needed for the study of trajectories on long time period. The selection of these 23 farms has been mainly based on the number of years that each farm spent in the technical-economic management program. After consulting studies related to farms typologies or trajectories of change, it has been chosen farms that have been participated 18 years and more in this data collecting program (it has been collecting data from 1993 until 2016), it has been considered that 18 years is a strongly suffisant time period to study a farm trajectory (examples of studies: 1- Pardos *et al.* (2008): Sheep farms characterisation and typification in Aragon. The data used were for a period of 5 years. 2- García Martínez (2007): The recent dynamic of bovine system in the central Pyrenees. The data used refers to 15 years. 3- Pardos *et al.* (2014): A technical economic study of meat sheep farms in

Aragón along 5 years. 4- A report of Spanish agricultural ministry where it was analysed the impact of CAP reforms on the sheep sector along 7 years period. Due to the long-studied time period (from 18 to 24 years) all economic data has been converted to constant Euros of 2016.

On the other hand, the period studied includes the most important changes that have taken place in the CAP applied to the sheep sector in Spain. In general terms, it has evolved from the payment of a coupled variable premium based on the price of lamb in the period 1996-2001, to a single payment decoupled at 100% and an associated direct payment.

A serie of variables has been selected based on previous studies (Hamrouni, 1993; Chertouh, 2005; Pardos *et al.*, 2008; López-i-Gelats *et al.*, 2011, Benoit *et al.,* 2011). It has been used 14 different types of variables mainly structural, technical and economic. First structural ones: it has been chosen structural variables related to total useful agricultural area (TUAA), percentage of forage area on total useful agricultural area (% FA/TUAA), rented grazing land (RGL) and the percentage of irrigated area on total useful agricultural area (%IrrigA/TUAA). It has been included the variables related to the number of ewes (NE) and its relationship with useful agricultural area (NE/TUAA) as well as its relationship with man labour units (NE/LU). The total labour man units (TMLU) and the percentage of family labour units (% FLU) has been introduced too. For technical variables, from one side, it has been chosen the variable related to the numerical production, the number of lambs' births per present ewe (NLB/PE). With respect to costs' variables, it has been chosen the variable related to the percentage of feed costs on total costs (% FC/TC) as well as the percentage of purchased feed costs on total feed costs (% PFC/FC). With respect to the revenues, it has been chosen the variable percentage of subsidies revenues on total revenues (% SR/TR). Finally, it has been included the economic variable related to gross margin per total labour unit (GM/LU). The gross margin per labour unit (GM/LU) can be considered as the most significant measure of economic results and an indicator of the possible continuity of the farms by including productivity per ewe and the correct size of the herd (Olaizola *et al.,* 1996)

To analyse the trajectories first we carried out a principal component analysis (PCA) based on the 14 variables previously commented. In this study the 23 farms represent 497 years-farm (number of individuals), which means each farm has been represented by the number of the years spent in the recording data program; remember that there are 18 years or more for each farm. For this long-time study period, the annual data (14 variables) per farm has been projected on the plan defined by the two first factors resulted from the PCA. The years' dots have been connected as curves that represent the trajectories (figures from 2 to 5). In graphic representation (figures) the big dot represents the first year of data recording and the arrow represents the last year of data recording for each farm.

It has been used two types of criterions to study the evolution of each farm. The present methodology has been used by Benoit & Laignel (2011):

1/ Variability between successive years: it shows the stability or the instability of the technical itineraries and performances. This variability has been figured out by calculating the mean distance per farm between successive years (MDF) for each variable. This distance has been calculated using the coordinates of each year-farm of the 14 factors defined by the principal component analysis.

2/ Distance between the year of the start and the end of data recording for each farm in the management program. This criterion gives us an idea on the occurred changes in farms' structure and the different modes of using farm land. It has been calculated with the same formula used in the calculation of (MDF) but using just two points: the beginning year and the ending year for the farm studying period.

The formula to define the mean distance between successive years (MDF) is the following:

$$\text{MDF}=\frac{\sum_{i=1}^{n-1}[\sum_{j=1}^{14}(x_{i+1}^{j}-x_{i}^{j})^2]^{1/2}}{n-1}$$

Where:
i: years (*n* is the available years for the farm)
j: the studied factor or variable
x^j_i = the value of the factor j for the year *i*

Results and Discussion

1. Description of the sample

It was previously mentioned that the sample is composed by 23 sheep farms in Aragon, Spain. They are distributed on the tree provinces of Aragon (Zaragoza, Huesca and Teruel), they present the same production systems and the same production orientation: meat production.

A general description of the sample is as following (Table 1). The average size of farms (NE) is 706 ewes per farm, handled by 1.62 total man labour units (TMLU). Family man labour units represent about 90 % of the total man labour units, which means that the sample farms are in majority family farms. With respect to labour intensification, the parameter number of ewes per man labour unit (NE/LU) is the most used index in this purpose. The average number of ewes per man labour unit is 442 which is quite good according to Pardos & Fantova (2007), they found that the best economic results are obtained with farms which handle 400-600 ewes per man labour unit. The number of ewes per hectare of useful agricultural area (NE/TUAA) is 6.99 ewes/ha. The average useful agricultural area (TUAA) for these farms is 101 hectares from which 16.12 % are irrigated. The average rented grazing land (RGL) is 635 hectares. While the average percentage of forage area on total useful agricultural (% FA/TUAA) is 25.53 %. With regards to costs, the average of the percentage of feed cost on total costs (% FC/TC) is 72 %, and the percentage of purchased feed cost on total food cost (% PFC/FC) is 72% too. The percentage of the subvention revenues on total revenues (% SR/TR) is about 32%. With respect to the economic results illustrated by the gross margin per labour unit (GM/LU), the average was 26,932.88 Euros per farm. Finally, with respect to technical indicators, the average number of births per present ewe (NLB/PE) is 1.59.

2. Relation between labour intensification and the obtained economic results

As the gross margin per labour unit was the economic result that is used to study, it has been done a comparison between the evolution of the gross margin per labour unit (GM/LU) and the number of ewes per labour unit (NE/LU) to figure out if the evolution of the labour intensity has influenced the evolution of the gross margin per labour unit.

Figure 1 describes better the evolution of two important parameters in a sheep farm management. It shows that the labour intensification was increasing along the studied period, but this trend did not influence the gross margin per labour unit which has a decreasing trend in multiple occasions, even if it has recorded some periods of increase. Benoit *et al.* (2011) had concluded that labour intensity didn't go always with high levels of gross margin per labour unit. This decreasing trend could be explained by some factors like the decrease in the price of lamb meat and the increase of feed prices, and some technical parameters like the deterioration of the zoo technical parameters which could be caused by the difficulties in handling high number of ewes by a labour unit. And in the periods of increasing trend, it could be explained by the common agricultural policies measures as an example the compensation of the lamb's meat prices and the subventions in general. As a conclusion the increase in the labour intensification didn't always leads to the increase in the gross margin per labour unit. More explanations will be provided while studying the trajectories of evolution in the next section of the result.

3. Reducing dimensions

Using PCA, the dimensions of the original matrix of variables have been reduced. It has been resulted 5 factors from the PCA, they explained 68.75 % of the total variance. The first two factors explained 34.91 % of the total variance where factor 1 explained 17.95 % and factor 2 explained 16.95 %. Both KMO index = 0.544 and Bartlett's (Chi-square) test for Sphericity were significant at p < 0,000 to interpret factor analysis results.

We performed the Varimax method for factors rotation; the results are reported in table 2.

In this section we will be describing the first and the second factor, because they are factors in which we are interested in to continue describing farms trajectories. As together they explain the highest percentage of the total variance (34.91%), so they will be used as a plan to project the 14 variables used in this analysis and then relate the dots to figure out the trajectory for each farm.

Factor 1 is significantly correlated with 4 of the 14 initial variables; it is highly and positively correlated with family labour (% FLU) (+ **0.852)** and the percentage of feed cost on total costs (% FC/TC) (+ **0.721)**, while it is moderately and negatively correlated with flock size (NE) (**-0.526)** and farm land size (TUAA) (**-0.517)**. This factor characterises farms with small flock and land size, high percentage of family labour, with low forage autonomy as evidenced by the high relative importance of feed costs.

