# The traditional extensive free range pig farm: a sustainable or an endangered production system

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**Abstract**

*The extensive pig production systems located in dehesa ecosystems (rangelands of the southwestern Iberian Peninsula), are considered very important from several points of view. From an economic point of view, Iberian pig sector represents the 14.4% of Total Agricultural Production of the regions where it is located. From an ecological point of view, extensive systems are one of the main factors that contribute to the maintenance of the dehesa agrosilvopastoral ecosystem. Finally, from the social point of view, farms and producers also play an important role in the conservation and development of a less-favored area.*

*Nowadays, the sector is going through a structural crisis that is threatening the subsistence of many farms. The producers are making decisions that may affect the extensive traditional farming systems with the risk that it entails for the environment and for rural areas.*

*This paper analyzes the extensive pig farms located in Extremadura (SW Spain region), identifying the different types of farms and quantifying the productive and commercial parameters that determine technico-economic results which are influencing their sustainability.*

*Data collection was made by surveys conducted on site during 2010 and 2011 to owners and farm managers. Different indicators related to general characteristics of the farm, livestock numbers, labor, intermediate consumption, yields and product marketing were analyzed. These indicators described the whole operation, and they allowed us to identify the best strategies adopted by farmers to adapt themselves to the present market situation.The results show that the best farming strategies are based on mixed farming with beef cattle and Iberian pigs. Also, the choice of acorn fattened pigs has the best economic results, specifically in those farms without sows where only the fattening period with acorns is completed.*

## 1.- Introduction

The dehesa agroforestry ecosystem is characterized by a combination of grazing, woodland and cropping land where different livestock species are raised. These dehesas are the most representative grasslands for the southwest quadrant of the Iberian Peninsula, occupying an area of 5.8 million hectares in Spain and 0.5 million hectares in Portugal. The Spanish region of Extremadura is the main area, with 2.2 million hectares (Joffre et al., 1999). Different breeds of beef cattle, Iberian[1] pig and sheep simultaneously graze pasture and wood resources of this ecosystem for meat production (Pulido et al., 1999).

1 Iberian is the main breed used for extensive pig farming. According to Spanish Regulations all sows must be Iberian purebred while boars can be Duroc-Jersey, Iberian or their crosses.

The Iberian pig sector is one of the most important livestock systems in Extremadura, and it is characterized by its traditional farming system linked to holm and cork oak woodlands. This traditional system can be developed in two ways: outdoor pig fattening (with feedstuff in different paddocks in the field), and acorn pig fattening (pigs eat holm oak acorns and pastures from early November to late February, with approximate 600 kg acorn in this period per hectare (Hernández et al., 2008)). These two fattening systems are regulated by Spanish laws (MAPA, 2007). Farmers may choose one way or the other or both systems at the same time.

In 2010 the production from the pig sector was 253.6 million euros and represented 35% of Extremadura's Animal Production and 14.4% of its Total Agricultural production. These figures make it the most important livestock sector in the region.

The extensive pig sector is facing a severe crisis since 2007. The main causes of this crisis are: current price drop of Iberian pig products, the rising price of cereals and feedstuff and an over-supply in the market. As a consequence, farmers have suffered a decline in their economic results. This situation has prompted an important decrease in extensive pig census form 2007 (2,96 million) to 2010 (1.92 million) according to Ministry of Agriculture data (MAPA 2012)

The objective of this study is to broaden and deepen the knowledge of extensive pig farms in southwestern Spain, establishing a farm typology. The construction of livestock farm typologies is a topic of burgeoning interest in livestock farming systems research. These typologies are constructed for a variety of purposes: (a) to evaluate changing trends in livestock farming; (b) to identify the main constraints on productivity (c) as a basis for identifying "target groups" in development projects; and (d) as a support tool for advisers working with individual farmers, allowing them to assess a given situation by reference to known functional types (Gibbon et al., 1999). Multivariate statistical tools have become a proven and effective method of generating farm typologies from technical and economic data. The variables responsible for the differences between farms are identified by principal component analysis and cluster analysis has been used to establish a classification of homogeneous groups of farms.

