LIVESTOCK VALUATION: AN ASSESSMENT MODEL BASED ON SOW AGE

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ABSTRACT

Food supply in Europe is based on the consumption of meat – of which pork is the most consumed. The livestock sector represents some 40% of total agricultural production. Livestock farms need tools for business management and valuation in order to make business productivity estimates and determine compensation, as well as calculate average and marginal costs. Pig farmers need to determine the optimal time for culling a sow: meaning that for livestock depreciation it is necessary to determine the value of sows depending on their age. In this study, a model is shown for valuing a sow according to its productive life and net present value generated. In the same way as any asset in a production process, the economic value of a sow should be estimated by its contribution to the process of generating future profits. The distribution of costs depends on the size of the farm, and so three sizes of farms are considered: fewer than 250 hybrid sows; 251 to 500 sows; and more than 500 sows. The economic values of the sows were obtained according to their age and number of farrowing. The models show variations between differently sized farms.

Keywords: evaluation, breeding, pig farm management, Net Present Value.

INTRODUCTION

Many nations were based on agriculture in terms of contribution to the gross domestic product (GDP) until the mid-twentieth century. Among them was Spain, where agriculture employed up to 60% of the workforce and contributed almost 50% of GDP at the beginning of last century. The farming sector currently suffers continuous production losses in developed economies, but remains essential in most economies. The agricultural sector represents around 2.5% in Spain for 2015 (INE, 2015).

The livestock sector is especially important and contributes around 40% of total Spanish agricultural production – this share remaining virtually unchanged since the 1960s. The importance of meat production is reflected in the consumption of fresh meat and processed meats, these products being the largest item in the shopping basket of Spanish consumers according to the National Institute of Statistics (2015). Specifically, of the nearly €68 billion spent on food by Spanish households, 22.7% was spent on meat and derivatives. This is far more than other products making up the basket of Spanish consumers, such as fish (13.1%), dairy products (12.2%), or fresh and processed fruit and vegetables (16.9%).

The Eurobarometer Qualitative Studies on Well-Being (2013) show that food in Europe is bases largely on the consumption of farmed animal meat – pork being one of the most important contributors. And according to EUROSTAT data for 2015 the ranking for meat production in Europe is: Germany with pork production almost 50% of total production (5.474

million tons); Spain (3.431 million tons); and France (1.939 million tons). Chicken is the second most popular meat (between one and two million tons), with Turkey being the main European producer. Beef is in third place (representing one-third of the volume of pork) with production led by France and Germany. Fourthly, and of much lesser importance with 2% of total production, is sheep and goats – with the UK and Spain responsible for over half of this production.

Another important aspect in livestock production is legal and health aspects influence it. European legislation on food safety, animal welfare, and traceability is especially important. This has generated an extensive literature from various food producing countries: Colombia (Cardona et al. 2008); France (Noblet and Jagelin-Peygaud 2007); and Mexico (Dominguez-Viveros et al. 2013). Studies have also been made on factors affecting the operation of livestock farms – such as: production risks; price change risk; the effect of new technologies; and relevant legislation or consumer preferences (Kuethe and Morehart, 2012).

A key aspect that worries the sector and farmers in particular, is livestock mortality. Many analyses have been made of piglet mortality (Chagnon et al., 1991), sow mortality when weaning (Koketsu et al., 2006; Sasaki and Koketsu, 2008), or factors affecting the longevity of sows (Engblom et al., 2008). In all these cases, special references are made to sows. Koketsu (2005) relates farm efficiency and the age-structure of the sows.

Pig farms need business management tools. These tools enable them to manage their finances and take decisions efficiently (Fenollosa and Guadalajara, 2007). We found several studies that refer to costs in pig farms (Region I.T.H.O., 1995; Fowler, 2009, Rouco and Muñoz, 2006; Haxsen, 2008), investment analysis (Rouco and Muñoz, 2006; Bohling et al 2012), and risk (Scott et al 2013), as well as studies on price fluctuations (Rouco and Muñoz, 2006).

Agricultural business management requires asset valuations, as well as valuations during the various stages of livestock processing. Various difficulties exist when applying valuation techniques for perishable goods and livestock. Breeding and rearing are key production factors in pig farms. Traditionally, economic valuation is undertaken in the livestock sector with a view to compensation calculations, business development estimates of productivity, or calculating average and marginal costs.