Factor 2 is significantly and positively correlated with two variables of the 14 initial ones. It is mainly correlated positively with the percentage of irrigated area (% IrrigA/TUAA) (+ **0.884)** and stocking density (NE/TUAA) (+ **0.858)**. This factor characterises farms with more irrigated area, and stocking density, they are intensified farms.

4. Farms` trajectories

After performing PCA, it has been calculated the average distance between successive years for each used variable and for each farm belonging to the used sample. With the same methodology it was also calculated the average distance between the first year of data recording and the last year for each farm. In our case study, this period of data collection varies between 18 and 24 years. After crossing the two used criteria (variability and the distance between the year of the beginning and the end of data recording for each farm, commented previously in the methodology part), it has been resulted 4 types of trajectories. The two criteria of evolution used to define farms trajectories are not directly related: a very unstable variability between successive years could correspond to a very stable evolution over the long term (Benoit & Laignel, 2011). In our study we could figure out 4 types of farms trajectories as follows:

1/ Farms with very stable evolution over the long term, as well as between successive years:
case 1 (n= 8).

2/ Farms with stable evolution between successive years and moderate evolution over the long term: case 2 (n=7).

3/ Unstable evolution on successive years and stable evolution on the long term: case 3 (n=3).

4/ Unstable evolution over the long term and medium evolution between successive years: case 4 (n=5).

The positioning of the used variables on the plan set up by factor 1 and factor 2 resulted from the PCA analysis, has allowed us to figure out the location of farms in the different areas of the plan. The main observation could we deduce is the heterogeneity of the farming systems. In some case, it has been represented a sample of farms on the figure to have more visibility of the farms' trajectories.

The results for each type of trajectory have been exposed with details as follows:

Case 1: farms (3, 8, 11). Farms with very stable evolution over the long term, as well as between successive years (See figure 2 and table 3)

The proximity of the consecutive annual points shows a relatively stable herd management without major changes in technical variables.

In terms of production structure, these are farms with medium-sized herds (NE), with exclusively family labour (% FLU) and little usable agricultural area (TUAA), which have undergone moderate changes in herd size, labour force and rented pasture area (Figure 2).

In these farms there has been an intensification of the labour force (NE/LU) and an increase in the useful agricultural area (TUAA) and in the forage area, which has resulted in an extensification in the use of the land (NE/TUAA). However, this has not resulted in a decrease in feed costs, nor in an improvement in their economic results.

It seems that these farms have been less sensitive to changes in the CAP, and that the smaller size of their farm (TUAA) and the availability of family labour (% FLU) and pasture have marked their evolution throughout the period analysed, adapting the size and management of their herd to these circumstances.

Although some farms have irrigated land, most of them are located in rainfed areas (the three selected farms depicted in Figure 2 are located far away from the % Irrig/TUAA and % FA /TUAA variables.). This, together with the smaller agricultural and grazing area, results a low food self-sufficiency. They are therefore highly dependent on purchased feed, which accounts for more than 70% of the total feed costs on most farms in this group. This is despite having increased their TUAA and % of forage area in the period analysed.

The decrease in the labour force dedicated to sheep production may be due to a decrease in family support (retirements and generational replacement problems), to a greater dedication to agricultural activity, or to the difficulty in finding salaried labour.

In the end, social, structural and economic factors (scarcity of arable land and pasture and high land prices) highlighted by other authors (Burton, 2006; García Martínez *et al.,* 2009; González *et al.,* 2014 Bertolozzi-Caredio *et al.,* 2020) have marked the evolution of these farms.

Case 2: farms (1, 7, 20, 21). Farms with stable evolution between successive years and average evolution on the long-term (see figure 3 and table 3)

Over the study period, these farms have undergone greater structural changes than those in the previous group, with a significant increase in its TUAA and the area of leased pasture (RGL). The moderate increase in flock size (NE) and decrease in available labour (TMLU) has allowed them to increase labour productivity (NE/LU). These farms seem to be moderately sensitive to CAP measures as we explain below.

To explain better the evolution of these farms with respect to CAP reforms, we can see on figure 3, the evolution of the chosen farms of case 2 (1, 7, 20, 21). To the left of the plan during the first years of data collection, it reflects the increase in their flock size, in order to perceive more subsidies which were at this period (1993-2004) coupled 100% with production. After aids decoupling, farm (21) has decreased its herd as it is illustrated by its direction in figure 3. We could see that labour force was a limited factor to continue in the same trend of increasing the flock size. We could figure out that farms with 100 % of family labour force were adopted the strategy to decrease their flock size (NE) or to maintain it stable as well as their total useful agricultural area (TUAA) after the decoupling of aids. In addition, they invested on the forage autonomy whether if it was their own forage crops or rented pastures.

In terms of the differences with the previous group, the existence of salaried labour for grazing, and the greater availability of TUAA and rented pastures (RGL), and lower stocking rates (NE/TUAA), stand out. As a result, they have lower feed costs and greater feed autonomy as they are less dependent on purchased feed, which are important aspects for improving the profitability of sheep meat farms (Bertolozzi-Caredio *et al.,* 2021). The greater availability of feed resources makes them stable between successive years. They also achieve better production results, which also contributes to improved profitability and makes them less dependent on the subsidies they receive. As Ripoll-Bosch *et al.* (2014) points out, higher productivity reduces the relative importance of coupled subsidies in the economic performance of farms.

Case 3: farms (9, 18, 19). Farms with unstable evolution between successive years and stable evolution on the long term (see figure 4 and table 3).

These are farms with small herd size, little total useful agricultural area (TUAA) and a low number of ewes handled per labour unit (NE/LU) compared to the rest of the differentiated groups (it didn't exceed 350 ewes/LU in the majority of the cases), with exclusively family labour.

As in Case 1, the structural limitations that have made it difficult to increase the size of the herd, and the TUAA available during the studied period, makes them present a stable long-term evolution. We can conclude that these farms react little to changes in the CAP measures.

Located in rainfed areas (as it is shown in figure 4, the 3 farms are located in the right below quarter of the plan) , they have been based the feeding of the herd on the use of the dry land pastures, although they use their own dry agricultural area also for livestock (higher percentage of forage area than in the first group), the little available TUAA makes them depending a lot on natural pastures that can be affected by the rainfall each year, generating instability between successive years. The latter was getting worse by the possibility of getting more or less surface area on their farm, given that they have a high percentage of rented area It has been depended on the economic ability to rent or not every single year, which leaded to instability. These farms have intensified reproductive management (NLB/PE), which may have been the cause of the increase in their feed costs (%FC/TC).

They have tried to correct their structural limitations with an increase in productivity per ewe (two of the three farms have gone from 1.5-1.6 lambs born per ewe and year to 2-2.4 in the studied period), trying to maintain economic results per labour unit. Bertolozzi-Caredio *et al.* (2021) and Farrell *et al.* (2020) have concluded that prolificacy and lambing rate are interesting technical factors to improve the economic results in sheep farms. They are therefore small farms that need to maintain livestock activity to complete their family income.

Case 4: farms (10, 13, 16, 17, 22). Farms with moderate evolution between successive years and unstable evolution on long term (see figure 5 and table 3)

This group has gathered farms that have undergone significant structural changes in the studied period. All farms have seen their herd size significantly modified, being reduced in one farm and significantly increased in the rest. There has also been an increase in the labour force (TMLU) (mainly salaried), the total agricultural area (TUAA), the percentage of irrigated land (% IrrigA/TUAA) (except for farms 10,16 and 17) and forage area (%FA/TUAA) for farms (13, 16 and 22). Livestock stocking rates (NE/TUAA) have also increased

By way of illustration, farm 16 in figure 5 has increased their flock size from 406 ewes in 1995 to 498 ewes in 2004 with 100 % of family labour units (% FLU), and from 464 ewes in 2005 to 1261 ewes in 2016 with 50% of FLU and 50 % of salaried labour units. The trend of the trajectory, of this farm, to be converted in a specialized sheep farm is clearly shown by the curve of evolution of this farm throughout the study period where the farm has been moved from the right side of the plan to the left side. This farm has been experiencing deep changes in its structure and in its herd management. For the rest of farms of this group it can be seen that the trend is more or less the same, each farm has been moving from a side to another which shows clearly the experienced changes for each one. The second farm is farm 17, they decreased their family labour units (% FLU) by 70 % during the years of participation in the programme, from (1993 to 2011). As it is shown on figure 5, it has been moving from the right side to the left side of the plan. It has more or less the same trend as farm 16. With respect to farm 13, this farm has been increasing its flock size (NE) too. They have been investing in their irrigated area which has been increasing by about 247 % from (1993 to 2016). It can be seen how it has been moving from the right bottom quarter of the plan to the right above quarter. Its trend gives us an idea about the deep changes which experienced throughout the studied period.

