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Economic Effects of Alternatives to Piglet Castration without Anesthesia in Germany

Briefing Paper 2017/2

Note: this is the English version of the orginal working paper which is available in German language:

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Summary

The amendment of the law on the prohibition of piglet castration without anesthesia which will come into force on January 1, 2019 requires a practice change in pig-producing farms in Germany. Viable strategies are boar finishing, vaccination against boar taint (so-called immunocastration) and the castration with anesthesia. The aim of this study is to provide an analysis of the economic impact of these alternative procedures and a comparison of the economic viability. In the first step, a reference situation (baseline) is specified for the currently applied castration of male piglets without anesthesia; further, the changes of the alternative scenarios are defined and quantified. The baseline is used as a reference for the quantification of the animal performance, costs and revenues in the alternative scenarios. As reference farms, North German structures as well as a Bavarian situation are modeled and depicted in a further calculation. The effects of the scenarios and certain variations are considered as a total cost calculation due to the fact that apart from the variable costs, investments and overhead costs, too, are affected by the changes.

Compared to the general practice of castration without anesthesia, the boar finishing can be regarded as favorable in terms of its profitability. Once the production rhythm is adapted to the reduced finishing period and the lower carcass weight (higher number of finishing cycles), the profitability is higher in the short and long term than in the baseline or the other scenarios. A precondition is that the occurrence of animals with boar taint is below 3.5 percent and that there is no price discount for animals with boar taint. In the scenario *vaccination against boar taint,* all key performance indicators are close to the baseline and can hence be evaluated as beneficial, too. The additional workload of the vaccination is compensated by a better feed conversion. The key performance indicators are lowest in the scenario with anesthesia procedures. This is due to the additional costs involved in piglet production and the lower performance of the castrated pigs in the finishing period until the moment of slaughter.

In terms of long-term profitability, the following order of profitability applies: boar finishing without investment – boar finishing with investment – immunocastration – baseline – castration with intramuscular anesthesia – castration with isoflurane anesthesia (inhalation). When using the Bavarian baseline, the relative benefits of the alternative methods for the piglet castration without anesthesia does not change, either.

JEL-Code: Q120

Keywords: piglet castration, boar finishing, immunocastration, castration with(out) anesthesia, farm economic impact

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1 Introduction

The amendment of the law on the prohibition of piglet castration without anesthesia that will come into force on 1 January 2019 means a change in the practice of pig-producing farms in Germany. As viable strategies to meet the challenge, boar finishing, vaccination against boar taint (so-called immunocastration) and castration under different anesthesia procedures are being discussed.

This Working Paper is based on a statement of the Thünen Institute of farm economics for the BMEL (German Federal Ministry of Food and Agriculture). With this existing data, further literature and own data sources, we perform an economic evaluation of the above mentioned alternatives to the castration without anesthesia. In chapter 2, we first specify a reference situation (baseline) with the current standard castration of male piglets without anesthesia. This baseline will be used as a reference for the quantification of animal performance, costs and revenues in the alternative scenarios. In Chapter 3, we present the identified scenarios with sub-scenarios and variational calculations.

Chapter 4 shows the calculation results and in chapter 5 we present the conclusions that can be derived from the analysis at the current state of knowledge.

The appendix contains extensive data and tables for the further presentation of the calculation bases and results.

2 Specification of the reference situation (baseline)

To compare the alternatives to castration without anesthesia, a comparative situation must be specified, here referred to as baseline = reference. This situation must reflect the current state of agricultural standard procedures, including the respective data concerning production and prices. The baseline includes the current practice of castration of male piglets without anesthesia.

The baseline refers to the calendar year 2015, the database used derived from the networks *agri benchmark Pig* (Deblitz, 2016) and *InterPIG* (2016). The enterprises under consideration are sow-keeping and pig farming.

The figures of both enterprises are calculated separately from each other in the baseline as well as in the scenarios and are then brought together at the end.
In the following, the results of the calculations are referred to as *imputed aggregation of the enterprises.*

The enterprises are characterized by the following basic figures:

Sow Enterprise

400 sows @ 27.89 reared piglets per sow and year = 11,128 reared piglets per year	
Price per reared piglet	48 EUR per piglet

Pig Finishing Enterprise

Capacity for 4,000 pigs	
11.128 produced piglets less 2.6 % mortality = 10,839 sold slaughter pigs per year	
Finishing time females and castrated pigs:	112 days
Final live weight females and castrated pigs:	121.5 kg live weight
Carcass yield females and castrated pigs:	79 %
Final carcass weight (warm) females and castrated pigs:	96 kg carcass weight
Price per finishing pig (females und castrated pigs, vaccinated boar):	1.40 EUR je IXP / kg cw
Price per finishing pig (intact young boar):	1.40 EUR je IXP / kg cw

In one further calculation, we use a baseline especially adapted to Bavarian conditions that was developed in collaboration with the Bavarian State Agency for Agriculture (LfL).