For decision-making and the economic management of a farm, it is essential to have a specific methodology for valuing breeding animals in accordance with their age. The theoretical and practical difficulties in the application of economic valuation methods are obvious. There are few tested valuation methods for farm animals that can be applied, although valuations of live animals have been made in the sector since animals have been traded in markets. Sabata (2008) concluded that one of the problems to be solved in the pig sector is livestock depreciation, and that it is necessary to determine the value of a sow depending on her age in order to determine the optimal time for culling.

The importance of the animal breeding factor contrasts with a lack of pricing models to help market players, pig farm managers, and even insurance companies value livestock, and so improve corporate governance and make efficient decisions. There is no methodology for the economic valuation of livestock. In classic works on farming valuation, livestock is valued at the cost of production (sum of costs necessary to maintain the animal and age relative to breeding production), or at the sale price. Salazar (1986) distinguishes between the real value of livestock and market price. A methodology for valuing dairy cattle has been established (Rodriguez, 1979). Pizarro and Salazar (1986) described the market value of livestock, production costs, and market capitalisation as part of livestock valuation methods. Alonso et al. (1995) considered that livestock should be valued at market price.

Livestock insurance places a unit value on animals. This value is often declared by the insured (depending on the animal and age) within a maximum and minimum established by a state agency. Such valuation is performed by applying a coefficient to determine the limit value for compensation at the time of a loss (Order AAA/2521/2013 in the Spanish Gazette (BOE) 13 January 2014).

The importance of the pig sector and the essential reproductive function of sows contrasts with the scarce literature available on the subject. This study aims to develop a theoretical model of sow valuation by age (in days) as a first phase. In subsequent phases, the corresponding validation will be made, as well as a curvilinear adjustment, using the days of reproductive life as an independent variable. Our interest is focussed on pig farms and breeding sows because their correct valuation can help generate significant improvements in efficiency and business management. This approach will make it possible to establish the value of sows at any stage of their lives. The size of the farms is also considered in the valuations.

In this study, the European and Spanish regulatory standards published by the Spanish Foundation for the Development of Animal Nutrition (FEDNA in Spanish) (De Blas et al. 2013) are applied with respect to feeding.

MATERIALS AND METHODS

The main objective was to determine the value of a sow at a given moment of its life. Stalder et al. (2004) evaluated the longevity of sows relative to net present value (NPV) in a closed cycle with gilts in segregated early weaning. Pérez-Salas and Segura (2005) started with the same idea and developed a valuation model for dairy cattle that valued cattle in the context of company management. An economic feasibility study of pork production was used to produce a tool to help decide if it is appropriate to expand production given low taxes in specific regions (Zavala-Pineda et al. 2012; Caballer, 2008).

The economic value of an asset in a production process should be valued for the contribution to future profits generated by its participation in the process, as determined by equation (1):

$$V_i = \int_i^N B_i e^{-rt} dt \qquad (1)$$

Where V_i = value of the sow at time i; B_t = profit generated by the sow at time t; N = useful life of a sow; r = immediate discount rate.

Considering the patterns of pig production, the previous model could be simplified by establishing separate periods for calculating profits, with the equation (2):

$$V_i = \sum_{j=i+1}^{N} \frac{B_j}{(1+r)^{j-i}} \qquad (2)$$

Where V_i = value of the sow in a productive period i; B_j = expected profits in the productive period j; N = number of productive periods; and r = discount rate for the period.

Profits are income minus costs:

$$B_j = I_j - G_j \qquad (3)$$

Where I_j = income attributable to a sow in the period j; G_j = total costs attributable to the sow in period j.

Income and costs attributable to a sow depend on piglet production. The variation of this parameter over the sow's useful life determines the variation in profits and thus the value of the animal throughout its life.

Sow valuation: estimated income and costs

The hypothesis is that income and costs are determined by farrowing. Formulas are established for income and costs, as detailed below:

a) Income per farrowing: income arises from the sale of piglets and the culled sow as shown in equation (4).

$$ITC = \sum_{i=1}^{8}((\ln p_i \times (1-ml_i) \times pld) + (pcd \times ppvcd \times (1-mc_i)) \quad (4)$$

Where ITC = total income for each sow (€), $\ln p_i$ = number of piglets per farrowing i; ml_i dead piglets per farrowing i, times one; pld = weaned piglet price (€/ud); pcd = dressed sow weight (kg); $ppvcd$ = culled sow liveweight (€/kg); mc_i = sow mortality during farrowing i, times one.