These are large and specialized farms, where it should be noted that the increase in the flock size (NE) has occurred even after the partial decoupling of aids in 2005 and total aids decoupling in 2010. The increase in the farm size has leaded to greater needs for labour, both salaried and family (in some cases these are farms that have passed from the father to several sons, which have increased the flock size, the farm size and have made investments in new facilities). Labour productivity has also increased, with increases in the number of sheep handled by labour man unit (NE/LU).

In general, these farms have increased their productivity, improving their annual fertility and prolificacy, this results in less dependency on subsidies in their total income (%SR/TR). Despite the greater number of lambs produced per ewe, which implies greater needs for purchased feed (concentrates for initiation and fattening), the increase in the size of the total useful agricultural area (TUAA) has resulted in a greater use of the own feed from the agricultural farm and an improvement in forage autonomy. The approach of forage autonomy has been illustrated by Benoit *et al.* (2011), who concluded that the most competitive sheep production systems will be those who will be relatively productive while limiting their extern herd feed dependence by the use of their own forage resources.

Conclusions

A sheep farm supposes the interaction of each of the productive factors and the obligation of the owners is to know the limiting factor or factors, the production level and in this case to know what the cost of overcoming that limitation will entail, and on the other hand what will be the benefits to be achieved.

In addition to the production factors that determine the structure of sheep farms, their management are determined by factors outside the farm, one of the most important is undoubtedly the measures laid down for the sector by the Common Agricultural Policy (CAP). In a production such as sheep meat where subsidies are considered essential for the survival of the farms, the conditions established by the CAP for their reception determine to a large extent the behaviour of livestock farmers in terms of farm management. In the period under study (1993-2016), there has been a shift from 100% coupling of subsidies to the number of heads of the livestock on the farm to partial or total decoupling of subsidies (from 2010 onwards).

In our case it has been studied the evolution of the sheep meat farms to figures out the main factors which have contributed to the trajectories they have followed. And the first element that can be highlighted is that this evolution has been unequal depending on the productive structures and the available labour at every moment and the possibilities of modifying these factors throughout the studied period. To this must be added the role that the different applied agricultural policies measures to the sector, have played in the evolution of sheep meat farms.

Four different trajectories were found in the sample of farms studied. The first trajectory shows farms with long-term and short-term stability, which means that there are no major changes in the factors of production employed (mainly rented pasture and family labour). The smaller TUAA and pasture area means that they have higher feed costs and less food autonomy, which influences their greater dependence on subsidies. They can be described as fragile and non-flexible farms.

The second trajectory groups farms with a stable short-term and moderate long-term development. This group of farms could be more flexible to common agricultural policies. Their higher TUAA and rented pasture area mean that they have lower feed costs and greater feed autonomy, which, together with higher productivity, improves their profitability and makes them less dependent on subsidies than the previous group.

The third group has gathered farms which recorded high instability on the short term and stable evolution on long term. Their dependency to the rented grazing land and the possibility to be able to rent or not lead to their short-term instability. As they were exclusively small family farms, they need to maintain sheep activity to complete their family income and survive. These farms also, were less flexible because of their structural limitation and dependency to subsidies.

The fourth trajectory gathered farms with moderate evolution on short term and unstable on long term. This group has gathered specialized meat sheep farms. Which were very flexible and adaptable to the CAP measures with high index of feed autonomy and less dependency to subsidies.

After analysing the different trajectories, it again becomes evident that, in the long term, improving food self-sufficiency and productivity of sheep is important to improve the profitability of sheep meat farms in Aragon, reducing their dependency on subsidies and improving their viability.

Finally, we can conclude that these results support once more previous results on the diversity of sheep meat systems. It was highlighted the flexibility and the adaptability of each group to the common agricultural policies measures and the limitations which characterized some groups. For this reason, it will be more interesting to take in account this diversity for more targeted policies mechanisms to make these systems less fragile and less depend to CAP subsidies.

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Table 1. Sample description

	Mean	Standard deviation
Number of ewes (NE)	706.24	323.28
Total man labour units (TMLU)	1.62	0.37
Percentage of family man labour units (%FLU)	90.48	21.27
Number of ewes per man labour unit (NE/LU)	442.22	140.36
Number of ewes per hectare of total useful agricultural area (NE/TUAA)	6.99	106.93
Total useful agricultural area (TUAA)	101	107.28
Percentage of irrigated area on the total useful agricultural area (% IrrigA/TUAA)	16.12	22.86
Rented grazing land (RGL) (ha)	634.97	666.22
Percentage of forage area on total useful agricultural are (% FA/TUAA)	25.53	25.66
Percentage of feed costs on total costs (% FC/TC)	72.00	9.40
Percentage of purchased feed costs on total feed costs (%PFC/FC)	72.17	19.87
Percentage of subsidies revenues on total revenues (% SR/TR)	31.92	8.04
Gross margin per total man labour unit (GM/LU)	26932.88	5621.61
Number of lambs' births/present ewe (NLB/PE)	1.59	0.38

Table 2. Component Rotated Matrix

Variables	Factors					Communalities
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
% Family labour units (% FLU)	**0.852**	0.027	-0.095	0.103	-0.002	0.746
% of feed cost on the total cost (% FC/TC)	**0.721**	-0.018	0.173	-0.042	0.094	0.561
Number of ewes (NE)	**-0.526**	0.293	0.238	0.238	0.468	0.695
Total useful agricultural area (TUAA)	**-0.517**	-0.314	0.272	-0.403	0.187	0.638
% irrigated area/TUAA (%IrrigA/TUAA)	-0.035	**0.884**	-0.072	-1.27	0.099	0.814
Stocking density (rate) (NE/TUAA)	0.050	**0.858**	-0.064	0.141	0.006	0.763
Number of lamb births per present ewe (NLB/PE)	0.086	-0.130	**0.835**	0.002	0.019	0.722
% of subsidies revenues on the total revenues (% SR/TR)	0.082	0.014	**-0.800**	-0.045	-0.061	0.652
% forage area in the total useful agricultural area (% FA/TUAA)	0.213	0.065	-0.066	**0.786**	0.072	0.677
% of purchased feed costs on the total feed costs (PFC/FC)	-0.085	0.055	0.408	**0.674**	-0.058	0.635
Rented grazing land (RGL) (ha)	-0.207	-0.204	-0.090	**0.560**	0.411	0,575
Gross margin per labour unit (GM/LU)	0.314	-0.143	0.165	-0.099	**0.755**	0.726
Number of ewes per man labour unit (NE/LU)	-0.178	0.318	-0.084	0.183	**0.749**	0.735
Eigen value	2.334	2.204	1.881	1.310	1.209	
% Variance	17.957	16.953	14.470	10.076	9.302	
% Cumulative variance	17.957	34.910	49.380	59.456	68.759	

Table 3. Evolution of the average data of the four differentiated trajectories.