For the calculation of the business enterprises, the transfer of the reared piglets is valued according to market prices, resulting in the market revenue for the *sow enterprise*. The same price is used as bought-in price of the reared piglets in the *pig finishing enterprise,* resulting in the bought-in costs for the *finishing enterprise.* In the *imputed aggregation* of both enterprises, both values equalize so that they are not considered in the profit and loss account. The billing of the carcasses is done according to the valuation with index points (IXP) per kg carcass weight of AutoFOM III (Tönnies, Westfleisch). Therefore, in the baseline as well as in other single scenarios,

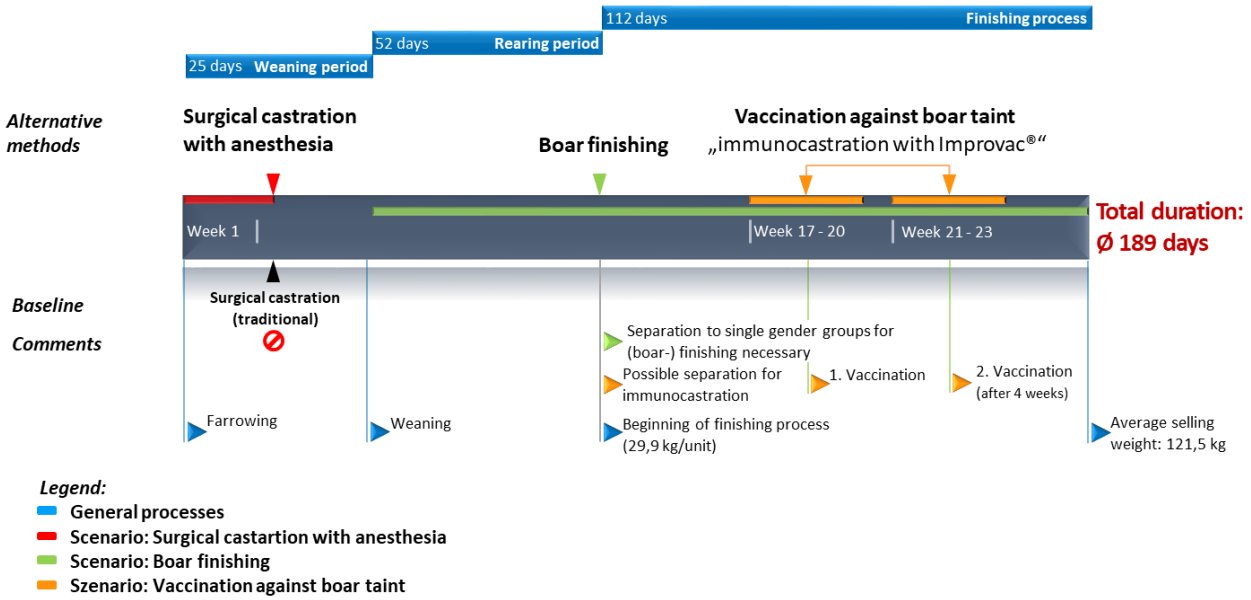
male and female animals are examined separately. By averaging the values of the sub indices, the billing systems of Tönnies and Westfleisch are considered. Further basic data of the baseline are in the appendix as well as in the description of the scenarios.

3 Specification of the scenarios

The specification of the scenarios is based on the evaluation of the available literature as well as telephone conversations and electronic communication with experts, especially veterinarians from different surgeries and state authorities.

The numbers presented in the tables – respectively for the baseline and for the scenario considered – are absolute values. The efficiency calculations in chapter 4 refer to these figures and the values from the baseline.

Figure 1: Alternatives to piglet castration without anesthesia over time



Source: own presentation.

Figure 1 shows an overview of the alternative methods to piglet castration without anesthesia in the course of time, taking into account the individual process phases and the specific characteristics of the methods. The surgical castration with anesthesia does not change the process of piglet rearing or the further finishing process. In the boar finishing, the animals aren´t castrated during the lactation phase. The separated stabling by sex can be started after the weaning or at the beginning of the finishing process. This allows an individual feeding adapted to the boars' needs and avoids premature pregnancies during the finishing. The same advantages of separated stabling apply for immunocastration. Furthermore, it allows a faster vaccination process, which must be carried out at intervals of four weeks during the finishing process. The following table gives an overview of the following scenarios and variational calculations.

Table 1: Overview of scenarios and variational calculations

	Piglet production	Pig finishing	Imputed aggregation of both enterprises
	Standard baseline (big enterprises)		
Scenarios & variational calculations (VC)			
Immunocastration	Chapter 3.1 / 4.1 / 5	Chapter 3.1 / 4.1 / 5	Chapter 3.1 / 4.1 / 5
Boar finishing without investment	Chapter 3.2 / 4.1 / 5	Chapter 3.2 / 4.1 / 5	Chapter 3.2 / 4.1 / 5
VC 1: reduced carcass weight	Chapter 4.2	Chapter 4.2	Chapter 4.2
VC 2: same finishing time for sows and boars	Chapter 4.3 / 5		Chapter 4.3 / 5
VC 3: same finishing time and increased number of finishing cycles	Chapter 4.4 / 5	Chapter 4.4 / 5	
Boar finishing with investment	Chapter 3.3 / 4.1 / 5	Chapter 3.3 / 4.1 / 5	Chapter 3.3 / 4.1 / 5
VC 1: reduced carcass weight	Chapter 4.2	Chapter 4.2	Chapter 4.2
VC 2: same finishing time for sows and boars	Chapter 4.3 / 5		Chapter 4.3 / 5
VC 3: same finishing time and increased number of finishing cycles	Chapter 4.4 / 5	Chapter 4.4 / 5	
Castration with Isofluran	Chapter 3.4 / 4.1 / 5	Chapter 3.4 / 4.1 / 5	Chapter 3.4 / 4.1 / 5
VC 4: shared use of the anesthesia equipment	Chapter 4.5	Chapter 4.5	Chapter 4.5
Castration with injection anesthesia	Chapter 3.5 / 4.1 / 5	Chapter 3.5 / 4.1 / 5	Chapter 3.5 / 4.1 / 5
Standard baseline (big enterprises)	Chapter 3.6 / 4.1 / 5	Chapter 3.6 / 4.1 / 5	Chapter 3.6 / 4.1 / 5

Source: own depiction.

