Economic values for traits of pigs in Hungary

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ABSTRACT: Marginal economic values for production and reproduction traits of pigs were estimated applying a bio-economic model to Hungarian commercial sow herds with integrated fattening of piglets. Data collected between 2002 and 2008 were used for the calculation. Marginal economic values (in € per unit of the trait per sow per year) estimated for fattening days in the station test, age at the end of the field test, lean meat percentage in the carcass, percentage of valuable cuts in the carcass and the number of piglets born alive were 2.84 €/day, 2.71 €/day, 22.45 €/%, 28.81 €/% and 54.22 €/piglet in the first litter, respectively.

Keywords: pig; breeding; economic values; bio-economic model

The goal of pig breeding is to meet the demand for quality pork meat. All production practices and breeding arrangements should serve this end. The Hungarian pig sector has been characterised by structural changes accompanied by a decrease in the total size of the pig population and an increase in the farm size during the past decade. From an economic viewpoint, national pig breeding companies have experienced continuously worsening circumstances. Out of the originally 7 central pig test stations only 2 have remained. Government subsidies for breeding animals were terminated in accordance with EU regulations. As a result, the number of pig breeders and that of pigs tested have shown a decreasing tendency. All these issues necessitate the breeding of profitable sows with excellent reproductive performance that produce offspring with high growth potential and good carcass quality.

In order to carry out efficient selection in the Hungarian pig breeding sector, a performance test system is used. Recently more emphasis has been placed on field test. The following traits are recorded: the number of piglets born alive (NBA), body weight at the beginning and at the end of the field test, age at the end of the test (AGE) adjusted to a body weight of 105 kg, fat depth between the 3rd and 4th lumbar vertebrae 8 cm laterally from the spinal cord (SFAT1), fat depth between the 3rd and 4th ribs 6 cm laterally from the spinal cord (SFAT2) and loin muscle depth between the 3rd and 4th ribs 6 cm laterally from the spinal cord (LM). Fat and loin depth are measured by SONOMARK 100. From the last three measurements, the lean meat percentage (LEAN) is predicted using the following equation:

$$LEAN = 56.333381 - 0.122854 \times SFAT1 - 0.786312 \times SFAT2 + 0.006160 \times SFAT2^2 + 0.237677 \times LM$$

The SEUROP field test was introduced in Hungary in 2000. LEAN based on slaughterhouse data is col-

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lected and will constitute a part of the breeding value estimation beginning in the year 2010. At the test stations the following traits are measured: days of test (DT) (from the age of 80 days until a live weight of 105 kg is reached), total amount of feed consumed during the test, percentage of valuable cuts in the carcass (VC) and meat quality score (MQS).

Methods of predicting the lean meat content in pig carcasses were also described by Vítek et al. (2008), who constructed regression formulae for ultrasound and probe apparatuses to increase the prediction accuracy. Stupka et al. (2008) described factors influencing the formation of pig carcasses.

Breeding value estimation in the Hungarian pig breeding sector is carried out monthly using the PEST software (Groeneveld, 1990). The BLUP evaluation officially introduced in 2007 replaced the conventional indices, and pig breeding companies conducting pure-breeding also placed more emphasis on progeny tests based on slaughter-house data than they did previously. A univariate repeatability animal model is used for the trait NBA. The breeding value estimation for the traits DT, VC, LEAN and AGE is performed using a multivariate animal model (Nagy et al., 2008). The breeding values are combined into a sire breed index:

$$I = 100 - 1.22 \times DT + 5.53 \times VC - 1.11 \times AGE + 10.45 \times \times LEAN$$

The dam breed index also includes the breeding value for the number of piglets born alive with 10-point weighting. The weights of the indices were calculated using the desired gain approach to give an equal emphasis to each trait in one unit of genetic response of the aggregate genotype. Economic values of the traits for the Hungarian pig population have not been estimated yet. These values are necessary for each trait included in a breeding objective in order to ensure that the selection emphasis is proportional to the economic importance of the trait.