	Case 1 n=8			Case 2 n=7			Case 3 n=3			Case 4 n=5		
	A*	B**	C***	A*	B**	C***	A*	B**	C***	A*	B**	C***
NE	566,7	755,6	725,3	587,9	737,8	743,0	210,0	441,4	533,5	428,9	802,9	1.070,1
TMLU	1,63	1,65	1,37	1,71	1,46	1,33	1,00	1,23	1,37	1,35	1,50	2,00
% FLU	100,0	100,0	100,0	75,2	94,7	68,5	100,0	100,0	100,0	100,0	92,0	76,7
NE/LU	348,7	457,9	529,9	342,9	506,3	559,3	210,0	357,9	390,4	317,7	535,2	535,1
NLB/PE	1,47	1,63	1,56	1,56	1,67	1,65	1,57	1,40	1,99	1,62	1,65	1,73
% SR/TR	37,3	34,4	38,0	36,1	33,4	35,4	34,7	30,7	36,0	35,0	30,8	29,6
% PFC/FC	70,5	86,0	82,8	63,6	77,7	67,9	60,3	47,7	64,3	58,4	74,4	68,4
%FC/TC	76,6	74,1	74,9	70,7	68,0	67,0	69,0	73,7	75,3	75,0	75,6	71,6
GMLU	22.324	35.494	19.213	24.208	32.360	25.366	13.264	24.358	18.025	23.823	47.626	24.907
% IrrigA/TUAA	23,9	24,3	22,8	6,3	14,3	20,1	11,3	8,7	5,3	6,8	11,8	27,1
TUAA (ha)	37,0	63,0	79,6	106,2	143,6	184,9	22,5	42,3	46,5	149,0	159,2	191,9
RGL (ha)	605,3	449,4	684,8	537,4	1.366,4	1.452,8	198,5	277,0	200,7	436,4	262,2	462,0
% FA/TUAA	13,0	24,6	36,8	23,0	27,4	26,2	22,7	31,7	39,7	8,1	24,2	11,9
NE/TUAA	15,3	12,0	9,1	5,5	5,1	4,0	9,3	10,4	11,5	2,9	5,0	5,9

*A: For each farm, first year of the series (1993, 1995 o 1998). Fully coupled aid.
**B: Year 2005. Start of decoupling of aid.
***C: For each farm, last year of the series (2010, 2011, 2012, 2015 o 2016). Essentially decoupled aid.

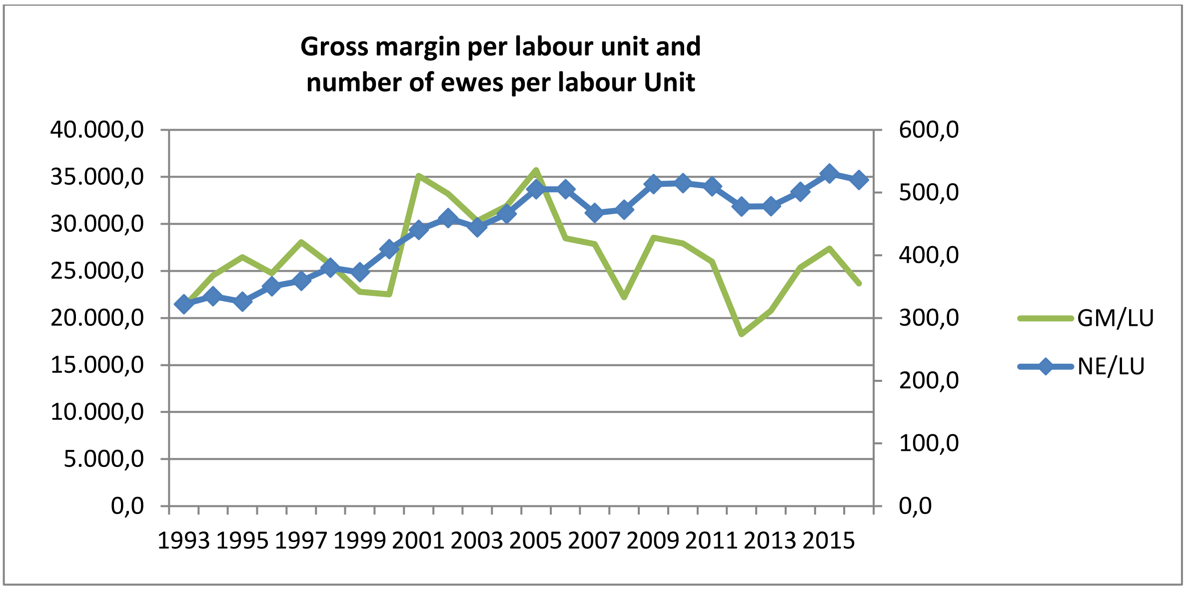

Figure 1. Evolution of the gross margin (GM/LU) and the number of ewes per labour unit (NE/LU)

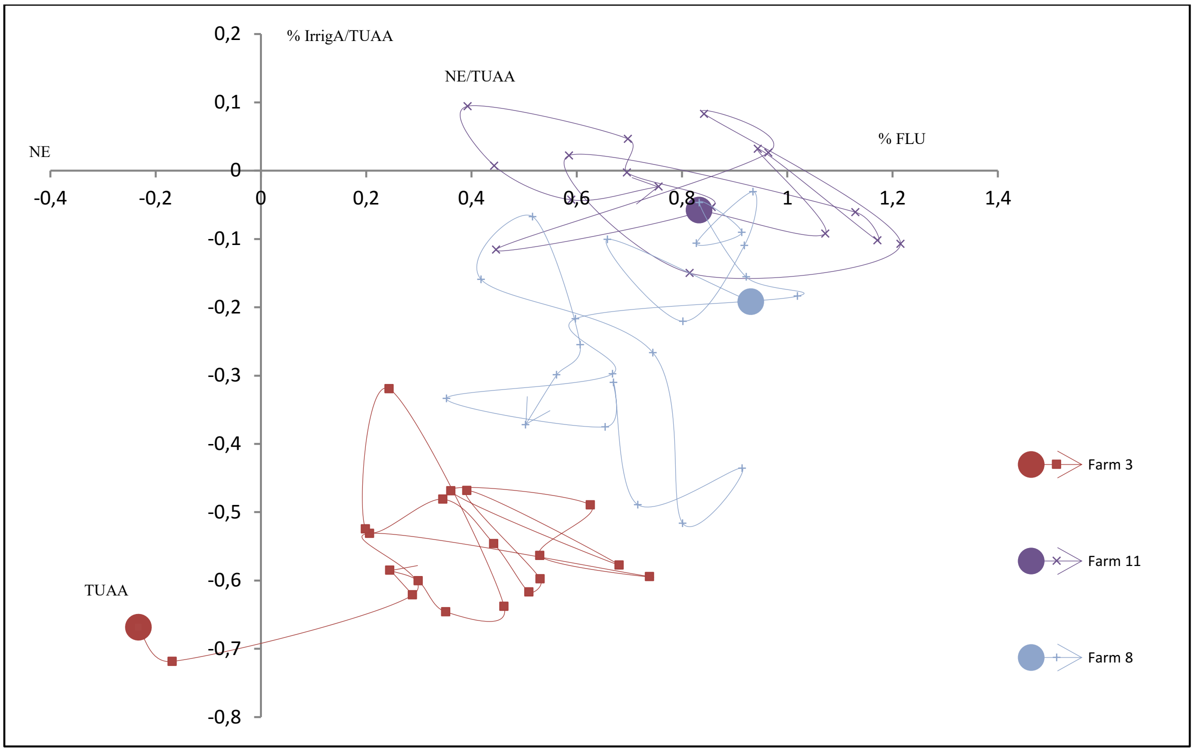

Figure 2. Case 1: Farms (3, 8, 11). Farms with stable evolution over the long term, as well as between successive years.