3.1 Scenario 1: vaccination against boar taint (immunocastration)

Vaccination against boar taint has the advantage that no surgical intervention is necessary. In this scenario, the effect of the vaccination without any further adjustment measures is depicted (table 2).

- The slightly decreasing mortality during the lactation period (no castration, less stress) is slightly overcompensated by marginally increasing mortality during the finishing period.
- The time saved by avoiding castration is partly compensated by the increased expenditure for selecting and stabling by sex. The pigs ought to be stabled separately so the vaccination procedure can be carried out quicker. On the other hand, there is an increased expenditure for the fixing of the animals during the vaccination and other injections. All measures considered, the vaccination scenario means a slightly increased workload.
- During the finishing period, the mortality decreases while feed intake, feed conversion and daily weight gain improve. The carcass yield decreases slightly (higher bone content), the content of fat free lean increases slightly.

- In some cases, like other vaccinations, too, those against boar taint may have no effect. Averaged values indicate a frequency of 5 percent for the occurrence of "vaccination failures" (Adam et al. 2013a, SVSM 2016). According to the meat processing industry, the problem of odor polluted meat, which is unsuitable for human consumption, occurs in 3.5 per cent of the male animals. This value is assumed, too, for the share of boars which develop testicles despite the vaccination. In the accounting of the animals, this had no effect on the farmers.
- Finally, costs for controlling the boar´s testicles must be calculated.

Table 2: Specification scenario 1: vaccination against boar taint (immunocastration) - compared to base line

		Baseline	Sow enterprise	
Process performance				
Piglet mortality (lactation period)	% piglets (m)	14,50	14,40	Kmiec (2005)
Piglet mortality (rearing)	% piglets (m)	2,60	2,63	Meyer et al. (2013)
		Baseline	**Piglet management**	
Process time				
Add. expenditure of time for piglet selection	min/piglet (m)	–	0,37	KTBL (2010)
Saving of time (no castration)	min/piglet (m)	–	-0,95	Fredriksen et al. (2009)
		Baseline	**Finishing enterprise**	
Process time				
Workload required	min/animal (m)	19,20	19,96	(calculated); KTBL (2010)
Process costs				
Additional: vet, medicine, vet. Equipment	EUR/animal (m)	–	3,52	
of that:				
Vaccination costs	EUR/animal (m)	–	3,52	Delta-list (01/2016) through TiHo Hannover
Process performance				
Mortality	% animals (m)	2,60	2,33	Isernhagen (2015)
Feed conversion	kg/kg	2,82	2,62	Pauly et al. (2009)
Average daily weight gain	g/d	818	868	Androine et al. (2016)
Carcass yield	% animals (m)	79,00	77,82	Pauly et al. (2009)
Lean meat content	% animals (m)	57,90	58,72	Ilper (2011)
		Baseline	**Effect on further value added process**	
Vaccination failure	% animals (m)	–	5,00	Adam et al. (2013a); SVSM (2016)
Additional costs for testicle control	EUR/animal (m)	–	0,64	Ilper (2011)

Notes
(m) = male animals

Source: own depiction based on literature.

3.2 Scenario 2: boar finishing with an increased number of finishing cycles without investment

In this scenario, the boar finishing is calculated. Here, we assume that the number of finishing cycles can be increased because of the shorter finishing period. It is assumed that additionally required animals are purchased (table 3).

- Entire boars have a limited ability of feed intake and therefore should additionally be fed ad libitum (Adam et al., 2013a).
- The number of finishing cycles increases from 2.8 to 3.2.
- This increases the number of sold boars by approx. 830 animals (3.2 percent).
- The share of female animals declined to almost 47 percent because of the purchased boars.

Table 3: Specification scenario 2: boar finishing with an increased number of finishing cycles – compared to baseline

		Baseline	Sow enterprise	
Process Performance				
Piglet mortality (lactation period) (%)	% piglets (m)	14,50	14,40	Kmiec (2005)
Piglet mortality (rearing) (%)	% piglets (m)	2,60	2,63	Meyer et al. (2013)
		Baseline	**Piglet management**	
Process time				
Add. expendit. of time for piglet selection	min/piglet (m)	–	0,37	KTBL (2010)
Saving of time (no castration)	min/piglet (m)	–	-0,95	Fredriksen et al. (2009)
		Baseline	**Finishing enterprise**	
Process time				
Workload required	min/year/animal (m)	19,20	17,50	calculated according to Adam et al. (2013b)
Process Performance				
Number of finishing cycles (boars)		2,80	3,21	(calculated)
Share of female animals	%	50,00	46,76	(calculated)
Mortality (%)	% animals (m)	2,60	3,48	Adam et al. (2013b); Meyer et al. (2013); Weber (2012)
Finishing feed I (%)	%	50,00	50,03	(calculated)
Finishing feed II (%)	%	50,00	49,97	(calculated)
Feed conversion (boar)	kg/kg	2,82	2,52	Adam et al. (2013b); Weber (2012)
Average daily weight gain (boar)	g/d	818	895	Weber (2012)
Average selling weight (alive, boar)	kg LW (m)	121,5	115,0	assumption
Carcass yield (boar)	% animals (m)	79,00	77,34	Adam et al. (2013b); Weber (2012)
Lean meat content (FOM)	% animals (m)	57,90	60,85	Ilper (2011)
		Baseline	**Effect on further value added process**	
Share of odour polluted meat	% animals (m)	–	3,50	Westfleisch (2016); Tönnies (2016)

Source: own depiction based on literature.