Methods for deriving economic values for pigs have been worked out and have already been used in some countries (Tess et al., 1983; De Vries, 1989; Stewart et al., 1990; von Rohr, 1998; Habier, 2004; Houška et al., 2004; Quinton et al., 2006). The impact of a change in the level of traits on the economic efficiency of a commercial pig production system is most frequently described by a bio-economic model. Hovenier et al. (1993) elaborated a method for calculating the economic values of optimum traits (e.g. meat quality in pigs). Houška et al. (2004) applied an approach developed by Wolfová et al. (1995) for the evaluation of categorical traits (e.g. carcass trait evaluated by the SEUROP grading system).

The objective of the present study is to calculate the marginal economic values for production and reproduction traits currently included in the Hungarian breeding goal.

MATERIAL AND METHODS

Production model

The economic values were computed using the recent version of the EPOS programme (Houška, 2007), which is based on a deterministic bio-eco-

Table 1. Input parameters for each parity

Parity	Culling rate (%)	Adjustment coefficient for litter size[a]	Live weight of culled sows (kg)
0 (barren gilts)	0.00	–	125
1	25.04	1.00	130
2	33.18	1.06	140
3	65.03	1.11	150
4	56.00	1.13	170
5	100.00	1.14	190

[a]these coefficient relate the litter size at the 1st parity to later parities

nomic model of a commercial sow herd with integrated fattening of pigs. A detailed description of the model, including equations for the calculation of particular income, costs and total profit of the system, was given by Houška et al. (2004, 2009). Therefore, only the basic features which are appropriate for Hungarian conditions will be presented here.

The data from typical Hungarian commercial herds between 2002 and 2008 were used as input parameters for the model. The production starts with 210-day-old gilts purchased from nucleus herds. Ten days later the gilts are mated, and those that have failed to conceive after three inseminations are culled. Sows remain in the herd at the longest until the fifth farrowing. Each reproduction cycle of a female begins with the conception and is divided into three stages: gestation, lactation, and weaning to conception or weaning to culling. Sows with health problems, low performance or sows that have not re-conceived are culled 60 days after weaning on the average. The parameters characterising each parity of a sow are summarised in Table 1. Further reproductive and management parameters of the sow herd are given in Table 2.

Three growth periods are distinguished for the offspring: from birth to weaning at 28 days of age, from weaning to feeder pig weight of 28 kg, and from feeder pig weight to constant slaughter weight of 105 kg. The average loss of piglets up to weaning is 10%; that of feeder pigs is 2%. During the fattening period, 3% of the animals do not reach the slaughter weight and are culled due to health problems at an average weight of 60 kg. Growth and carcass characteristics of the offspring are summarised in Tables 2 and 3.

Profit function

The economic efficiency of the entire production system (*PSY*) was expressed as profit per sow and year and was calculated as follows:

$$PSY = 365 \times (TRFAT - TCS - CPIG - CFAT)/\text{DAYS} \times n$$

where:

TRFAT = total income from fattened pigs

TCS = total cost during the entire life of females from purchase to culling, which is adjusted for returns from culled gilts and sows

CFAT, CPIG = total costs in fattening and total costs of the feeders' rearing

DAYS = total number of days a sow spends in the herd

n = number of sows in the herd

Table 2. Reproductive, growth and management input parameters for sow and piglets

Parameter (unit)	Value
Number of piglets born alive at first parity	10.0
Number of piglets at 21st day (after first farrowing)	9.0
Litter weight at 21st day (after first farrowing) (kg)	50.0
Conception rate of sows (%) after	
1st insemination	57.9
2nd insemination	31.8
3rd insemination	31.1
4th insemination	8.9
Gestation length (days)	114.0
Interval from weaning to 1st insemination (days)	7.0
Interval from 1st mating to culling of unconceived gilts (days)	42.0
Average daily gain of piglets till weaning (kg/day)	0.217
Average daily gain of feeders (till 28 kg of weight) (kg/day)	0.400
Average daily gain in fattening (till 105 kg of weight) (kg/day)	0.600

Table 3. Carcass evaluation of fattened pigs

Carcass class	Range of classes (% of lean meat in carcass)	Proportion of carcasses (%)	Average lean meat in classes (%)	Price (€/kg of carcass)
S	> 60	18.36	61.61	1.23
E	55–59.9	55.74	57.39	1.22
U	50–54.9	21.12	53.11	1.17
R	45–49.9	3.71	48.11	1.11
O	40–44.9	0.73	42.96	1.02
P	< 40	0.34	35.68	0.97
Average			56.74	1.20

The number of sows includes gilts from conception to the 1st farrowing and sows at different parities.

