ACCOUNTING FOR THE SEX EFFECT ON PREDICTION OF PIG CARCASS LEAN MEAT PERCENTAGE IN THE COMMUNITY

DAUMAS G., DHORNE T., GISPERT M.

Institut Technique du Porc, LE RHEU, France

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SUMMARY

A collaborative pig carcass dissection trial was carried out in the E.C. in 1990. Three sexes where represented : gilts, castrated males and entire males. Three Member States were studied : Spain, France and The Netherlands.

Significant differences between gilts and castrates were found in France and in The Netherlands for prediction of lean meat percentage from lateral depths and also from split depths in France. On the other hand no difference was noticeable between the three sexes in Spain, but the protocol was not efficient.

If there is a sex effect it can be taken into account by using one equation for each sex. This solution, being the most efficient, could be easily implemented in France, where sex is known for most of the carcasses, for the benefit of both producers and slaughterers.

Introduction

The development of carcass components is different between sexes, resulting in significative differences in carcass composition. A significative effect of sex on the prediction of pig carcass lean content from fat and muscle measurements taken over the loin had been found in The Netherlands (ENGEL and WALSTRA, 1991b and 1993) and in Great Britain (PLANELLA and COOK, 1991). Cook and Yates (1992) showed a significative effect of sex as well as a sex and Member State interaction in the collaborative trial where different Member States were included. We studied the effect of sex in France, Spain and The Netherlands using the data from this harmonization trial, as well as the way of taking it into account in practical conditions.

1. Material and methods

1.1. Experimental design

A collaborative trial was carried out by 10 Member States during 1990, towards the harmonization of methods for grading pig carcasses. The trial was carried out according to an EC protocol (Commission of the E.C., 1990). Details of each national protocol used in this work were reported by GISPERT and DIESTRE (1994) for Spain, ENGEL and WALSTRA (1993) for The Netherlands, and DAUMAS and DHORNE (1994) for France. The sample size and the means of predictors, lean content and concomitant variables used in double-regression are shown in table I. For each country, lateral measurements over the loin were taken in the same position although the equipment was different. Lean content was calculated using carcass weight without flare fat, kidneys and diaphragm. The Z concomitant variable was calculated using different methods as follows :
- France : lean percentage of the four main cuts.
- Spain : weight of lean from the four main cuts, the filet, and lean of the backfat and neckfat as a percentage of carcass weight.
- The Netherlands : estimated carcass lean percentage from dissected and not dissected cuts.

The stratification of sample and subsample was made separately for each sex in The Netherlands, but not in France and in Spain. In the subsample, extreme observations were selected using estimated lean percentage in The Netherlands, X4 and X5 predictors in France, and P2 stratified into four weight classes in Spain. In fact, the weight stratification adopted by Spain induced not expected differences between sexes. The lowest lean percentage was obtained in boar carcasses, but carcass weight was approximatively 15 kg higher in the subsample. Also, fat thickness of boar carcasses (X4) was slightly lower than barrows having the former heavier carcasses (4 kg) in the overall sample.

1.2. Statistic analysis

French and Spanish results were obtained using SAS (SAS Institute Inc., 1988a, b and c) and Dutch results were taken from references. Double regression (ENGEL and WALSTRA, 1991a) was used in order to obtain lean prediction equations separately for each sex and each country.

To calculate these equations, outliers observations were eliminated, but in the Residual Standard deviations they were included.

The Netherlands seem to have calculated the residual variance according to the unbiased estimator given in the former article, i.e. :

$$S^2 = S_{12} + S_{02} + [g_{12} - V(g_1)]$$

where : S_{12} = residual variance in the regression between Y and Z, X4, X5 on the subsample,

S_{02} = residual variance in the regression between Z and X4, X5 on the overall sample,

g_1 = Z coefficient in the regression between Y and Z, X4, X5 on the subsample,

$V(g_1)$ = variance of g_1

This variance estimator can be negative. CAUSEUR (1993) has established the formula of an unbiased estimator, which is always positive and has a lower variance than the estimator from ENGEL and WALSTRA :

$$S^2 = [1 - \frac{1}{N-p-1} - \frac{N-n}{(n-p-3)(N-p-1)}]\, S_{12} + (g_{12} \times S_{02})$$

where p = predictor number

This formula has been used for France and Spain.