## 2.- Materials and Methods

To carry out this work, 63 surveys to pig farm owners and managers where conducted on site from october 2010 to october 2011 collecting data of tha agricultural year 2010-2011. Farms were selected within the geographical area of Extremadura out of 5200 holdings according to the data provided by the Extremaduran Department of Agriculture and Rural Development.

The questionnaire was design taking in account previous work related to iberian pig production systems (Babot, 2008; Caravaca et al, 2007, Daza, 2000) and comprised two principal blocks: a technical part to gather descriptive data on the area, infrastructure, and livestock management regime of the farm), and an economic part to collect data on the intermediate consumption and output generated in the system. From the information gathered directly from the survey different types of variables were generated related to the general characteristics of the farm.

Statistical analyses were split into two stages: first, the identification of the variables that differentiate the farms, and second, the establishment of homogeneous groups of farms in terms of those variables. The techniques used were: in the first stage, principal component analysis (PCA), a multivariate technique based on the elimination of the redundancy involved in dealing with many variables; and in the second stage, cluster analysis to classify the farms into homogeneous segments. The statistical package SPSS (vn. 19.0) was used to perform the analyses.

PCA was applied to reduce the number of variables needed to categorize the farms, using as inputs 39 variables related to land use, stocking rate, and economic and livestock productivity indicators. Bartlett's sphericity test and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were applied to test the validity of the sampling.

K-means cluster analysis has been the method used for grouping the cases (farms). This method is based on the distances between cases in a set of variables. K-means Cluster analysis is a tool for assigning cases to a fixed number of groups whose characteristics are not known yet but are based on a set of specified variables. It is very useful when we want to classify a large number of cases.

This cluster analysis was used to classify groups of farms which were similar to each other but different from others. The objective was to maximize intragroup homogeneity and inter-group diversity. The previous PCA results were used as the input data for the cluster analysis in order to avoid both a large number of variables and the existence of strong correlations between them. Besides reducing the number of variables, the use of the PCA makes standardization of the variables on a common scale unnecessary.

## 3.- Results

### 3.1.-Principal Component Analysis

The PCA produced 9 Principal Components (PC) which are shown in Table 1 ranked by decreasing percentages of the total variance of the model they explained. The total variance explained by these 9 PCs was 68.69% – a satisfactory percentage (Malhotra, 2004).

The final PCs were then defined by using the rotated matrix components. Taking into account the correlations between the PCs and the original variables, we can interpret these selected 9 PCs as follows:

**PC 1: Predominant ruminant species**

This first PC explains 15.13% of total variance and is defined by variables related to the predominant ruminant species of the farm. These variables explain both the mixture in the farm of Iberian pig with cattle and the mixture sheep-Iberian pig.

Within this PC there are variables with positive correlation with the PC, which are related to Iberian pigs and sheep: *Sheep Livestock Unit (LU), Ewe replacement rate, Percentage of autochthonous sheep, Lambs born per ewe, Feedstuffs for sheep and Sheep sales*. There are also variables with negative correlation with the PC related to beef cattle production such as: *Cattle LU, Percentage of autochthonous cattle, Feedstuffs for cattle and Cattle sales*.

Therefore, farms that obtain a high values for this PC are those that raise mainly Iberian pig with sheep while the low values in this PC are those with a mix of pigs with beef cattle.

**PC 2: Land use**

This PC explains 8.78% of total variance. The variables that define it are *the percentage of pasture area without woodland, the percentage of cultivated area (not usable by livestock but used for forage production)*, *the cost of seeds and fertilizers for the cultivated area and the percentage of wooded area*, which has an inverse correlation with the other. This percentage of wooded area is the most related to the PC (0.919). Farms with a higher value on this PC will be those with the highest percentage of land without wooded cover and most cultivated area within the total area.

**PC 3: Type of Iberian pigs raised**

PC 3 explains 7.68% of the total variance. The main variables related to the PC are: *sows replacement rate, percentage of Iberian purebred sows in the farm, the percentage of Duroc purebred sows* in the farm, *number of pig fattened per sow and purchase of piglets for fattening*.

Farms that have a high score on this PC are those that raise sows producing piglets for fattening (outdoor fattening with feedstuff and acorn fattening), and those with lower scores are those that do not raise sows but buy piglets to another farm in order to complete only the fattening period with acorn.