The total cost in the sow herd included feed, insemination, and fixed costs (housing, veterinary and labour costs, interest on investment, insurance, etc.). Returns for the culled gilts and cows were calculated assuming a price of 0.97 €/kg of carcass. The costs of piglets from birth to weaning were included in the sow costs. Therefore, the feed costs of lactating sows were a function of the number

Table 4. Main parameters for the calculation of costs

Parameter (unit)	Value
Price of purchased gilts (€/animal)	170.00
Price of boar semen (€/dose)	9.43
Average number of semen doses per AI	2.50
Price of feed mixture (€/100 kg) for	
barren sows	13.21
pregnant sows	15.09
nursing sows	16.98
feeder pigs	18.87
fattened pigs	15.09
Feed mixture consumption (kg/animal and day) of	
barren sows	2.80
pregnant sows	3.00
nursing sows (base feeding ration)	2.00
nursing sows (addition of feed according to litter size, kg/piglet and day)	0.40
Average consumption of metabolisable energy in fattening (MJ ME/kg of gain)	36.00
Fixed costs (€/animal and day) for	
barren sows and gilts	0.19
pregnant sows	0.19
nursing sows	0.21
feeder pigs	0.19
fattened pigs	0.16

of piglets and their growth rate. The total costs of feeder pigs and of fattening covered the feed costs and fixed costs.

The levels of the cost components and pork prices were adjusted to the market situation in Hungary in 2008. For a given frequency of slaughter pig carcasses in a particular SEUROP class (Table 3), the average price obtained per kg of carcass was 1.20 €. For pigs slaughtered before reaching the target slaughter weight, this price was lowered by 20%. The main parameters for the calculation of costs are presented in Table 4.

Evaluated traits and calculation of their economic values

Number of piglets born alive (NBA)

A change in the number of piglets born alive per litter was assumed to appear in all parities. An increase in NBA was followed by an appropriate increase in the number of piglets weaned and piglet losses were taken into account. Feed costs for nursing sows were expected to increase. However, no changes in the average piglet weight at birth and at weaning were expected. The birth weight and growth rates in all periods were kept constant in order to avoid double counting, as the growth rates were evaluated separately. The feed and non-feed costs as well as the income from the extra pigs weaned were taken into account in the feeder and fattening periods.

Growth traits

It was assumed that a change in the total growth rate would be expressed in each of the three growth periods of pigs. An increase in weight gain during the period from birth to weaning was expected to lead to a higher weaning weight. This higher gain required extra feed for lactating sows. It was assumed that a sow needs 4 g extra feed/day during lactation for an increase in piglet daily gain by 1 g/day (Mavromichalis, 2001). A higher daily gain of feeder piglets and of pigs during fattening resulted in a shorter feeder and fattening period leading to a decrease in the total non-feed costs in feeder piglets and in pigs during fattening.

Since the age of pigs at the fixed slaughter weight or days required to reach the fixed slaughter weight are more favourable from the statistical point of view than the growth rate, these traits were used for the estimation of breeding value of the growth potential. Therefore, the economic value of growth rate was converted into the economic value of age at slaughter (which is appropriate for the AGE trait in the field test) and to the value of the number of days in fattening (which is appropriate for the DT trait at test stations).

Carcass quality traits

Carcass quality is generally expressed by lean meat content (LEAN). The SEUROP system is used for the classification of carcasses in Hungary. Each of the SEUROP classes is characterised by the upper and lower limit for lean meat content and by a specific price/kg of carcass. A change in LEAN resulted in a change of the carcass distribution across the SEUROP classes and consequently modified the average price/kg of carcass and the total income from slaughtered animals. No changes in feed costs or other costs were assumed.