In order to know if it was necessary or not to assess one equation for each sex, equality tests were made between residual variances for each of the 3 steps in double regression. A Fischer test was used at the 2 first steps. At the third step, an approximate Fischer test was applied from both approximate chi-2, which freedom degrees were estimated by the formula from ENGEL and WALSTRA (1991a) :

$$ddl = \frac{S_4}{\frac{S_{14}}{(n-3)} + \frac{g_{14} + S_{04}}{(n-2)} + 2S_{04} \times g_{12} \times V(g_1)}$$

2. Results

2.1. In France

2.1.1. From lateral measurements (ELT)

The 3 steps in double regression have given :

_ For females :

$Z = 64,20 - 0,674 \times X4ELT + 0,222 \times X5ELT$
$S_0 = 1,86$

$Y = - 6,723 + 0,942 \times Z - 0,083 \times X4ELT + 0,026 \times X5ELT$
$S_1 = 0,72$

$Y = 53,77 - 0,717 \times X4ELT + 0,234 \times X5ELT$
$S = 1,89$ $V(S^2) = 0,36$ $df = 40,7$

_ For castrates :
$Z = 66,22 - 0,694 \times X4ELT + 0,191 \times X5ELT$
$S_0 = 2,09$

$Y = - 17,49 + 1,156 \times Z + 0,059 \times X4ELT - 0,074 \times X5ELT$
$S_1 = 0,64$

$Y = 59,06 - 0,743 \times X4ELT + 0,146 \times X5ELT$

$S = 2,50$ $V(S^2) = 0,67$ $df = 32,1$

Residual variances were not significantly different at the 2 first steps but difference was significant ($p < 0,05$) at the third step. It should be therefore more accurate to use one equation for each sex from measurements over the loin.

2.1.2. From split measurements (REG)

The 3 steps in double regression have given :

_ For females :
$Z = 59,50 - 0,563 \times GREG + 0,224\ MREG$
$S_0 = 1,83$

$Y = - 14,91 + 1,025 \times Z + 0,022 \times GREG + 0,036 \times MREG$
$S_1 = 0,62$

$Y = 46,06 - 0,555 \times GREG + 0,265 \times MREG$
$S = 1,97$ $V(S^2) = 0,41$ $df = 36,1$

_ For castrates :
$Z = 59,60 - 0,550 \times GREG + 0,213\ MREG$
$S_0 = 2,79$

$Y = - 5,57 + 0,855 \times Z - 0,094 \times GREG + 0,094 \times MREG$
$S_1 = 0,71$

$Y = 45,36 - 0,564 \times GREG + 0,276 \times MREG$
$S = 2,48$ $V(S^2) = 0,70$ $df = 21,4$

Residual variances were significantly different ($p < 0,01$) at the first step but not at the 2 last steps. It should be therefore more accurate to use one equation for each sex from measurements taken on the split-line.

2.2. In Spain

The 3 steps in double regression have given :

_ For females :
$Z = 46,35 - 0,640 \times X4FOM + 0,109 \times X5FOM$

$S_0 = 1,51$

$Y = 21,23 + 0,886 \times Z - 0,330 \times X4FOM + 0,046 \times X5FOM$
$S_1 = 0,79$

$Y = 62,69 - 0,896 \times X4FOM + 0,143 \times X5FOM$
$S = 1,53 \quad V(S^2) = 0,62 \quad df = 15,3$

_ For castrates :
$Z = 48,45 - 0,670 \times X4FOM + 0,088 \times X5FOM$
$S_0 = 1,38$

$Y = 9,28 + 1,294 \times Z - 0,211 \times X4FOM - 0,081 \times X5FOM$
$S_1 = 0,46$

$Y = 71,99 - 1,078 \times X4FOM + 0,032 \times X5FOM$
$S = 1,83 \quad V(S^2) = 2,18 \quad df = 8,1$

_ For entire males :
$Z = 43,75 - 0,651 \times X4FOM + 1,168 \times X5FOM$
$S_0 = 1,98$

$Y = 25,49 + 0,716 \times Z - 0,562 \times X4FOM + 0,190 \times X5FOM$
$S_1 = 0,61$

$Y = 56,80 - 1,028 \times X4FOM + 0,310 \times X5FOM$
$S = 1,43 \quad V(S^2) = 2,70 \quad df = 2,9$

As degrees of freedom were few at the 2 last steps, Fischer tests were made on the 3 combinations of 2 sexes. All these tests were negative. On the contrary, at the first step, test was significant ($p < 0,05$) between castrates and entire males and near the signification between females and entire males. Meanwhile at the first step, degrees of freedom is sufficient to do a Bartlett test for a multiple comparison of variances ; this test was not significant. It is therefore possible to use a common estimator of residual variance and then to test the equality of the equations.