- The figures of mortality, of changes regarding the piglet separation and avoidance of piglet castration are the same as those of the vaccination scenario (scenario 1).
- In the boar finishing, the working time per animal is slightly increased. On the other hand, the total working time required per animal decreases because of the shorter finishing cycle.
- The mortality increase by approx. 1.2 percent.
- The feed conversion and the daily weight gain improve.
- Because of the shorter finishing time, the final finishing weight decreases from 121.5 to 115 kg live weight. Compared to the baseline, the carcass yield decreases by almost 1.6 percent, the share of fat free lean increases by about 3 percent.
- On the average, losses due to odor polluted meat from boars amount to 3.5 percent (Westfleisch, 2016). However, these were not billed separately.

3.3 Scenario 3: boar finishing with an increased number of finishing cycles and additional investment

Scenario 3 is identical with scenario 2, with the exception of adjustments in the feeding system made in order to meet the changed needs of the boars. At the farms making those investments, this effect must be taken into account. The costs for the necessary adjustments of the feeding system are estimated at EUR 25 per finishing place.

Table 4: Specification scenario 3: boar finishing with an increased number of finishing cycles and with additional investment – compared to baseline

		Baseline	General	
Process costs				
Additional Investment costs	EUR/Platz/Jahr	–	25,00	Adam et al. (2013b)
		Baseline	**Sow enterprise**	
Process Performance				
Piglet mortality (lactation period) (%)	% piglets (m)	14,50	14,40	Kmiec (2005)
Piglet mortality (rearing) (%)	% piglets (m)	2,60	2,63	Meyer et al. (2013)
		Baseline	**Piglet management**	
Process time				
Add. expendit. of time for piglet selection	min/piglet (m)	–	0,37	KTBL (2010)
Saving of time (no castration)	min/piglet (m)	–	-0,95	Fredriksen et al. (2009)
		Baseline	**Finishing enterprise**	
Process time				
Workload required	min/year/pig (m)	19,20	17,50	calculated according to Adam et al. (2013b)
Process Performance				
Number of finishing cycles (boars)		2,80	3,21	(calculated)
Share of female animals	%	50,00	46,76	(calculated)
Mortality (%)	% animals (m)	2,60	3,48	Adam et al. (2013b); Meyer et al. (2013); Weber (2012)
Finishing feed I (%)	%	50,00	50,03	(calculated)
Finishing feed II (%)	%	50,00	49,97	(calculated)
Feed conversion (boar)	kg/kg	2,82	2,52	Adam et al. (2013b); Weber (2012)
Average daily weight gain (boar)	g/d	818	895	Weber (2012)
Average selling weight (alive, boar)	kg LW (m)	121,5	115,0	assumption
Carcass yield (boar)	% animals (m)	79,00	77,34	Adam et al. (2013b); Weber (2012)
Lean meat content (FOM)	% animals (m)	57,90	60,85	Ilper (2011)
		Baseline	**Effect on further value added process**	
Share of odour polluted meat	% animals (m)	–	3,50	Westfleisch (2016); Tönnies (2016)

Source: own depiction based on literature.

3.4 Scenario 4: surgical castration with inhalation anesthesia

In this scenario, a castration using an automated anesthesia with isoflurane is calculated. Here, mainly the costs for the castration and the relatively many working hours per pig have an effect on the total costs.

- In scenario 4, the additional expenditure of time for castration is significantly higher than for castration with injection anesthesia, as only two piglets can be treated at the same time. This has a considerable impact on the veterinary costs for monitoring the anesthesia.
- The depreciation and maintenance costs for the inhaler, evaporator and other material required for the inhalation are included in the costs of "technical use of anesthesia".
- Not taken into account are possible additional costs for the filtering of used air which releases CfC´s.
- There is no higher mortality than in the baseline.

Table 5: Specification scenario 4: surgical castration with inhalation anesthesia – compared to baseline

Sow enterprise			
Process costs			
Veterinarian, medicine, veterinarian equipment	EUR/piglet (m)	6,13	
of that:			
Anesthesia performed by veterinarian	EUR/piglet (m)	3,22	Hemkemeyer (2016)
Technical use of anesthesia	EUR/piglet (m)	0,43	Hemkemeyer (2016); SVSM (2016)
Dosing of medicine	EUR/piglet (m)	0,48	Hemkemeyer (2016); Delta-list (01/2016) through TiHo Hannover; Steigmann (2013); Zöls (2006)
Average travel costs	EUR/piglet (m)	2,00	Hemkemeyer (2016)
Piglet management			
Process time			
Additional workload: surgical castration	min/piglet (m)	3,40	Fredriksen et al. (2009); Hodgson (2007)

Source: Own depiction based on literature.

3.5 Scenario 5: surgical castration with injection anesthesia

In scenario 5, instead of the inhalation of Isofluran, the anesthesia is performed with an injection of Ketamin and Azaperon.

- Here, the veterinary costs and the time expenditure for the castration are lower than in scenario 4 (inhalation), because several piglets can be anesthetized at the same time and then castrated one after the other.
- Instead of investment costs for inhalation equipment, in this scenario, relatively high costs are incurred for consumable equipment (syringes and accessories) for the application of narcotic drugs and analgesics.
- The mortality increases as a result of the sleeping time following the anesthetic. Usually, the sleeping time is accompanied by cooling and subsequently reduced feed intake.