In the station test, the percentage of valuable cuts in carcass (VC, in %) is estimated instead of LEAN. Therefore, the economic impact of a change in both traits on profit was estimated.

Calculation of economic values

For each trait, the effect of a marginal change in the average trait level on the net profit was calculated. To calculate the economic value for age at the end of a field test, the average daily gain in all three growing periods of piglets was increased by 1%. The resulting change in profit was then divided by a change in the age at slaughter. In calculating the economic value for days in the station test, the average daily gain in fattening was increased by 1%, and the resulting change in profit was then divided by a change in days in fattening.

The number of piglets born alive at the first farrowing was increased by one piglet. This increase raised the number of piglets at the second farrowing by 1.06 piglets, at the third farrowing by 1.11 piglets, etc., in accordance with the adjustment coefficients given in Table 1. Although the change in profit from increased prolificacy (the economic value of NBA) is expressed per piglet in the first parity, it also includes the economic impact of changes in NBA in all parities during the whole life of a sow.

To obtain the marginal economic value for average lean meat content, an underlying normal distribution for this trait was assumed. The method and program described by Wolfová et al. (1995) were adapted to calculate the new proportions of carcasses in each SEUROP class. This economic value was then converted into the economic value for the percentage of valuable cuts in the carcass using the following relationship between LEAN (in %) and VC (in %) estimated by Pulkrábek et al. (1994):

$$\text{LEAN} = -9.9015 + 1.2834 \times \text{VC}$$

The marginal economic value of VC is then equal to the economic value of LEAN multiplied by 1.2834. The sow is the referential base unit for economic values of all traits in our calculation; one year is the time unit for expressing income, costs and profit. This base unit represents females in all parities including parity zero, which is assigned to pregnant gilts from conception to farrowing.

In order to make the economic importance of different traits comparable, the marginal economic values were standardised by multiplying them by the genetic standard deviation of the traits. Genetic standard deviations were taken from Farkas et al. (2007) and Farkas (2008) (Table 6).

RESULTS

The culling rates of gilts and sows in the studied commercial herds led to the sow herd structure shown in Table 5. In this table, the progeny structure is also given, which was calculated on the basis of the sow reproduction characteristics and the survival rates of piglets in different periods of life. The average productive lifetime of the sows was 460 days, and the average number of farrowings per sow per year was 2.1. The age of the piglets at the end of the feeder period (at 28 kg live weight) was 80.31 days; the average length of the fattening period (to 105 kg) was 128.33 days.

The total income and total costs in the sow herds and the integrated fattening of pigs were 1 964.8 € and 1 861.3 € per sow per year, respectively, resulting in a profit of 103.5 € per sow per year (which means 5.78 € per fattened pig or 0.06 € per kg of slaughter weight of fattened pigs). The profitability (calculated as 100% × profit/costs) for the integrated production system was therefore 5.56%.

The marginal economic values for the evaluated traits are summarised in Table 6. An increase in the growth rates of piglets in all growth periods by 1% resulted in an increase in the lifetime average daily gain (from birth to slaughter) by 5 g/day (from 498 g/day to 503 g/day). As a result of the constant weaning age, the increase in growth rate until weaning led to a higher piglet weight at weaning (an increase from 7.07 kg to 7.13 kg). The feeders' age at 28 kg of live weight decreased by 0.65 days (from 80.31 to 79.66 days). The length of the fattening period decreased by 1.27 days (from 128.33 to 127.06 days). Therefore, the age at slaughter decreased by 1.92 days (from 208.64 to 206.72 days). The equivalent change in profit was 5.20 € per sow per year. By dividing the change in profit by the change in age at slaughter, the marginal economic

Table 5. Structure of sow herd and progeny

Parameter (unit)	Value
Proportion of sows (%) on parity	
0 (pregnant gilts)	28.55
1	28.55
2	21.40
3	14.30
4	5.00
5	2.20
Number of piglets weaned per sow per year	18.83
Number of piglets at the end of feeder period per sow per year	18.45
Number of pigs slaughtered at target slaughter weight	17.90