2.3. In The Netherlands

Only the last step has been published (ENGEL and WALSTRA, 1993).

$Yfemale = 61,21 - 0,74 \times X4HGP + 0,14 \times X5HGP$
$S = 1,86 \quad df = 67$

$Ycastrate = 59,43 - 0,67 \times X4HGP + 0,13 \times X5HGP$
$S = 2,17 \quad df = 75$

The difference between residual variances was not significant. But equations were significantly different. As the muscle coefficients were not significantly different, the Dutch have therefore chosen the same coefficient, which results in the following equations :

$Yfemale = 61,38 - 0,74 \times X4HGP + 0,13 \times X5HGP$ (1)

$Ycastrate = 59,35 - 0,67 \times X4HGP + 0,13 \times X5HGP$ (2)

common $S = 2,02$

Discussion

In the French trial, we found a difference between females and castrated males on the prediction of carcass lean, though protocol was not optimal. In The Netherlands, they found this effect either on the constant and the fat thickness coefficient. On the other hand they detected no differences between residual variances. However, they had limited the test to the last step of the double regression. In the Spanish sample, we didn't put in evidence of the differences between the three sexual types : females, castrates and entire males. Nevertheless, the experimental design was not aimed to find this objective. The three sexual types were very unbalanced with few observations in the subsample for castrates and entire males. Also the stratification on the carcass weight can produce parasites effect.

In the Dutch and French trials, an effect of sex was found, still remains how to include this effect in the method. The easiest and the most efficient system is using an equation for each sex. It is possible in France, where sex of 80%-90% of slaughtered pigs is recorded. In The Netherlands, carcasses are not sexed and they don't want to do this in future. However, as the Dutch experimental design was stratified on sex, it was necessary to exempt this effect linked with the stratification. That has been done by the prediction of the sex from the fat and muscle depth measurements. This prediction equation has been established from a logistic regression model (COX and SNELL, 1989).

The probability p to be a female is (E.C. Commission, 1992) :

$$p = \frac{1}{1 + e^{-u}}$$

$$\text{avec } U = -3{,}277 - 0{,}4580 \times X4HGP + 0{,}3038 \times X5HGP + 0{,}007777 \times (X4HGP)^2 - 0{,}001792 \times (X5HGP)^2 - 0{,}002557 \times X4HGP \times X5HGP$$

In The Netherlands, the new equation since January 1992 is :

$$Y = p \times Yfemale + (1 - p) \times Ycastrate$$

where the equations Yfemelle and Ycastrate were reported respectively (1) and (2) on the paragraph 2.3.

Definitively, this complex non linear equation does not depend on sex, but only on the predictors X4HGP and X5HGP. The increase of accuracy in comparison with a double regression equation without taking into account sex is low, due to poor prediction of sex by X4 and X5. Therefore, using an equation for each sex seems like the best solution ; moreover it is easy to carry out. It's clear that to put on evidence the effect of sex, each sex must be sampled separately to find accurate equations. It could be necessary to adapt the restraint from the EC regulations (EC Commission, 1985) concerning the sample size to assure an adequate size for each sex. In that case, the experimental costs can be maintained in acceptable level thanks to the use of double regression. In order to optimize the sample size, the best concomitant variable has to be chosen (CAUSEUR et al., 1994).

Conclusions

Using the EC trial for harmonizing the pig carcass grading methods, an effect of sex has been found in France and in The Netherlands. In Spain, this effect has not been detected, however the protocol was not powerful.

In France, this effect has been ignored. The Netherlands use a unique equation predicting sex from fat and muscle depths.

The best solution would be using one equation for each sex. This can be very easily implemented in France where most of the carcasses are already sexed. Now, the deviation between females and castrates is sub-estimated. An equation for each sex should favour the sex differenciation in farm and improve the behaviour in both sexes, achieving best equation between supply and demand and also permitting abattoirs and cutting rooms to sort carcasses and cuts more efficiently.

To assess accurate equations for each sex may generate an increase of the experimental cost, which can be moderated using double regression with a good concomitant variable.

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