b) Farrowing costs: costs are based on feed costs measured as kilocalories of metabolisable energy per kilogram (kcal ME/kg). Piglet feed costs and sow feed costs are differentiated with pregnancy phases, lactation, and the weaning-mating period taken into account – see equation (5).

$$CTC = CTG + CTL + CTDC + CTLE + CTD \quad (5)$$

In equation (6) total pregnancy costs are defined CTG:

$$CTG_{ij} = \frac{\left(\sum_{i=1}^{8}\left(\sum_{j=\max(ed,(i-1)\times 144+1)}^{114+(i-1)\times 144} \frac{104.5 \times PV_i^{0.75} + 22.807 \times \ln p_i \times kgl + 1.557}{PGC} \times cpcg\right) \times (1-mc_i)\right)}{rctsca} \quad (6)$$

Where

CTG_{ij} = total mating costs for i and j days of gestation (€), ed = sow age (days); $PV_i^{0.75}$ = mating sow liveweight i; $\ln p_i$ = number of piglets per farrowing i; kgl = kg piglet (kg); PGC = sow gestation feed (kcal EM/kg); $cpcg$ = cost of sow gestation feed (€/kg); $rctsca$ = ratio of total costs over feed costs.

Equation (7) shows total weaning costs CTL:

$$CTL_{ij} = \frac{(\sum_{i=1}^{8}(\sum_{j=\max(ed,(i-1)\times 144+115)}^{139+(i-1)\times 144} \frac{112\times PV_i^{0.75}+1268.32\times mld_i-3275}{PLC}\times cpl)\times(1-mc_i))}{rctsca} \quad (7)$$

Where CTL_{ij} = total sow mating costs i and j weaning days (€); mld_i = average number of weaning piglets per farrow i; cpl = weaning sow feed costs (€/kg); PLC = weaning sow feed (kcal EM/kg).

Equation (8) shows total weaning-mating costs, CTDC:

$$CTDC_{ij} = \frac{(\sum_{i=1}^{8}(\sum_{j=\max(ed,(i-1)\times 144+140)}^{144+(i-1)\times 144}(pdc\times cpcg)\times(1-mc_i)}{rctsca} \quad (8)$$

Where CTDCij = total sow costs for weaning-mating i and j weaning-mating days; pdc = weaning-mating sow feed (kg); $cpcg$ = gestation sow feed costs (€/kg).

Equation (9) shows total piglet costs CTLE:

$$CTDC_{ij} = \frac{(\sum_{i=1}^{8}(\sum_{j=\max(ed,(i-1)\times 144+128)}^{139+(i-1)\times 144}\ln p_i\times(1-ml_i)\times cpl_i\times cupl}{rctsca} \quad (9)$$

Where $CTLE_{ij}$= total piglet costs for farrowing i and j weaning days (€); mld_i= average number of weaning piglets per farrowing i; ml_i= piglet mortality during farrowing i, times one; cpl_i = feed consumption of piglets from farrowing i (kg); $cupl$ = unit cost of piglet feed (€/kg).

And finally, total cull costs, CTD, in the equation (10).

$$CTD = \frac{(\sum_{j=1152}^{11808} pdc \times cpcd \times (1 - mc))}{rctsca} \quad (10)$$

Where CTD = total sow cull costs (€); pcd = cull sow feed (kg); $cpcd$ = weaning-mating sow feed (kg).

Model testing

The value of a sow was calculated in relation to farm size to test the model. The starting point was current product prices and other factors – and the results were compared to market sources (value of a replacement hybrid sow and cull value).

The hypothesis for the validation of the model is: productive life of a 250-day old sow; 150 kg liveweight and mated; gestation period is 114 days, average 25-day weaning period, and weaning-mating period of five days on average. Eight farrowings were considered. After the eighth farrowing, a fattening period of 28 days was considered before the sow was culled (220 kg liveweight). The proposed model values the sow for a period of between 1 and 1180 days.

Data was provided by PigCHAMP, a Spanish pig-farming company, for the years 2005-2011. The data was grouped into farms of three sizes: less than 250 sows; between 251 and 500 sows; and more than 501 sows. The number of sows analysed for farms with less than 250 sows was an average of 5088 for the first eight farrowings – (varying between 7746 sows for the first farrowing and 2209 sows for the eighth farrowing). For farms of between 251-500 sows, the average census was 32,055 sows (varying between 51,105 for first farrowing and 11,833 for eighth farrowing). For farms with more than 501 sows, the average census was 57,465 sows (varying between 96,072 for first farrowing and 18,273 for the eighth).