Within this PC, there is a variable related to the percentage of Iberian purebred sows. Most of breeding farms have to raise Iberian purebred sows, as the Spanish Regulation (MAPA, 2007) requires the use of this breed in order to market the final products as Iberian Pork. The percentage of Duroc sows is explained because some farmers raise Duroc females to obtain Duroc Purebred boars for replacement.

**PC 4: Importance of outdoor fattening without acorn**

PC 4 explains 7.56% of the total variance. It has strong positive correlation with the variables: *outdoor fattened pigs sales* (0.754) and *feedstuff for pig fattening* (0.823), and a negative correlation with the variables *calves born per cow* and *subsidies per LU*. Farms with small values in this PC are mainly oriented to cattle production.

**PC 5: Veterinary expenses and farm maintenance**

This PC explained 6.51% of the total variance. The variables with positive correlation are *Maintenance costs per LU and Veterinary expenses per LU*. We can find also negatively correlated variables such as *Total LU* and *Ruminant stocking rate*. Those farms with higher scores in this PC are those with high expenses and low values of LU, that meaning that smaller holdings have higher costs per LU.

**PC 6: Ruminants replacement rate**

PC 6 explains a 6.22% of the total variance. This PC has positive correlation with the variables that affect the *purchase of cattle* (0.836) and *purchase of sheep* (0.886) both for breeders replacement. It has also correlation with the variable *cattle replacement rate* (0.582). Farms that have a high value on this PC are those with higher levels of replacement of the ruminant flocks.

**PC 7: Labour**

This component explains 5.77% of the variance and is positively related with labour variables: *Total AWU (Annual Work Units) per 100 LU* and *Labour Costs per LU*. Those farms with a high value on this PC use more labour per LU and thus have more costs. They are usually small holdings.

**PC 8: Economic results**

PC 8 explained 5.70% of the total variance and it has positive correlation with the variables *Acorn fattened pigs* and *Gross return*, and negative correlation with *Feedstuffs for piglets used for acorn fattening*. Therefore, farms with a higher value on this PC are those that have better economic performance, this being usually due to the sales of acorn fattened pigs.

**PC 9: Rented land**

This last PC explains 5.35% of the total variance and it is correlated with two variables: *Rented area and Rents paid per LU*. These variables explain the percentage of the farm that is owned by the farmer and the annual cost that rentals mean. Holdings that have a high value on this PC are those where an important part of the land is rented, and therefore not owned by the farmer.

Table 1. Principal components selected on the basis of the principal component analysis, eigenvalues, the explained and accumulated variances, and squared multiple correlation coefficients of the indicators with the different PCs

| | **Eigenvalues**<br>**% explained variance**<br>**(%accumulative variance)** | **Indicators and correlations with the PC** | |
|---|---|---|---|
| **PC 1** | 5.748 | Cattle LU (%) | -0.726 |
| | 15.127 | Sheep LU (%) | 0.893 |
| | (15.1%) | Autochthonous cattle (%) | -0.485 |
| | | Ewe replacement rate (%) | 0.557 |
| | | Autochthonous sheep (%) | 0.715 |
| | | Lambs born per ewe | 0.799 |
| | | Feedstuffs for cattle (%) | -0.476 |
| | | Feedstuffs for sheep (%) | 0.709 |
| | | Cattle sales (%) | -0.720 |
| | | Sheep sales (%) | 0.881 |
| **PC 2** | 3.337 | Wooded area (%) | -0.919 |
| | 8.781 | Area pasture without woodland (%) | 0.821 |
| | (23.9%) | Cultivated area (%) | 0.643 |
| | | Cost of seed and fertilizer for the cultivated area (€/LU) | 0.781 |
| **PC 3** | 2.917 | Sows replacement rate (%) | 0.438 |
| | 7.676 | Iberian purebred sows (%) | 0.847 |
| | (31.6%) | Duroc purebred sows (%) | 0.413 |
| | | Number of pig fattened per sow | 0.610 |
| | | Purchase of piglets for fattening (%) | -0.850 |
| **PC 4** | 2.872 | Calves born per cow | 0.425 |
| | 7.559 | Feedstuffs for fattened pigs (%) | 0.823 |
| | (39.1%) | Outdoor fattened pigs sales (%) | 0.754 |
| | | Subsidies per LU (€/LU) | -0.455 |
| **PC 5** | 2,474 | Total LU | -0.687 |
| | 6,510 | Maintenance costs per LU (€/LU) | 0.566 |
| | (45.7%) | Veterinary expenses per LU (€/LU) | 0.679 |
| | | Ruminant stocking rate (LU/ha) | -0,433 |
| **PC 6** | 2.362 | Cattle replacement rate (%) | 0.582 |
| | 6.216 | Purchases of cattle (€/LU) | 0.836 |
| | (51.9%) | Purchases of sheep (€/LU) | 0.886 |