Table 6. Marginal economic values (MEW, in € per unit of trait, per sow and year when improving the trait level), genetic standard deviation (GSD) and standardized economic values (SEW, in €/GSD)

Trait (unit)	MEW	GSD	SEW
Number of piglets born alive (piglets)	54.22	0.61	33.07
Age at slaughter (days)	2.71	15.02	40.70
Days in fattening	2.84	9.91	28.14
Lean meat content in the carcass (%)	22.45	1.62	36.37
Percentage of valuable cuts in the carcass (%)	28.81	2.55	73.46

value for the trait AGE (5.20/1.92 = 2.71 €/day) was obtained.

An increase in the growth rate of pigs only in the fattening period by 1% caused an increase in daily gain in fattening by 6 g/day (from 600 g/day to 606 g per day). A 1.27-day shorter fattening period reduced the number of days to slaughter age by 1.27 days (from 128.33 to 127.06 days). The change in profit was then 3.60 € per sow per year. By dividing the change in profit by the change in days in fattening, we obtained the marginal economic value for the trait days in fattening (DT) (3.60/1.27 = 2.84 €/day). This economic value is somewhat higher than the economic value for the trait AGE, which reflects the fact that an increase in daily gain in fattening only would yield greater profit than an increase in daily gain in the previous growth periods.

An increase in the litter size at the first farrowing by 1 piglet caused an increase in the number of weaned piglets per sow per year by 2.38 (from 18.33 to 20.71 piglets). The corresponding change in profit per sow per year (economic value of NBA) was then 54.22 €.

A change in the average lean meat content in the carcass by 1% caused an increase in the average price/kg of the carcass. This led to a change in profit per sow per year by 22.45 €, which is the marginal economic value for the LEAN trait. Converting this value, as described in Material and Methods, the economic value for the percentage of valuable cuts (VC) in the carcass of 28.81 €/% was obtained.

Table 6 shows the standardized economic values of the traits, which allows the first rough comparison of the selection importance of all traits. In standardising the economic values, the VC was the most economically important trait among these traits evaluated.

DISCUSSION

In the relevant literature, two basic approaches to the economic value of pigs can be distinguished. The first one is based on the model of De Vries (1989), where a commercial herd is supplied with replacement gilts purchased from a superior herd. In an integrated commercial production system, all the pigs born are fattened in the herd. This approach was applied, for example, by Ducos (1995), Von Rohr (1998) and Houška et al. (2004), who calculated the economic weights in French, Swiss and Czech pig production systems, respectively. The second model (Stewart et al., 1990) arises from a commercial sow herd producing its own replacement gilts. The weaned piglets are sold to growing-finishing enterprises. Quinton et al. (2006) combined both approaches and calculated the economic values for commercial sow herds producing their own replacement gilts and supplying the market either with finished pigs or with feeders. They demonstrated that marginal economic values for some traits differ substantially for both markets. The situation in Hungarian commercial herds corresponds to the model of De Vries (1989), which was also the basis for the model and the program of Houška (2007). Therefore, this approach was used for our calculations.

Economic values are generally defined as partial derivatives of the profit function with respect to the trait of interest (Hovenier et al., 1993; Quinton et al., 2006). By using more complex bio-economic models, the partial derivative is approximated by a difference quotient (de Vries, 1989; Houška et al., 2004), and this approach was applied in our calculation as well. Economic values can be expressed as a change in profit per unit of output or profit per sow (or gilt) as described by Brascamp and de Vries (1992). These different approaches result in differences in the magnitude of economic values. Amer and Fox (1991) emphasized that farm profit should always be used as a starting point. This approach leads to balance while using diverse bases. Dividing the economic values ascertained at the farm level by the number of animals or units of output enables us to obtain economic values for different bases. For a national breeding programme, the entire population of commercial pigs should be included. When a constant number of sows is used, the farm-level based calculation corresponds to the expression of economic values per sow per year. Therefore, this basis was used for the calculation of economic values for Hungary.