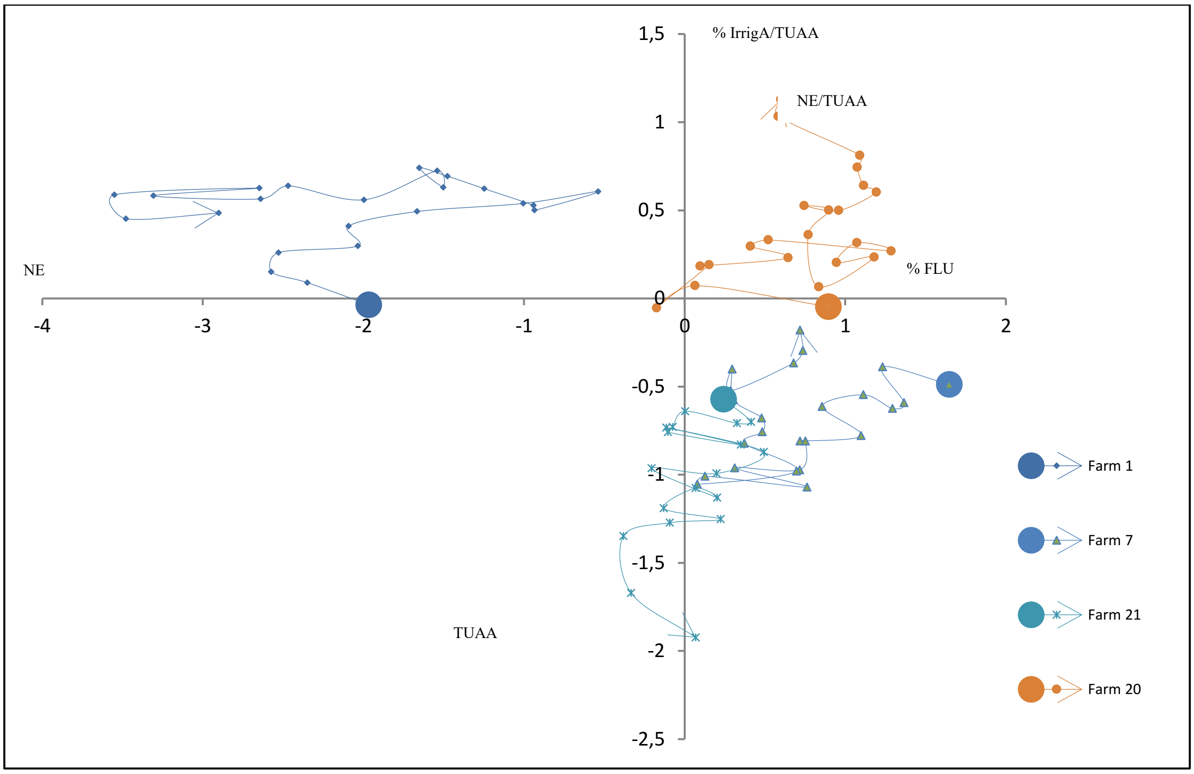

Figure 3. Case 2: Farms (1, 7, 20,21). Farms with stable evolution between successive years and average evolution on the long-term.

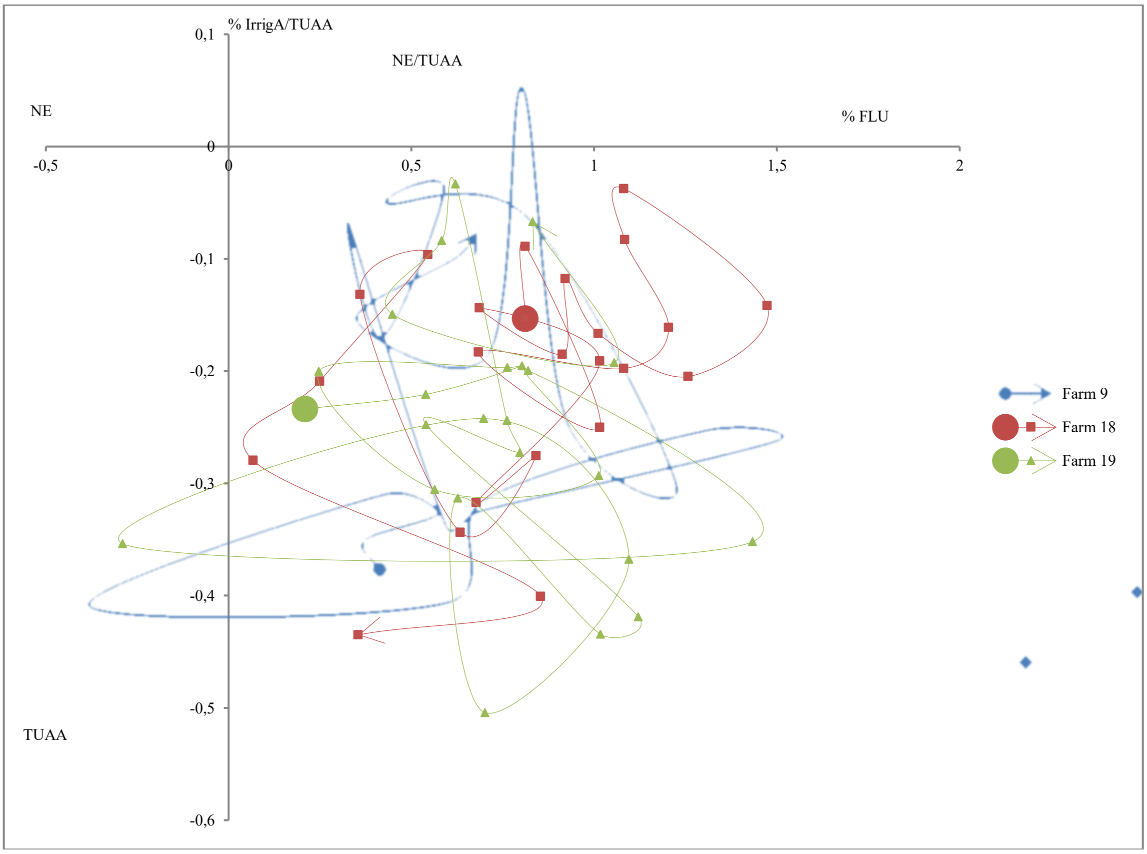

Figure 4. Case 3: Farms (9, 18, 19). Farms with unstable evolution between successive years and stable evolution on long term.

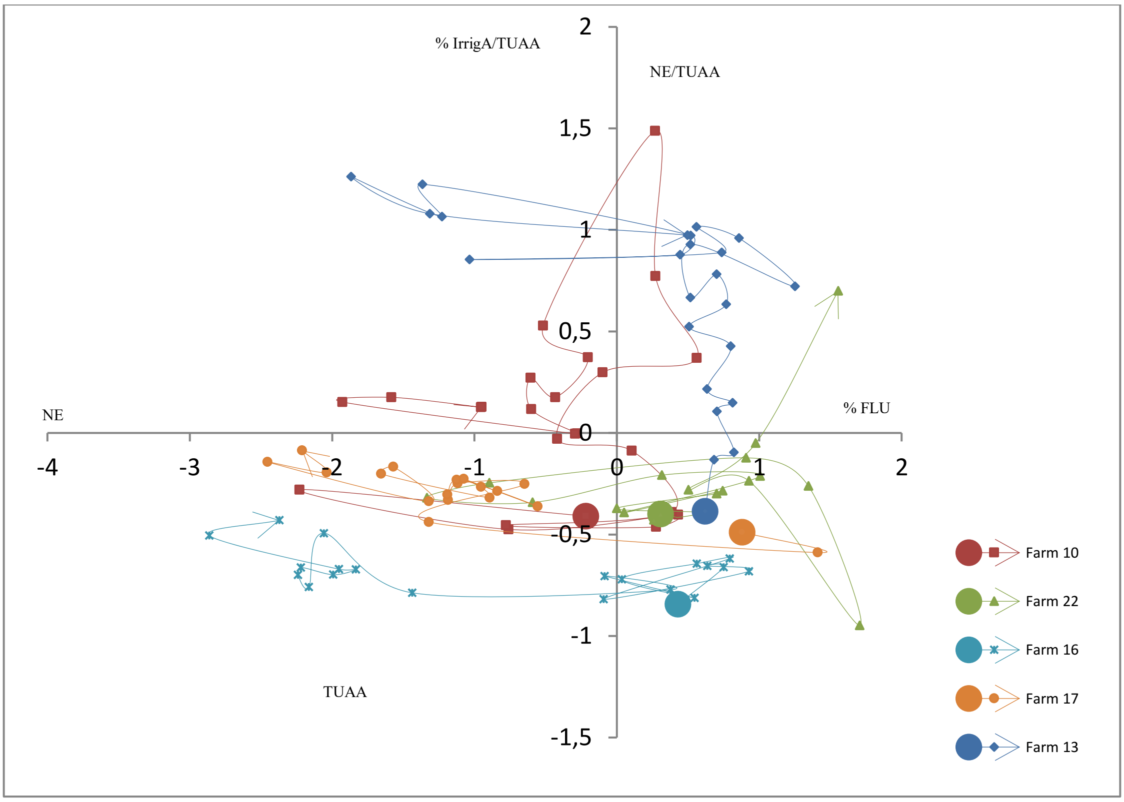

Figure 5. Case 4: Farms (10, 13, 16, 17, 22). Farms with moderate evolution between successive years and unstable evolution on the long term.