| | | | |
|---|---|---|---|
| **PC 7** | 2.194 | Total AWU per 100 LU (€/LU) | 0.831 |
| | 5.774 | Labor cost (€/LU) | 0.762 |
| | (57.6%) | | |
| **PC 8** | 2.164 | Feedstuffs for piglets (%) | -0.763 |
| | 5.696 | Acorn fattened pigs sales (%) | 0.476 |
| | (63.3%) | Gross return | 0.703 |
| **PC 9** | 2.034 | Rented area (%) | 0.872 |
| | 5.352 | Paid rent per LU (€/LU) | 0.890 |
| | (68.7%) | | |

### 3.2.- Cluster analysis

The cluster analysis yielded the most significant results for a six-cluster solution. Six clusters (or groups) consisted of 17, 5, 8, 3, 22 and 8 farms. These groups were compared by an ANOVA. Table 2 lists the different groups of the set of indicators. The characteristics distinguishing the six groups are the following:

**Group 1: Traditional Holdings with acorn pig fattening**

This group of 17 holdings represents 26.98% of the farms. It has an average of 174.18 LU (48.02% of these LU are cattle and 12.57% sheep). A total 13 farms within this group have swine, cattle and sheep. Land use in this group is characterized by a high level of rented land (47.05% on average) and therefore they have higher paid rent per LU. These farms are located in most of its wooded area (92.70% on average). With regard to pigs they have a low average number of pigs fattened per sow (5.64), because this group is oriented to acorn fattened pig production, thus meaning that the rest of the production is sold as piglets (one month old and 25kg) just after weaning that go directly for slaughter.

Therefore in this group, the acorn fattened pig sales represent the 50.74% of the total livestock sales. Regarding the gross return, this group has an average of 205.63 €/LU, the subsidies perceived are 131.29 €/LU on average.

**Group 2: Outdoor pig fattening farms with cultivated land**

This group represents 7.94% of the sample and is composed of 5 farms with heterogeneous livestock. The farms in this group are characterized by a large area (406.01 ha) and a high percentage of cultivated area (42.92% of the total land), results prove that montanera fattening pigs need to consume grass and it could be sowed to facilitate forage availability (Rodríguez-Estévez 2009). They have a high average of LU (316.5 LU).

The gross returns of this group amounted to 209.7 €/LU, and 161 € were subsidies. The most important cost in this group is feedstuffs for outdoor fattened pigs (79.12%). The result is a high average number of pigs fattened per sow (11.31). Related to this figure, the sales of outdoor fattened pigs represent 45.49% of the total sales of the farms.

**Group 3: High ruminant stocking rate farms**

This group has 8 farms and represents 12.7% of the total sample. It has an average of 182.32 LU of which 48.39% are cattle and 11.44% are sheep. This group has the highest ruminant stocking rate (0.84 LU/ha) in a quite small area (176.62 ha).

Regarding beef cattle farming, this group has a high cattle replacement rate (22.39%). The average cost of feedstuffs for cattle is the highest (12.97%) due to the above mentioned stoking rate.

Compared to group 1, this group also has a high percentage of sales of acorn fattened pigs, but with less Gross return (134.15 €/LU). The subsidies for sheep and cattle amount to 109.53 €/LU.

**Group 4: Small farms with poor economic results**

This is the smallest group, and represents 4.76% of the sample (3 farms). The farms of this group are the smallest of the sample, with an average of 76.89 LU in 97 ha of land. The land is mainly wooded area (92.86% of the farms). This group of farms has costs in feedstuffs only for feeding sows (and boars) and piglets prior to fattening period (they do not expend anything for ruminants). In those farms there is no cost in ruminant feedstuff. They have the highest level of labour working in the farm and also the highest maintenance costs and veterinary expenses per LU. The cost of labor is also the largest of the six groups (116 € / LU). As a result those farms present a negative gross return of -143.67 €/ LU on average.