Mortality according to farm size was variable, farms with less than 250 sows suffered a mortality of between 3.61% and 4.09%. In farms of between 251 to 500 sows, the rate was 2.68% and 3.43%. Finally, mortality in farms with more than 500 sows was similar to medium-sized farms (Figure 1).

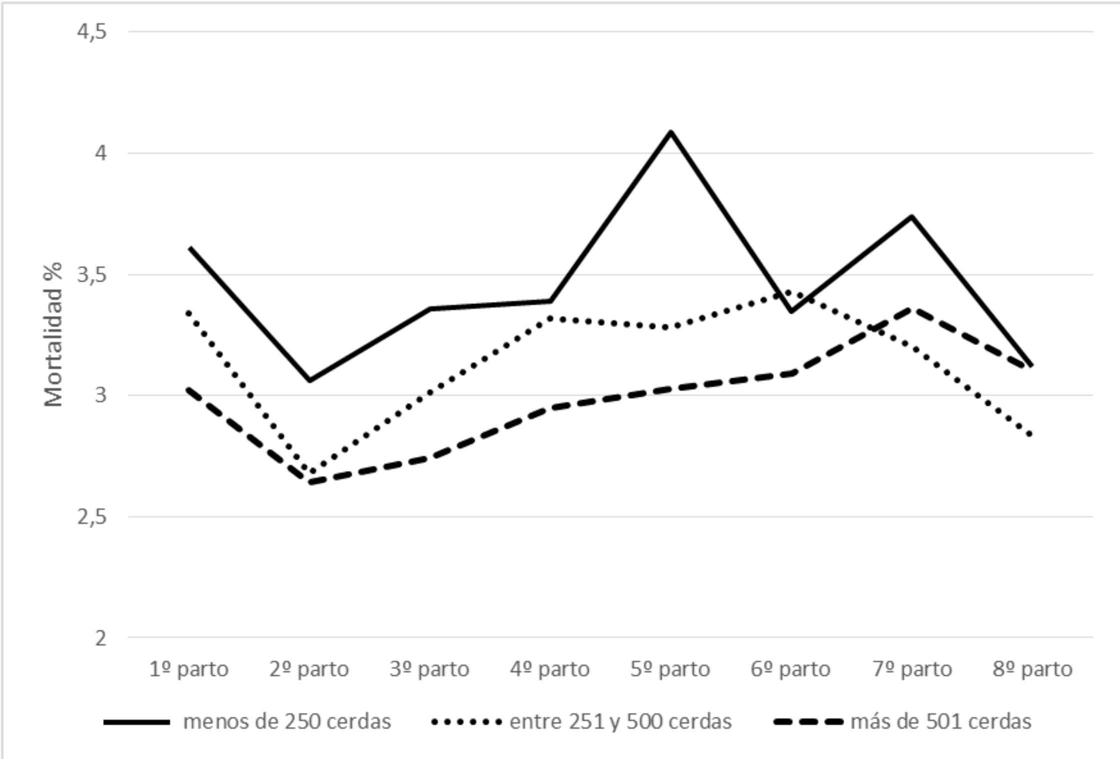

Figure 1. Total mortality of sows by size of farm

Source: Author.

Conception rates also varied by farm size – being higher in larger farms (ranging from 81.7% to 85.1%). Similar curves were found for conception rates in the other two size groups; but with average values of 79.2% for the group with less than 250 sows and 81.7% for farms of between 251 and 500 sows.