5.3 GENERAL DISCUSSION

Sheep farming systems are productive units that use different productive factors and whose combination determines a greater or lesser intensification in the use of the same. These factors can influence positively or negatively the right management within each farm. They can be internal or external to farm which are generally technical, economic, environmental and social (González, 1996; Bernués, 2007; Olaizola et al., 2008; Garcia Martinez, Olaizola and Bernués, 2009; Pfiefer et al., 2009; Evans, 2009; Bernués et al., 2011; Herreo et al., 2014; Toro-Mujica et al., 2015). González, García and Garcáa Arias (2014) classify the factors which affect evolution and changes in agrarian farms in four groups: macroeconomics factors, public policies, localisation and characteristics of the exploitation. Therefore, sheep farms have to adapt sustainable farming systems to be able to remain insuring their critical and irreplaceable role in the overall economic, environmental and social sustainability. In the PhD thesis we have attempted to study mainly the economic sustainability, in fact, in all the presented research papers in the results section in the present work, we have attempted to figure out the relationship between the studied indicators and the economic results of the farms. We have chosen the economic sustainability because it is a very important component of the overall sustainability of the farms. As the general tendency of these farms is dependency to CAP measures mainly those related to subsidies (Milán, Arnalte and Caja, 2003; Weltin, Zasada and Piorr, 2016; Benoit et al., 2020; Soriano Bertolozzi-Caredio, and Bardaji, 2018), only farms with good economic results will be more resilient and more flexible to the changes in the Common Agricultural Policy aids. These farms will be economically independent and develop more viable management systems.

In order to identify the main existing farming systems and identify their drivers of change and to be able to figure out the lack in their management, we have determined a general and four specific objectives. The main objective of the present work is the characterisation and typification of meat sheep farms in Aragon (Spain). Moreover, study farms trajectories and the changes which have occurred in different indicators (structural, technical and economic). In order to answer the principal interrogations of the main objective, it has been determined four specific objectives for which it has been answered the following questions with the results of the four research studies presented in the results section: 1) What are the relevant structural indicators that could influence greater in the economic profitability of meat sheep farms. 2) What are the technical

indicators that could influence greater the economic profitability of meat sheep farms? 3) What is the combination of the structural, technical and economic indicators which could influence significantly the economic profitability of meat sheep farms? 4) What are the trajectories of evolution of the studied meat sheep farms and what are the main drivers of change on the short and long term. And the impact of the Common Agricultural Policy measures on the dynamics of each group of these farms?
In sheep farming there is great variability and heterogeneity in the farming systems due to the limitations that the exploitations have in terms of labour, land, animal breeds, feeding systems, knowledge of management, etc. (Pardos et al., 2008; Benoit et al., 2019 and 2020). Thus, a typification was necessary to address the differences between farms and allows us to better description of the relationship between the different types of the analysed indicators and the economic results in each farm system. The high degree of heterogeneity that exists between the farms that forms a population makes cross-cutting decision-making difficult. In this sense to group farms according to their main differences and relationships, it seeks to maximize homogeneity within groups and heterogeneity between groups (Cabrera et al., 2004). In the present work we have started mainly from the hypothesis of farming systems heterogeneity and diversity, for this reason in each research study, a previous typification has been performed.

The results of the presented four research studies have confirmed once more the diversity of sheep farms which is studied by numerous authors (Hamrouni, 1993; Pardos, 1994; Manrique et al., 1999; Milán, Arnalte and Caja, 2003; Chertouh, 2005; Pardos et al., 2008; Ripoll-Bosch, Joy, and Bernués, 2014; Mena et al., 2016; Benoit et al., 2019 and 2020). When studying the structural typification (research paper 1), it has been resulted two different groups which were mainly differentiated by the size regarding to the different used structural indicators, but there was no difference in the economic results. Thus, farms' size is not always an indicator of better economic results. When studying the technical typification (research paper 2) which studied mainly the reproduction indicators, it has been resulted three independent groups. The three groups were differentiated by the degree of reproduction intensification. By comparing between group 1 and group 2 it has concluded that farms with different reproduction intensification could record almost the same gross margin per labour unit. This result could help to adjust the farms management systems especially those related to reproduction management which could help to decrease the costs and increase the farm profit. And when it has been performed a global typification (structural, technical and economic) (research paper 3) it has been resulted three different groups. Two groups have been characterised by different structural indicators and almost the same reproduction management which had recorded different economic results. It can be concluded that the differences in the structural indicators had more power in the differentiation of the groups in this case. And when the trajectories have been studied (research paper 4), even if the number of the farms in the studied sample was just 23 farms, it has been figured out four (4) different trajectories which could translated in four different management systems conditioned by the different factors previously mentioned.

When it has been explored deeply the predictive impact of the structural, technical and economic studied indicators on the economic results by performing multiple linear regressions, it has been noticed that the adjusted R^2 recorded when it has been used the structural, technical and economic variables for the global typification (research paper 3) were quiet high (between 54 % and 80.9 %) comparing to the adjusted R^2 when just the structural indicators have been used for the typification (research paper 1) (R^2 between 32.7 % and 66.9%) or when just the technical indicators have been taken into account for farms typification (research paper 2) (R^2 between 11.6 % and 24.7 %). It could be concluded that the studied economic results (Gross margin per labour unit) of the farms could be predicted better with the combination of the structural, technical and economic indicators than by each type of indicators used separately. When comparing the resulted R^2 for the structural typification (research paper 1) between the two models when taking into account the family labour and when it has not been taken into account in the economic results, it has been resulted a slight difference in the results for the whole sample (R^2 38% and 36% respectively) and for group 1 (R^2 35 % and 32 % respectively). However, for the second group, which counts with 28.6 % of the whole sample farms, has recorded higher R^2 in both case with and without family labour with a slight difference too (R^2 66.9 % and 61.8 % respectively). It can be concluded that the structural indicators tend to explain the economic results better in big sized farms with more hired labour units, flock size and land size as the case for group 2. For the technical typification (research paper 2) the resulted R^2 were low as it has been mentioned previously. When comparing the whole sample and the resulted three groups, the technical variables have explained better the economic results for the whole sample than the separated group, except for group 1 which has recorded the highest R^2 in the model without subsides are taken into account (24.7 %). When comparing the results of R^2 in the global typification (research paper 3) it has been recorded the highest R^2 comparing to research papers 1 and 2. The global typification explains better the economic results with and without taking into account the subsidies. This latter has been supported by the highest predictive standardised coefficients for structural, technical and economic indicators in the models of the multiple linear regressions.

When analysing the main results of each manuscript it has been concluded that the first structural indicator which has been highlighted was labour intensification or labour productivity which is expressed in number of ewes per labour unit. It has recorded a positive power on the gross margin per labour unit with or without taking into account the cost of family labour in the structural typification (research paper 1). And it has recorded the positive power on the gross margin per labour unit when taking into account the subsidies in the global typification (research paper 3). The highest importance of labour force in general and labour intensification, in particular in extensive sheep farming systems, have been pointed out by numerous studies (Perez, Gil and Sierra, 2003; Benoit and Laignel, 2011, Benoit et al., 2020; Pardos et al, 2008). It can be concluded that labour productivity is a real mean to improve the economic results in sheep extensive farming systems. However, family labour has a positive predictive power on the gross margin per labour unit when the subsidies have been taken into account and when they have not been taken into account (research paper 3). The importance of family labour is not just in improving the economic results of the farms but it has a real role in employing labour outside the large urban centres mean that the sector plays an important role in preventing the depopulation of deprived areas (Pardos et al., 2008). Although these aspects have not been taken into account in the present study, they would fall within the scope of social sustainability.

The stocking rate has recorded a negative power on the gross margin per labour unit when the cost of family labour has been taken into account and when it has not been taken into account mainly for farms with greater agricultural area and greater stocking rate when performing the structural typification (research paper 1). And the same indicator has recorded a negative power in the economic results without subsides for smaller family farms when performing the global typification (research paper 3). Chabosseau et al. (2000) have found that high stocking rates have a negative impact on the economic results of the farms which is explained by the use of more external inputs as fertilisers and concentrate feed without generating more profit. From other side, Ateş et al. (2016) have concluded that high stocking rate resulted in poor sheep performance, particularly in the winter lambing system. Joly et al. (2022) have concluded that cautious stocking rates reducing die-off frequency in a hazardous environment and climate change.