The absolute economic values of traits as well as their relative values calculated for different countries or breeding companies are difficult to compare. Even if the same model is used, different market conditions can strongly influence the ratio of economic values between two traits (De Vries, 1989; von Rohr et al., 1998). Differences in the economic values of traits are also caused by different assumptions made according to the impact of variation in the trait level on income and costs. The economic value of daily gain, for example, mostly arises through saving in costs due to a shorter fattening period (or also nursing and growing period) (de Vries, 1989; von Rohr, 1998) or through increasing incomes due to the higher weight of the animals at selling (Quinton et al., 2006). On the other hand, Holzbauer and Cue (1998) subtracted from this value the costs of an expected correlated response in the mature weight of sows (higher maintenance costs, higher slaughter weight). This approach yielded an economic value of daily gain in fattening under Quebec conditions 2.3 times lower than that previously calculated without an assumed correlated response in sow weight. However, if possible, assumptions concerning covariances should not be incorporated into the profit function, but should be stated explicitly in the matrices of genetic parameters (Goddard, 1998).

Under Hungarian market conditions, feeders and finished pigs are sold at a constant market weight. Therefore, improving the growth potential of sow's offspring in our calculation reduced the time to sale or slaughter. Days in fattening or age at slaughter were therefore chosen as the breeding goal traits. Both these traits are at present included in the selection index for pigs in Hungary. However, when constructing an index based on economic values, only one of the traits may be included in the index in order to avoid double counting of the growth potential. The same applies to traits characterising carcass quality. Lean meat content and the percentage of valuable cuts are in principle the same trait. Therefore, only one of them may be included in an economic selection index.

Economic weights for reproduction traits in the U.S. national swine improvement program are mostly calculated within the farm producing weaned piglets, whereas for production traits they are calculated in fattening farms. The economic weight for NBA is given by the total costs associated with the production of extra weaned pigs per litter (See, 1997), whereas in the present calculation, e.g. in the papers of de Vries (1989), Fiedler et al. (1995) and Houška et al. (2004), the price of extra fattened pigs was also inserted into the calculation of the economic value for NBA. Quinton et al. (2006) reported an economic value for litter size for the sow farms with pig finishing nearly twice as high as for sow farms producing piglets for the feeder market.

Further reproductive and functional traits of pigs have been estimated in the literature. Quinton et al. (2006) estimated economic values for age at puberty, interval weaning to conception, perinatal mortality, and survival rate of piglets until weaning. Houška et al. (2004) evaluated the conception rate of sows and sow longevity. For such traits, there are no data available yet in Hungary. Therefore, litter size was the only evaluated reproductive trait. Houška et al. (2004) and Quinton et al. (2006) found that the NBA had the highest relative economic value, which was not confirmed in our study. However, the latter authors called attention to the fact that the economic value of litter size is highly dependent on the average value of the trait in the population. The economic value for litter size (in Canadian $ per piglet born total) decreased from 30.7 in a litter size of 8 pigs to 13.9 in a litter size of 20 pigs for farms with pig finishing, and from 16.2 to 7.3 for farms which sold feeder pigs. Therefore, the recalculation of economic value for litter size will be necessary if the average level of the trait changes substantially.

CONCLUSION

Breeding value estimation for production traits in Hungary is calculated by a multi-trait animal model. The genetic correlation near zero was estimated between the trait of the number of piglets born alive or litter weight at day 21 on the one hand, and the growth and carcass traits on the other (Chen et al., 2001). Therefore, when developing an economic selection index, the breeding values can be directly multiplied by the marginal economic values to obtain the appropriate weights for the index traits. From each group of traits (growth and carcass traits) only one trait may be selected in order to avoid the overestimation of the genetic potential of these traits, especially in dam breeds. As many test stations have been closed down in Hungary, and more emphasis has recently been placed on the field test, we recommend that the traits LEAN and AGE be included in the selection index for sire breeds and the trait NBA be added to the index for dam breeds.

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