**Group 5: Beef cattle and pig farms**

This group is the biggest, with 22 holdings and represents 34.92% of the total sample. Within this group, 15 farms breed cattle and pigs and another 4 farms breed only cattle and buy piglets to other farms in order to complete the acorn fattening period. This is the group with the largest farms in terms of LU (412.93 LU on average) and most of them are cattle LU (45.04%)

This group, unlike the others, is mainly dedicated to cattle and outdoor fattening pigs, so there is a lesser production of acorn fattened pigs. The main costs are referred to the feedstuffs for outdoor pigs (with 64.91% of the total). Finally, regarding the economic results, although they have profits, these are the smallest when compared to the other clusters (Gross returns 91.96 €/LU).

**Group 6: Acorn fattening pigs farm without reproducing.**

It represents 12.7% of the total sample. The farms included raise acorn fattened pigs born in other farms. They just buy the piglets to fatten them later. Almost two thirds of these farms also raise cattle, thus making this cluster to reach the highest rate of gross return of all groups (310.46 €/LU). These farms do not have major costs, neither for breeding and feeding in the first months of life of the piglets and or labor costs, and are thus less likely to be affected by an increase in feedstuff prices. . This group has the highest percentage of sales in acorn fattened pigs (59.69%) and the average amount of subsidies is 163.26 (€/LU) (cattle subsidies). Dependence on subsidies is higher in the beef-cattle farms than with other livestock types. (Gaspar et al 2008).

Table 2. Means of indicators from the ANOVA according to their membership to *a group.*