Table 6: Specification scenario 5: surgical castration with injection anesthesia – compared to baseline

Sow enterprise			
Process costs			
Veterinarian, medicine, veterinarian equipment	EUR/piglet (m)	6,62	
of that:			
Anesthesia performed by veterinarian	EUR/piglet (m)	2,25	Hemkemeyer (2016)
Dosing of medicine	EUR/piglet (m)	0,87	Delta-list (01/2016) through TiHo Hannover; Zöls (2006)
Consumable equipment	EUR/piglet (m)	1,50	Eckart (2016) Bavarian Chamber of Veterinarians
Average travel costs	EUR/piglet (m)	2,00	Hemkemeyer (2016)
Process performance			
Piglet mortality (lactation period)	% piglets (m)	2,80	Kmiec (2005); Lahrmann et al. (2004)
Piglet management			
Process time			
Additional workload: surgical castration	min/piglet (m)	0,20	Kmiec (2005); Lahrmann et al. (2004)

Source: Own depiction based on literature.

3.6 Scenario 6: adaption of the baseline to Bavarian structures

Due to differences in production figures, enterprise sizes and performance parameters as well as in market structures and market demands for Bavarian farms, a differentiated consideration is necessary. In this scenario, the baseline is adapted accordingly. The figures are based on calculation data from the Bavarian State Agency for Agriculture (LfL). The already mentioned alternative scenarios are applied to this changed baseline.

Overall, this baseline is characterized by a lower farm size and lower performance parameters. However, the prices for the products are higher than in the basic scenario: in 2015, the piglet price was almost 5 percent above the nationwide average of EUR 50.52 per piglet.

The marketing channels and marketing shares in Bavaria differ from other regions in the country. Nearly 30 percent of the pigs produced are exported to southern Europe, and around 10 percent are slaughtered and marketed by regional slaughterhouses (slaughter throughput less than 200 pigs per week). In 2015, farmers received a higher price (EUR 1.45 per kilogram of carcass weight) for these pigs. Here, the actual carcass weight is valued instead of using AutoFOM III. In Bavaria, too, the largest share (around 64%) of the pigs is processed by big slaughterhouses (slaughter throughput more than 200 pigs per week). The same price per index point and kilogram of carcass weight as in the basic scenario is assumed. Thus in Bavaria the average carcass weight price of pork (EUR 1.42 per kilo) is around 1.5 per cent above the national average. (Kohlmüller (AMI), 2016).

Table 7: Prices and shares of the differentiated marketing channels of Bavarian pig producers 2015

	Share	**Total share**	**Prices** (EUR/(IXP) kg CW)
Marketing channel			
Export	–	27%	1,45 €
Domestic market	–	73%	
of that:			
big slaughterhouses	87%	64%	1,40 €
regional slaughterhouses	13%	9%	1,45 €

Source: LfL (2016); AMI (2016).

Table 8: Modified baseline scenario 6: Important modifications of the key figure „Sow enterprise“

		Sow enterprise
Production system		
Number of places	No. places	100
Livestock		
Number of sows	No. heads	100
Number of boars	No. heads	1
Performance		
Born piglets per sow	piglets/sow/year	26,33
Litters per sow and year	litters/sow/year	2,25
Lactation time per litter	days	28
Weaning weights	kg LW	6,8
Cull rate sows	%	39,40
Cull rate boars	%	50,00
Fraction of own replacement	%	100,00
Sow mortality	%	7,00
Boar mortality	%	7,00
Piglet mortality (lactation period)	%	11,00
Piglet mortality (rearing)	%	2,00
Weaner	piglets/sow/year	23,43
Average piglet rearing time	days	54
Reared piglets	piglets/sow/year	22,96
Selling weights		
Selling weight sow	kg CW	175,0
Selling weight boar	kg CW	220,0
Selling weight weaned piglet	kg LW	6,8
Selling weight reared piglet	kg LW	29,9

Source: data from calculations, LfL.

In case of smaller farm sizes and decreasing productivity, the keeping of breeding sows changes: smaller litter sizes and less mortality can be found.

Table 9: Changed baseline scenario 6: important modifications of the key figure „Finishing enterprise“

		Finishing enterprise
Livestock		
Places	No. Places	825
Number of sold animals (female & castrated)	No. heads	2.257
Share of female pigs	%	50,0
Performance		
Stalling-in weight	kg LW	29,90
Stalling-in weight (boar piglets)	kg LW	29,90
Average finishing time	days	117,00
Days without animals in stable	days	12,89
Mortality	%	1,75
Average selling weight (alive)	kg LW	121,50
Carcass yield	%	79,00
Share of fat free lean	%	57,90
Carcass weight	kg CW	96,00
Average daily weight gain	g/d	780,00
Feed conversion	kg/kg	2,85
Number of finishing cycles		2,81

Source: data from calculations, LfL.

In the production of pork, the significantly smaller number of finishing places is noticeable. In addition, a lower daily weight gain leads to a longer finishing period. The feed conversion, too, is considered to be slightly worse. Further key figures for the Bavarian baseline are given in the appendix.

4 Calculation results

4.1 Comparison of scenarios

In the following, the calculation results relating (1) to the production units (reared piglets, finishing pigs) and (2) to 100 kg produced weight are compared for the baseline and for the different scenarios. This type of presentation was chosen because the comparison of the different scenarios is of interest. The economic results for each sow place and for each finishing place as well as the tabular presentation of the results can be found in the appendix.