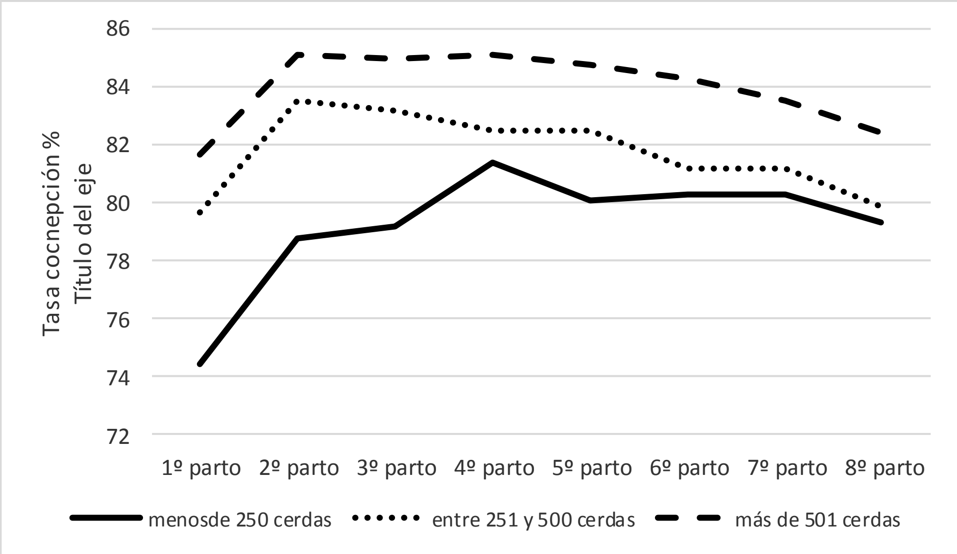

Figure 2. Conception rate according to farm size

For the generation of the cost function we used the nutritional requirements established by Spanish nutrition foundation FEDNA for pig feed formulation (2013) (Table 2). The model calculates the costs according to the nutritional feed requirements for gestation (2870 kcal EM / kg) and lactation (3,000 kcal EM / kg).

Table 1. Daily energy needs†

Kcal EM kg^{-1} d^{-1}	Días 1	2	≥3
Gestation:			
Maintenance	4479	5558	6570
Fetal growth and annexes	367	367	367
Reserve weight gain	1558	1347	842
Suckle weight gain	55	55	55

Lactation			
Maintenance norms	5504	6288	7252
Milk production	12,683	12,683	12,683
Mobilisation of reserves	-3275	-3275	-3275

† Following FEDNA norms 2013.

Unit costs of milk feed and piglet feed were obtained as average market prices. Discounts for volume were not considered given the small volumes involved. For the more significant feeds (such as lactation and gestation) a price scale was supplied by SIP Consultors. A scaling factor was also considered for the price of culled sow and the cost of hybrid sows (Table 2).

Table 2. Economic data†

Costs	Farm size (number of sows)		
	Under 250	Between 251 and 500	More than 501
Unit cost piglet feed (€/kg)	0.672	0.672	0.672
Unit cost piglet milk (€/kg)	1.825	1.825	1.825
Piglet price (€/unit)	16.72	16.72	16.72
Unit cost gestation weaning feed (€/kg)	0.260	0.275	0.290
Price of culled sow (€/unit)	167.33	188.67	209.67

Cost hybrid sow (€/unit)	148.67	192.33	236.00

[†] Following FEDNA 2013 and SIP Consultors.

The 'rctsca' ratio (defined as the ratio between feed costs and total costs) is calculated to estimate the total costs from feed costs. The ratios (averages for 2009-2013) were obtained in relation to the size of farm, FEDNA feed norms, and the figures given by SIP Consultors. On the largest farms, the ratio is 57.04%, in the medium farms it is 59.29%, and in the smallest farms it is 60.51%. The smallest ratio is found in the largest farms, which indicates the lesser importance of feed costs, although the difference in these costs is insignificant when compared with the other two sizes of farms. The observed difference can be accounted for by how the mothering sows are managed – smaller farms giving greater attention during this phase.

The prices used in the calculation of income were obtained from INTIA. Prices for the sale of meat in the slaughterhouses and for the purchase of hybrid sows varied with the size of the farm. INTIA does not offer a scaling factor for the price of piglets (Table 3).

Table 3. Economic data on income[†]

Price/farm size	Fewer than 250	Between 251-500	More than 501
Dressed sow price (€/unit)	167.33	188.67	209.67
Hybrid sow price (€/unit)	148.67	192.33	236.00

Piglet price (€/unit)	27.25	27.25	27.25

† From INTIA – Navarra regional government (2006-2007-2008-2009-2010-2011-2012).

Piglet production is measured as the number of weaned piglets – those born less mortality during lactation. Piglet production data is provided by PigCHAMP from 2005 to 2011. The average number of piglets born alive was calculated and a significant difference was noted between the sizes of farms – as shown in Table 4.