| Variable | Grup 1 (n=17) | Grup 2 (n=5) | Grup 3 (n=8) | Grup 4 (n=3) | Grup 5 (n=22) | Grup 6 (n=8) | F |
|---|---|---|---|---|---|---|---|
| Total LU | 174.18 | 316.5 | 182.32 | 76.89 | 412.93 | 185.4 | 6.582* |
| Cattle LU (%) | 48.02 | 23.95 | 48.39 | - | 45.04 | 63.79 | 2.883* |
| Sheep LU (%) | 12.57 | 25.84 | 11.44 | 13.79 | 9.17 | 9.92 | 0.441 |
| Ruminant stocking rate (LU / ha) | 0.47 | 0.41 | 0.84 | 0.08 | 0.66 | 0.59 | 4.224* |
| Total area (ha) | 280.94 | 406.01 | 176.62 | 97.01 | 386.72 | 245.25 | 1.701* |
| Rented area (%) | 47.05 | 28.89 | 16.73 | 33.33 | 10.55 | 25 | 1.972 |
| Wooded area (%) | 92.7 | 8.32 | 83.49 | 92.86 | 94.26 | 99.63 | 43.457* |
| Area pasture without woodland (%) | 5.71 | 72.18 | 11.54 | 7.14 | 5.4 | - | 20.098* |
| Cultivated area (%) | 1.45 | 42.92 | 2.25 | - | 12.8 | 1.31 | 8.696* |
| Sow replacement rate (%) | 18.2 | 17.55 | 48.55 | 34.52 | 14.96 | - | 3.873* |
| Iberian purebred sows (%) | 93.27 | 99.35 | 100 | 100 | 80.19 | - | 16.839* |
| Duroc purebred sows (%) | 0.84 | 0.65 | - | - | 1.63 | - | 1.733 |
| Number of pig fattened per sow | 5.64 | 11.31 | 11.2 | 5.21 | 7.34 | - | 4.338* |
| Cattle replacement rate (%) | 8.48 | 4.37 | 22.39 | - | 6.03 | 5.45 | 4.558* |
| Autochthonous cattle (%) | 29.36 | 13.07 | 2.68 | - | 20.39 | 27.94 | 0.943 |
| Calves born per cow | 0.77 | 0.62 | 0.61 | - | 1 | 0.84 | 1.171 |
| Ewe replacement rate (%) | 1.86 | 3.54 | 5.01 | - | 3.79 | - | 0.948 |
| Autochthonous sheep (%) | 11.76 | 78.6 | 28.77 | 33.33 | 27.27 | - | 2.880* |
| Lambs born per ewe | 0.8 | 1 | 0.99 | 0.91 | 0.92 | 0.75 | 0.947 |
| Feedstuffs for cattle (%) | 7.96 | 2.66 | 12,97 | - | 9.19 | 6.32 | 1.323 |
| Feedstuffs for sheep (%) | 7.21 | 8.09 | 6,13 | - | 7.56 | 25.36 | 0.552 |
| Feedstuffs for sow (%) | 9.52 | 4.19 | 6.07 | 16.53 | 9.23 | 6.07 | 0.779 |
| Feedstuffs for piglets (%) | 7.7 | 5.94 | 8.01 | 41.62 | 9.11 | 11.41 | 5.965* |
| Feedstuffs for fattened pigs (%) | 67.61 | 79.12 | 66.81 | 41.84 | 64.91 | 50.84 | 0.8 |
| Cost of seed and fertilizer for the cultivated area (€/LU) | 0.59 | 16.02 | 0.52 | - | 1.25 | 0.55 | 8.037* |
| Maintenance costs per LU (€/LU) | 33.63 | 45.16 | 19.13 | 72,98 | 24.67 | 24.2 | 1.699 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Veterinary expenses per LU ( €/LU) | 25.06 | 20.37 | 12.4 | 46,06 | 16.77 | 25.96 | 2.939* |
| Paid rent per LU (€/LU) | 75.84 | 18.15 | 27.87 | 14,06 | 13.39 | 6.48 | 3.739* |
| Total AWU per 100 LU (€/LU) | 0.33 | 0.61 | 0.41 | 1.8 | 0.61 | 0.56 | 4.252* |
| Labor cost (€/LU) | 53.65 | 102.09 | 55.37 | 116.25 | 85.85 | 64.25 | 1.836 |
| Purchases of piglets for fattening (€/LU) | 201.87 | - | 3.34 | 36.94 | 38.76 | 152.81 | 3.738* |
| Purchases of cattle (€/LU) | - | 22.32 | 18.46 | - | 15.85 | - | 0.117 |
| Purchases of sheep (€/LU) | - | - | 12.64 | - | 1.27 | - | 31.134* |
| Cattle sales (%) | 14.31 | 11.9 | 16.61 | - | 17.85 | 15.87 | 1.794 |
| Sheep sales (%) | 21.17 | 21.27 | 8.82 | 21.89 | 11.35 | 24.44 | 1.077 |
| Outdoor fattened pigs sales (%) | 13.78 | 45.49 | 23.64 | 51.61 | 46.04 | - | 5.237* |
| Acorn fattened pigs sales (%) | 50.74 | 21.34 | 50.92 | 26.5 | 24.76 | 59.69 | 6.412* |
| Subsidies per Lu (€/LU) | 131.29 | 161 | 109.53 | 73.62 | 69.56 | 163.26 | 3.348* |
| Gross return | 205.68 | 209.7 | 134.15 | -143.67 | 91.96 | 310.46 | 6.905* |

*p<0,05

**5.- Conclusions**

In this study 63 dehesa farms were classified according to 9 Principal Components related both to livestock species bred, to their level of intensification and also to technical-economic characteristics. These farms are grouped according to their profitability. Due to the increasing cost of feed for pigs, pig farms with the highest number of outdoor fattened pigs pay lower yields than those holdings that raise acorn fattened pigs. As acorn fattening uses feedstuff produced directly by the ecosystem, it does not generate feeding costs, bearing in mind that acorn fed pork reaches a higher price, linked to the higher quality of these products.

Mixed pig-beef farms have shown better economic results because pigs can use the acorns while livestock uses the pasture, thus increasing the total production of the farm without increasing its dependence on external resources. It also must be taken into account that beef farms receive EU's subsidies, thus being an extra income for the farm.

Within the pig farms, it can be observed that those farms oriented to raise acorn fattened pigs born in other farms do not have to face problems related to feedstuff price fluctuations and therefore show a better performance as they do not haveto bear the cost of feeding either the sows and the piglets.

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