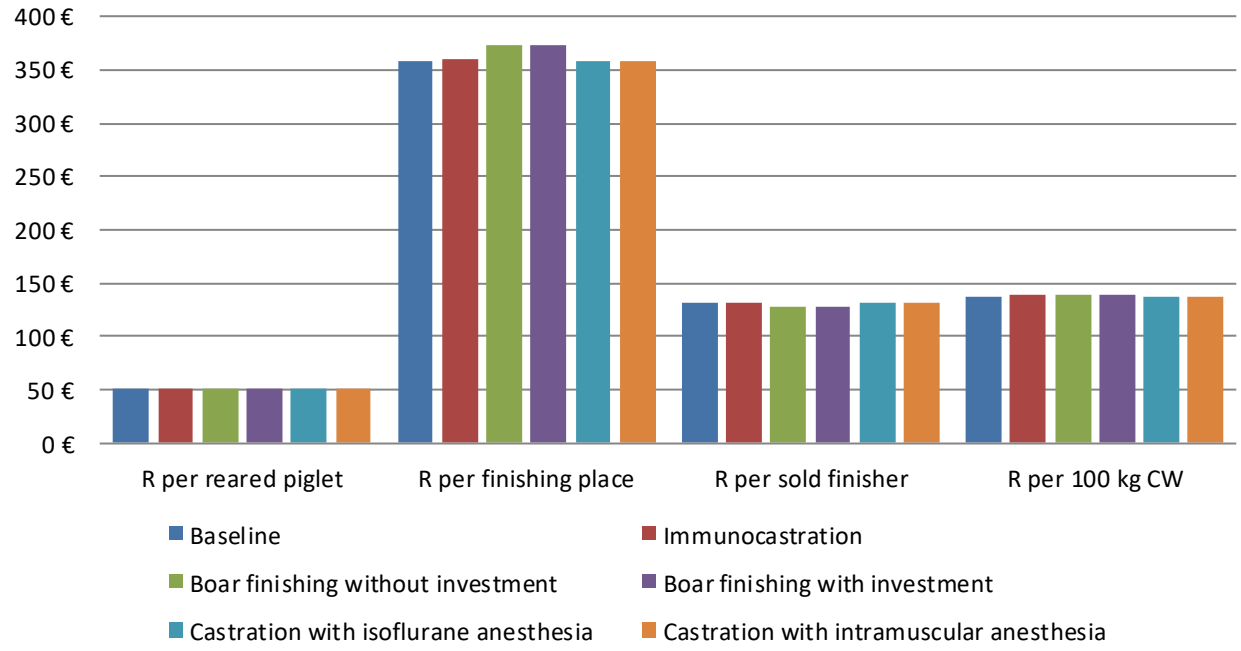
When interpreting the results, it must be taken into account that these are to a considerable extent dependent on the assumptions made. The actual results of individual companies may fluctuate around the calculated values. It can be assumed that the differences between individual farms are already bigger in the baseline than between the scenarios calculated in the presented study.

Table 2 depicts the performance for the baseline and the different scenarios as well as for the different reference values.

- The performances in the sow keeping include the returns for piglets, culled sows and culled boars, amounting to EUR 50 per reared piglet.
- The performances in the pig finishing include the returns from the slaughter pigs which is EUR 132 per finishing pig. Boars have a lower carcass weight than sows or castrated pigs. Therefore, the returns per finishing pig are lower in the two relevant scenarios.
- The returns vary, depending on the effects of the scenarios on the mortality, the carcass weight and the realized price per index point per animal or weight unit.
- In many cases, the effects regarding the different mortality rates offset each other. As a result, the differences between scenarios are relatively small.

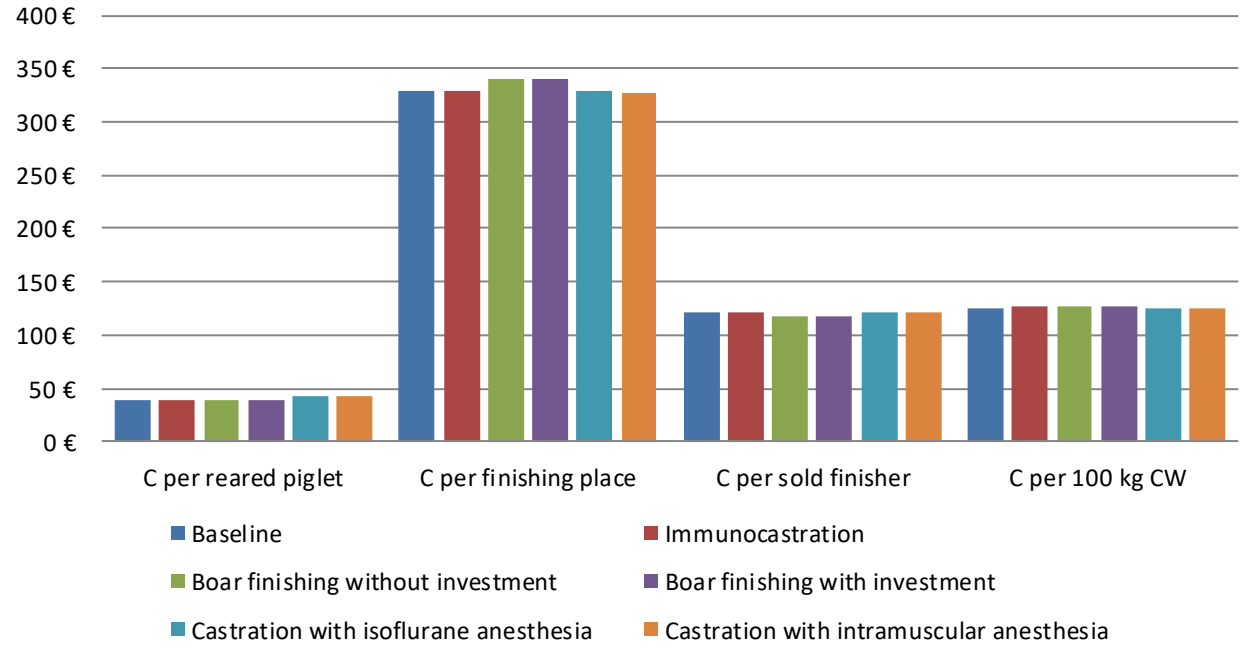
Table 3 shows the corresponding variable costs. Between the baseline and the scenarios, the differences in variable costs per animal and per kg are relatively small. One exception are the two scenarios with anesthesia because of the additional costs for the veterinarian and for medicinal products. Another exception are the two boar finishing scenarios. Here, the variable costs per finishing place are about EUR 12 higher, which can be explained with the purchase of piglets for the boar finishing.