Table 4. Piglets in relation to farm size

Farrowings	1º	2º	3º	4º	5º	6º	7º	8º	Total
Live births in relation to farm size									
<250	11.5	12	12.6	12.8	12.8	12.6	12.3	12.2	98.8
251-500	11.6	12	12.6	12.8	12.8	12.6	12.4	12	98.8
>500	12.3	12.5	13.2	13.3	13.3	13.1	12.8	12.6	103.1
Weaned piglets in relation to farm size									
<250	9.7	10.2	10.1	9.9	9.8	9.6	9.5	9.4	78.2
251-500	9.9	10	9.9	9.8	9.6	9.5	9.4	9.3	77.4
>500	10.4	10.5	10.3	10.1	9.9	9.8	9.8	9.9	80.7

RESULTS AND DISCUSSION

Once the income and costs have been calculated for the first eight farrowings, cash flows could be generated for each of the three farm sizes.

The net present value of cash flows are then calculated with a discount rate of 6%. Performance according to farm size is shown in Figure 3.

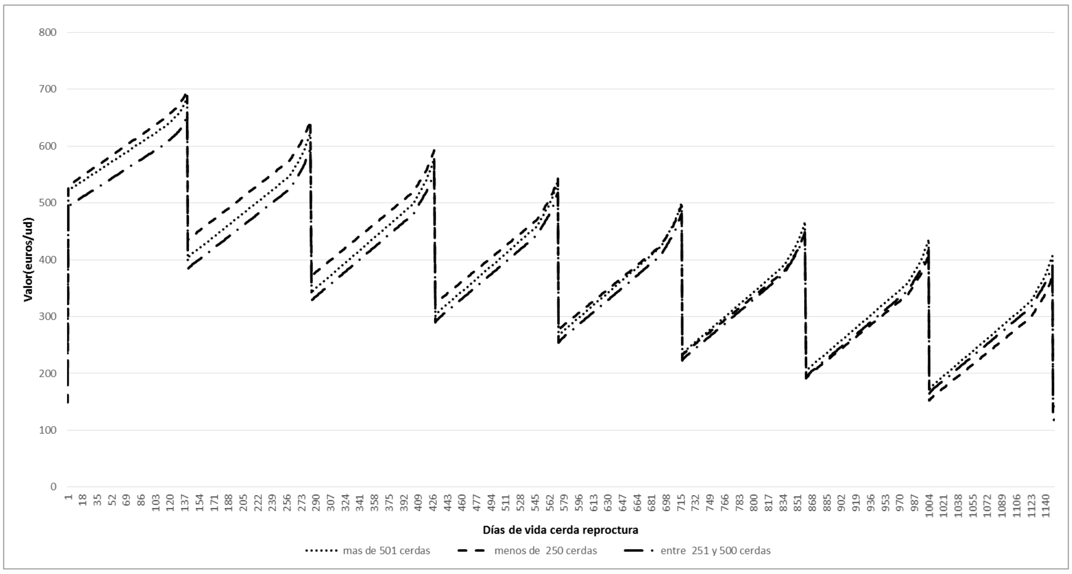

Figure 3. Sow value according to days of life (eight farrowing cycles) and by size of farm.

As expected, the curves for farm size and value of the sow are serrated with a slight downward slope (Figure 3). These curves reflect the loss of value suffered by the hybrid sow after each farrowing. It is noteworthy that the highest incomes coincide with each weaning and the subsequent sale of piglets. The values of the sows vary according to age and farm size.

On the farms with fewer than 250 sows, the highest value of €697.36 is obtained for sows after the first farrowing. Farms with more than 501 sows (therefore employing more technology) obtain second place with a value of €685.24. Finally, a value of €652.40 is reached for sows in farms with between 251 and 500 sows. The cause of this difference in values is due to variance in the costs of hybrid sows and the sales income from piglets.

This trend continues until the sixth farrowing when the highest value is reached for farms with more than 500 sows – and so placing the value of sows for farms with fewer than 250 sows in an intermediate position. After the final weaning, very similar values are reached for farms with more than 500 sows (€142.80) and farms with between 251 and 500 sows (€ 142.24). A sow value of only €118.85 was obtained in farms with less than 250 sows.

The values for sows in farms with more than 500 sows (Figure 4) maintain parallel curves following farrowing. The highest average sow value logically corresponds to the first farrowing and reaches an average of €592.51 before falling to an average of €273.68 after the eighth farrowing. The largest decline in the value of sows is produced between the first and second farrowing (16.14%), while the smallest fall (8.84%) occurs between the fifth and sixth farrowing. The decline in maximum values according to farrowing is 59.36%, while the decline in minimum values is just 34.64%.