The own forage or fodder crops contribute in improving the economic results (Benoit and Laignel, 2011). However, when the farms are small farms, this could generate more costs and presents a negative impact on the economic results even if these farms were family farms. Cultivating forage crops leads to use irrigation which leads to more costs as labour, energy and fertilisers etc…, and when the farms are small the revenues would not cover the costs. Thus, using the naturel resources is more profitable and sustainable for these farming systems. For larger farms the irrigation percentage has resulted in improving the economic results, because these farms use irrigation for other crops for sale not as smaller farms use irrigation mainly for forage crops (Pardos, 1994). Studying the impact of the feeding costs on the gross margin per labour unit, it has been highlighted the negative impact of this indicator in the economic results for the different resulted groups and when the subsidies were taken into account or not in the studied economic results when performing the global typification (research paper 3). Numerous studies have studied feeding costs and it has been concluded that is a main concern in extensive sheep farming systems and it is classified as the leading risk factor for the viability of these systems (Bertolozzi-Caredio et al., 2021; Benoit et al., 2019 and 2020). According to Benoit et al. (2019), low-productivity but fully self-sufficient fodder livestock systems can achieve excellent economic performance, but require both specific skills and marketing adequacy. Thus, feed autonomy is one of the efficient solutions to maintain and improve the economic results of the meat sheep farming systems. Despite, fodder crops results in better economic results, the use of natural feed resources could be more efficient and more sustainable for the viability of the extensive sheep farming systems (Pardos, 1994; Benoit and Laignel, 2011; Benoit et al., 2020).

Added to the importance of the previous discussed structural variables in improving the economic results of the farms, the production indicators have been resulted very important in improving the economic results of meat sheep farms when performing both the technical and the global typification (research papers 2 and 3). It has been figured out that reproduction intensification is an important mean to improve the economic results (Harrison, 1980; Morel, Kenyon, and Morris, 2004; Keady and Hanrahan, 2006; Benoit and Laignel, 2011; Bohan et al., 2018). It has concluded that the numeric productivity highlighted by the number of sold lambs per ewe per year, has been one of the leading production factors which predict and contribute to better economic results, when subsidies have been taken into account. Its importance is confirmed once more when the subsidies have not been taken into account, with higher standardised coefficients in the resulted regression models mainly for medium and small sized family farms when performing the global typification (research paper 3). Therefore, the number of sold lambs per ewe per year could be an efficient tool to improve the economic results for these farms with structural limitations. These results are consistent with Pardos (1994) where he pointed out that small farms have an intensified reproduction management to alleviate their size limitations. Gazzarin and El Benni (2020) have concluded that productivity, defined as the number of sold lambs per ewe and year, is strongly related to gross margin. Other reproduction indicators as prolificacy and fertility expressed in number of lambings per ewe per year (In research papers 2 and 3) have a great importance in improving the economic results of the sheep farms. Ripoll-Bosch, Joy and Bernués (2014) pointed out that higher prolificacy could mitigate the relative importance of the coupled subventions to farms gross margin. In the case of our study, the mean lambing interval for the whole sample is 342 days, which means that the number of lambings per ewe could be improved. Shortening the lambing interval to 240 days (3 lambings in 2 years), improving annual fertility, resulted in a substantial increase in gross margin (+44%), return on labour (+27%) and income per hectare (+57%) compared to the reference scenario (Gazzarin and El Benni, 2020).

One of the most critical issues that impacts negatively the economic results of meat sheep farms is lambs' mortality rate. It has been concluded that if lambs' mortality is higher than 10 %, the negative impact of this indicator on the economic results is recorded with any sheep farming system (small, medium or large sized farm). Which means that lambs' mortality offers a great possibility to improve the economic results by taking it into account in the management systems of the sheep farms with more adjustment of the different sanitary or prophylactic practices which currently lead to high lambs' mortality rates. According to Pardos (2014), those farms that have a greater reproductive intensification: greater number of lambings per present ewe per year, greater prolificacy, lower lambs' mortality rate and greater number of sold lambs per ewe and year, have the best economic results. Furthermore, adjustments in other reproduction aspects like the number of ewes per stud and the ewe annual rate replacement could contribute in improving the economic results. According to Farell et al. (2020) better economic results obtained with the lower annual ewe replacement rate combined with the higher flock lambing rate.

When studying the trajectories (research paper 4), it has been confirmed the previous conclusions related to the discussed structural, technical and economic aspects of sheep farming systems. The four resulted trajectories have been characterised by greater or lower stability on short or long term throughout the studied period. This diversity in the farms trajectories was the result of the continuous changes in the Common Agricultural Policies mainly the shift from 100 % coupling aids to partial or total decoupling aids (from 2010 onwards). Also, the climate change mainly longue periods of drought has influenced negatively the feeding with natural resources for sheep farming systems. These changes in the Common Agricultural Policy (CAP) measures have influenced directly the management and the decision making of the farms given the dependency of the majority of them to those aids (Pardos et al, 2008; Benoit and Laignel, 2011; Toro-Mujica et al., 2015). The structural limitation and the high feed costs has leaded to fragile and non-flexible farming systems. Thus, it is undisputable that sheep farming systems with greater feed autonomy index and better reproduction results are more flexible, adaptable and resilient systems. Furthermore, these resilient systems could become more profitable and ensure their principal role which is the social, economic and environmental sustainability again.

Finally, with the results of the four presented articles it could answers to the questions related to each specific objectives and to main objective. Despite, it is recommended to carry out an efficiency study for the used sample to figure out with more precision the efficiency of each group of farms.

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CONCLUSIONS

After presenting and discussing the results of the four research papers, developed throughout the present PhD thesis in order to answer the main set up objectives, the main findings and conclusions will be presented as following:

- Extensive meat sheep farming systems in Spain particularly in Aragon region are diverse and heterogeneous from structural, technical and economic point of view. The different performed typification and trajectories followed by the farms have supported this feature of diversity of these extensive sheep farming systems.

- Two main farms groups that differ fundamentally by their size have been resulted from the structural typification. The smaller farms use a higher proportion of family labour and rent less forage area, while the larger ones are more intensive in the use of the labour factor. However, these structural differences do not translate into different economic results, and therefore size is not a determinant of profitability.

- With the technical typification, it has been noticed that the main differentiated factor for the three resulted groups the intensification of the reproduction practices. Furthermore, when relating the studied indicators to the economic results, it has been concluded that different reproduction intensification degrees could lead to almost the same economic results. This result could be important for farms in order to adjust their reproduction practices which help to decrease the costs and increase farms' economic profit.

- The economic results assessed by using the gross margin per labour unit with taking into account the subsidies or not, are better predicted by the combination of the structural, technical and economic indicators than by using them separately.

- When relating the economic results with the structural variables it has been observed that these are related to a greater intensification of labour factor with respect to the number of ewes predict positively economic results with and without taking into account or not both the cost of family labour and subsides in the gross margin per labour unit. Labour intensification has been a key element in maximising labour productivity thus improve the economic results of the farms. With the condition to don't exceed the right number of ewes per labour unit, if not the zootechnical performance of sheep could be affected.

- A higher percentage of use of family labour contributes to better results when it is not remunerated. Family labour has a positive prediction power in improving the economic results both with and without taking into account subsidies. Labour force is very important component of sheep farming mainly family labour. This latter allows maintaining the economic viability of the farms, in a context of high dependency to CAP subsidies.

- In small farms, the best economic results are associated with a greater availability of useful agricultural area, since it is probably a limiting factor. A high stocking rate expressed in number of ewes per hectare of useful agricultural area is related to worse economic results.

- The own forage or fodder crops contribute in improving the economic results. However, the use of natural feed resources could be more efficient and more sustainable for the viability of the extensive sheep farming systems. For larger farms the irrigation percentage has resulted in improving the economic results, because these farms use irrigation for other crops for sale. Small farms use irrigation mainly for forage crops.

- Feeding costs have a negative impact on the gross margin per labour unit, thus on the economic results. This latter has been observed in the different resulted groups and in both cases when the subsidies were taken into account or not. It has been concluded that is a main concern in extensive sheep farming systems and it is classified as the leading risk factor for the viability of these systems.

- The intensification of reproduction practices is an important mean to improve the economic results. It has been concluded that the numeric productivity highlighted by the number of sold lambs per ewe per year has been one of the leading production factors which could improve the economic results with and without taking into account the subsidies. To take full advantage of this possibility of improving the economic results of the farms, it would be necessary to control other parameters that directly affect it, such as lambs' mortality rate.

- The number of sold lambs per ewe and year is tightly linked to other aspects of reproduction intensification, as prolificacy and number of lambings per ewe. These two indicators had a positive predictive power in improving the economic results of the farms. Furthermore, adjustments in other reproduction aspects like the number of ewes per stud and the ewe annual rate replacement could contribute in improving the economic results.