Figure 2: Returns (R) in the baseline and in the investigated scenarios and different reference values



Source: own calculations.

Figure 3: Variable costs (C) in the baseline and in the investigated scenarios and different reference values



Source: own calculations.

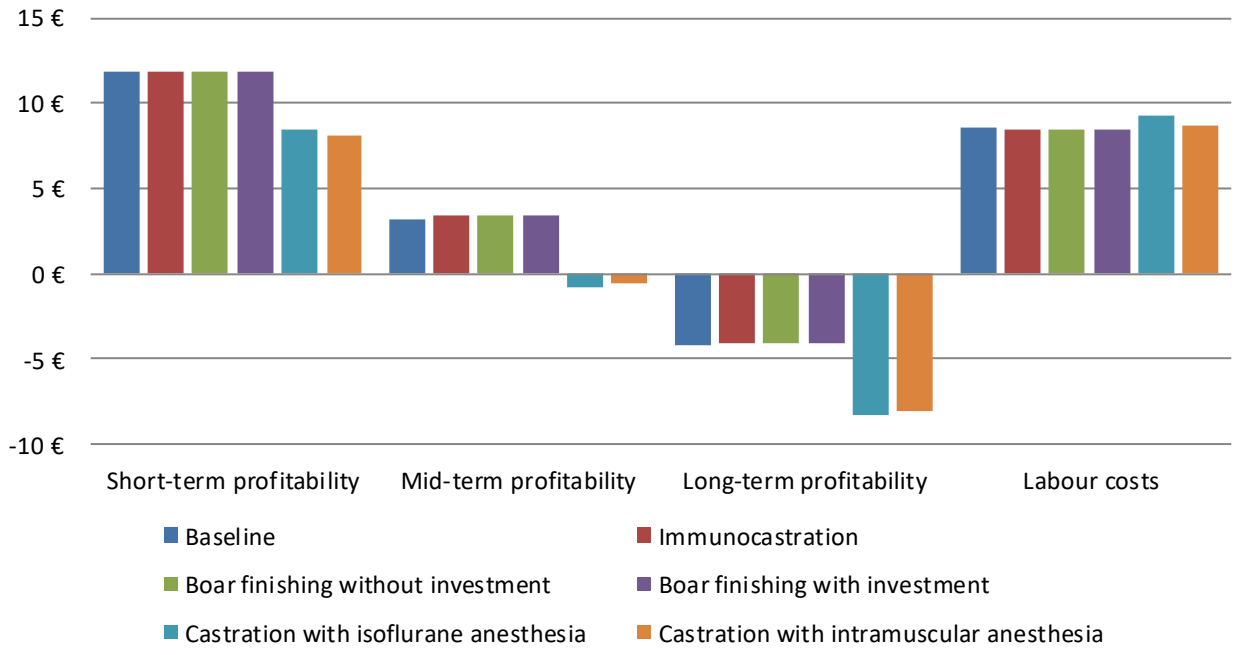
The further calculation of the key performance indicators

If the *variable costs* are subtracted from the *returns*, the result is the *short-term profitability*. Reduced by the *labour costs* (rated with EUR 20 per hour), the result is the *mid-term profitability*. If this is reduced by the *depreciation costs of buildings*, the *long-term profitability* is the result. Those profitability indicators and costs are presented in the tables below.

Figure 4 shows the results per reared piglet in the sow enterprise and is important for the results of the piglet production. The short-term and long-term key performance indicators are very similar between the baseline and most of the scenarios.

- Due to the high labor costs, the procedure with anesthesia has the worst results.

Figure 4: Profitability and other costs for the investigated scenarios (EUR per reared piglet)