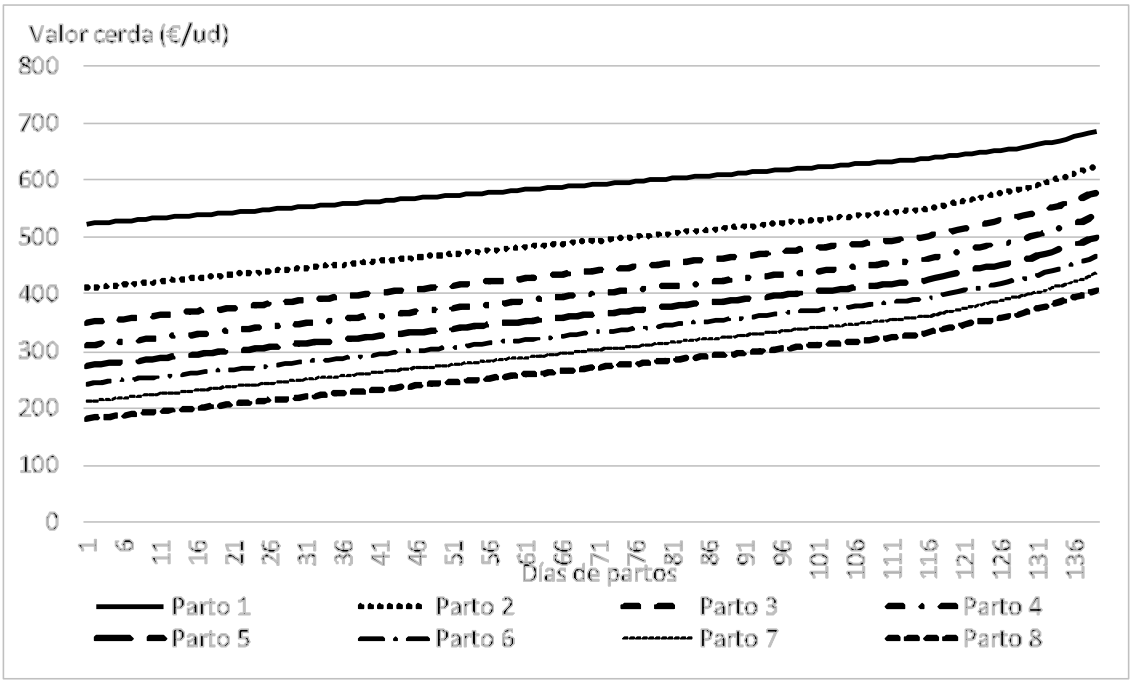

Figure 4. Value of breeding sow according to farrowing in farms with more than 501 sows.

Obtaining econometric models to determine the useful life of fixed farm assets is of great interest, and studies include tractors (Guadalajara and Fenollosa, 2010); and cattle (Pérez-Salas and Segura, 2005). Various authors have considered the possibility of obtaining linear or nonlinear models to explain the growth and development of livestock. Dominguez-Viveros et al. (2013) described the growth of Tropicarne cows and differentiated these from other beef cattle breeds. Giles et al. (2009) produced a model for assessing the growth and development of pigs. Rebollar et al. (2014) produced a linear model to determine the demand and supply of pork in certain regions.

The complexity of the model proposed in this study prevents its immediate use, however, from the data obtained we can quickly adjust and use the parametric value-age curves: a linear model is shown in Table 5 for the values in the above graphs.

Table 5. Lineal model (confidence level 95%)

Farm size	Constant	b1	R squared
More than 501	556.617	-0.280	0.628
Between 251 and 500	531.081	-0.263	0.620
Fewer than 250	588.814	-0.329	0.713

The results obtained for the three farm sizes show average values and their respective coefficients of determination. An economic analysis of the age variable and sow value demonstrates that the model is acceptable from an economic point of view.

CONCLUSIONS

The farming sector needs an objective system for valuing assets. This is especially evident for livestock farms.

In this study, three valuation models for hybrid sows were estimated in relation to the size of pig farms. The values obtained with the proven model can be used to determine the value of sows by age, and show the daily sow values throughout their useful life. These results can be used to calculate insurance claims and for business management (cash flow analysis, livestock valuations, estate management, calculation of technical depreciation and inventory). The model can be of great value when making decisions about replacing sows.

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