- It has been found four different trajectories of farms after studying the constant sample. After analysing the different trajectories, it again becomes evident that, in the long term, improving feed self-sufficiency and productivity of sheep is important to improve the profitability of meat sheep farms in Aragon, reducing their dependency on subsidies and improving their viability. However, each type of trajectory obeys a different way of adapting to the common agricultural policy measures depending on the limitations presented by the farms of each group. It will be more interesting to take in account this diversity for more targeted policies mechanisms to make these systems less fragile and less dependent on CAP subsidies.

Finally, it can be concluded that having a technical-economic management system makes it possible to figure out which factors condition the results of the farms to a greater extent and the best way to adapt to the constant changes in the environment, which can include climate change or the CAP policy measures

CONCLUSIONES

Después de presentar y discutir los resultados de los cuatro trabajos de investigación, desarrollados a lo largo de la presente tesis doctoral para responder a los objetivos planteados, los principales hallazgos y conclusiones se presentan a continuación:

• Los sistemas extensivos de ganado ovino de carne en España, particularmente en la región de Aragón, son heterogéneos desde un punto de vista estructural, técnico y económico. La tipificación realizada y las trayectorias seguidas por las explotaciones apoyan la diversidad de estos sistemas extensivos de ovino.

• De la tipificación estructural se han obtenido dos grandes grupos de explotaciones que se diferencian fundamentalmente por su tamaño. Las fincas más pequeñas utilizan una mayor proporción de mano de obra familiar y alquilan menos superficie forrajera, mientras que las más grandes son más intensivas en el uso del factor mano de obra. Sin embargo, estas diferencias estructurales no se traducen en resultados económicos diferentes, por lo que el tamaño no es un determinante de la rentabilidad.

• Con la tipificación técnica se observa que el principal factor diferenciador de los tres grupos resultantes fue la intensificación en las prácticas reproductivas. Además, al relacionar los indicadores estudiados con los resultados económicos, se ha concluido que diferentes grados de intensificación reproductiva podrían conducir a similares resultados económicos. Este resultado podría ser importante para que las explotaciones opten por prácticas reproductivas que ayuden a reducir sus costes y aumenten su rentabilidad económica.

• Los resultados económicos medidos a través del margen bruto por unidad de trabajo teniendo en cuenta o no las subvenciones, se predice mejor por la combinación de los indicadores estructurales, técnicos y económicos que con cada grupo de indicadores por separado.

• Al relacionar los resultados económicos con las variables estructurales se ha observado que una mayor intensificación del factor trabajo con respecto al número de ovejas predice positivamente los resultados económicos tanto si se tiene en cuenta como no tanto el coste de la mano de obra familiar, como las subvenciones. La intensificación de la mano de obra es pues un elemento clave para maximizar su productividad y así mejorar los resultados económicos de las explotaciones. No debe excederse no obstante el número correcto de ovejas por unidad de trabajo, de lo contrario podría verse afectado el rendimiento zootécnico de los animales.

• Un mayor porcentaje de utilización de mano de obra familiar contribuye a mejores resultados cuando no es remunerada. El trabajo familiar tiene un poder de predicción positivo en la mejora de los resultados económicos tanto si se tienen en cuenta como no las subvenciones. La mano de obra es pues un componente muy importante de la ganadería ovina, principalmente la mano de obra familiar, que permite mantener la viabilidad económica de las explotaciones, en un contexto de alta dependencia de las subvenciones de la PAC.

• En pequeñas explotaciones, los mejores resultados económicos están asociados a una mayor disponibilidad de superficie agrícola útil, ya que probablemente es un factor limitante. Una alta carga ganadera expresada en número de ovejas por hectárea de superficie agrícola útil se relaciona con peores resultados económicos.

• Los cultivos forrajeros propios contribuyen a mejorar los resultados económicos. Sin embargo, el uso de recursos naturales de alimentación podría ser más eficiente y más sostenible para la viabilidad de los sistemas de la ganadería extensiva ovina. Para las explotaciones más grandes el porcentaje de regadío se traduce en mejores resultados económicos, debido a que estas fincas utilizan el riego para otros cultivos comerciales. En las fincas más pequeñas utilizan el riego principalmente para cultivos forrajeros.

• Los costes de alimentación tienen un impacto negativo sobre el margen bruto por unidad de trabajo, y por tanto sobre los resultados económicos. Ello se ha visto en los diferentes grupos obtenidos y tanto teniendo en cuenta como no las subvenciones. Se ha concluido que es una de las principales preocupaciones en los sistemas de la ganadería ovina extensiva y se clasifica como el principal factor de riesgo para la viabilidad de estos sistemas.

• La intensificación de las prácticas reproductivas es un medio importante para mejorar los resultados económicos. La productividad numérica medida por el número de corderos vendidos por oveja y año es uno de los principales factores productivos que pueden mejorar los resultados económicos con y sin tener en cuenta las subvenciones. Para aprovechar el máximo de esta posibilidad de mejora de los resultados económicos de las explotaciones habría que controlar otros parámetros que le afectan directamente como la mortalidad de los corderos.

• El número de corderos vendidos por oveja y año está estrechamente ligado a otros aspectos de la intensificación reproductiva, como son la prolificidad y el número de partos por oveja. Estos dos indicadores han tenido un poder predictivo positivo en la mejora de los resultados económicos de las explotaciones. Además, los ajustes en otros aspectos de la reproducción como el número de ovejas por semental y la tasa anual de reposición de ovejas pueden contribuir a mejorar los resultados económicos.

• Se han encontrado cuatro trayectorias diferentes de las explotaciones después de estudiar la muestra constante. Tras analizar las distintas trayectorias, se vuelve a evidenciar que, a largo plazo, mejorar la autosuficiencia alimenticia y la productividad de las ovejas es importante para mejorar la rentabilidad de las explotaciones de carne de ovino en Aragón, reduciendo su dependencia de las subvenciones y mejorando su viabilidad. No obstante, cada tipo de trayectoria obedece a una forma diferente de adaptarse a las medidas de política agraria común en función de las limitaciones que presentan las explotaciones de cada grupo. Sería interesante tener en cuenta esta diversidad para implementar políticas más específicas que hagan que estos sistemas sean menos frágiles y menos dependientes de las subvenciones de la PAC.

• Finalmente, se puede concluir que disponer de un sistema de gestión técnico-económico permite averiguar qué factores condicionan en mayor medida los resultados de las explotaciones y la mejor manera de adaptarse a los constantes cambios del entorno en los que se puede incluir el cambio climático o las medidas de la política agraria común.

MAIN FINDINGS AND RECOMMENDATIONS

- The results of the present PhD could contribute into better management systems in extensive sheep farming in Aragon and the results could be extrapolate to other regions of extensive farming systems.

- The study of trajectories has figured out the relationship between the resilient, flexible or sensible systems and the Common Agricultural Policies measures over 24 years. This study could help to understand better the dynamics of extensive sheep farms and the use of its results in improving their adaptability to the changing policies environment.

- New technologies, workshops organised by experts and integrating specialised cooperatives in sheep farming could help farmers to better decision making and improving the structural and technical aspects of their farms, thus alleviating the dependency on the common agricultural aids.

LIMITATIONS

The present research study presents a list of limitations, as any other research study, which could be resumed as following:

- The used data base included mainly the technical economic information, the reason for which it has been focused in these studies on studying the parameters related to the technical and economic indicators for the studied farms. We are aware that a more holistic study including social and environmental indicators would be more interesting and would give more benefit to the area of extensive sheep farming systems references. As the sustainability of the extensive farming systems is dependent on the technical, economic, social and environmental sustainability. However, the performed technical-economic study has a huge interest in understanding the farms dynamics and their evolution in a context of uncertain circumstances mainly economic.

- A technical and economic efficiency study would be a plus for deeper understanding and figuring out the main inputs and outputs which could be adjusted to improve the economic results of the different studied management systems for the studied sample. For the reason of the lack of time, we could not perform this study even if it has been done the statistical analysis.

- When we studied the economic indicators, it has been chosen one cost indicator which was the feeding costs to study, because it represents almost 70 % of the total costs of the farms. It will be more interesting to include other costs indicators in future studies which would give a wider idea how these costs could be reduced.