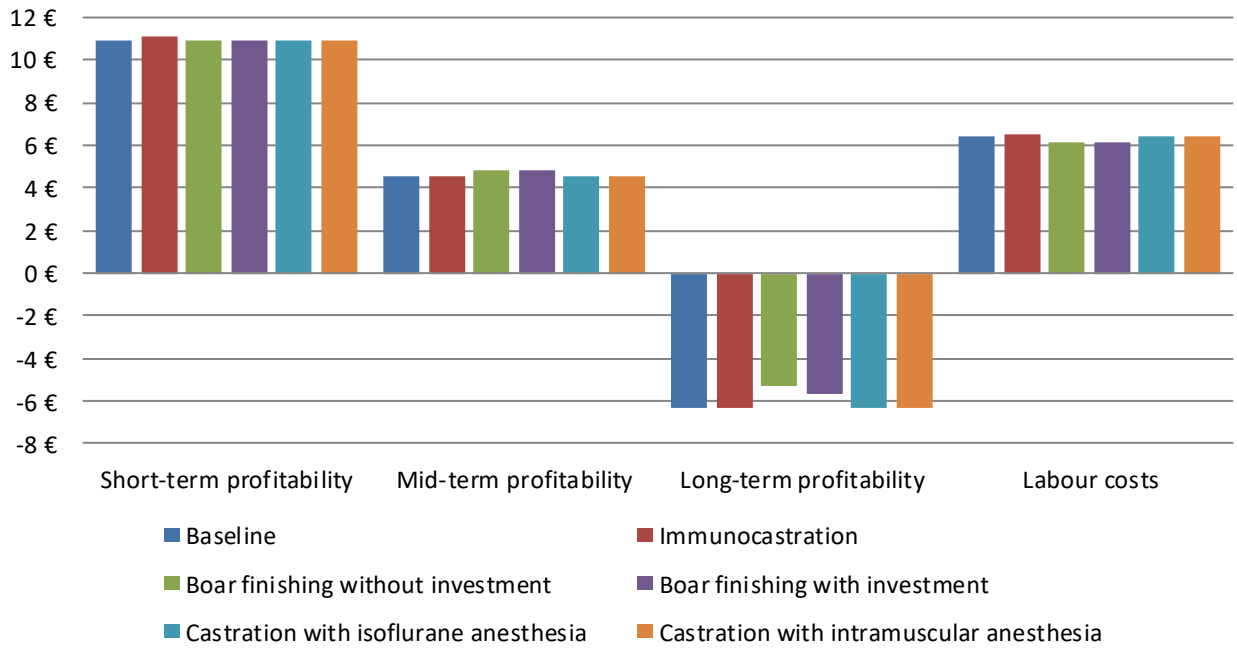


Source: Own calculations.

Figures 5 und 6 show the profitability situation in the pig finishing enterprise.

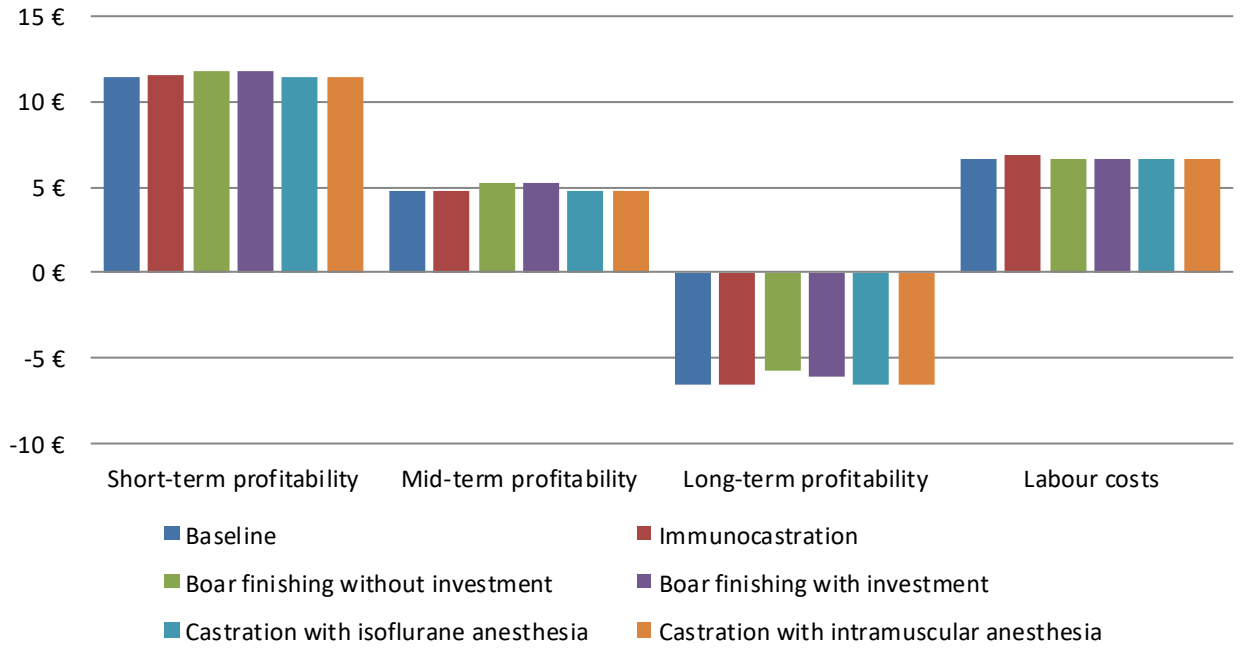
- The baseline and all scenarios virtually show no differences in the short-term profitability per finishing pig. The short-term profitability is positive in all scenarios and the price is about EUR 11 per finishing pig.
- The labor costs in the different scenarios and in the baseline are practically the same, too. Due to the shortened finishing period in the boar finishing and in spite of a higher working load, there are slightly lower labor costs per finishing pig. This effect offsets when 100 kg carcass weight are considered so that the differences between all calculations of this kind are very small.
- Immunocastration shows slight advantages for finishing pigs in the short term. As a result of the increased workload for the vaccination, this scenario turns out to be slightly less profitable in the long term compared with the baseline.
- The methods of boar finishing show better results in all key performance indicators than the baseline. By increasing the number of finishing cycles, the costs per finishing place are reduced (higher number of sold pigs per year), so that these costs are much lower per pig. The better performance data of boars in the production additionally ensures a higher profitability in the pig finishing.

Figure 5: Profitability and other costs for the investigated scenarios (EUR per finishing pig – pig finishing enterprise)



Source: own calculations.

Figure 6: Profitability and other costs for the investigated scenarios (EUR per 100 kg carcass weight – pig finishing enterprise)



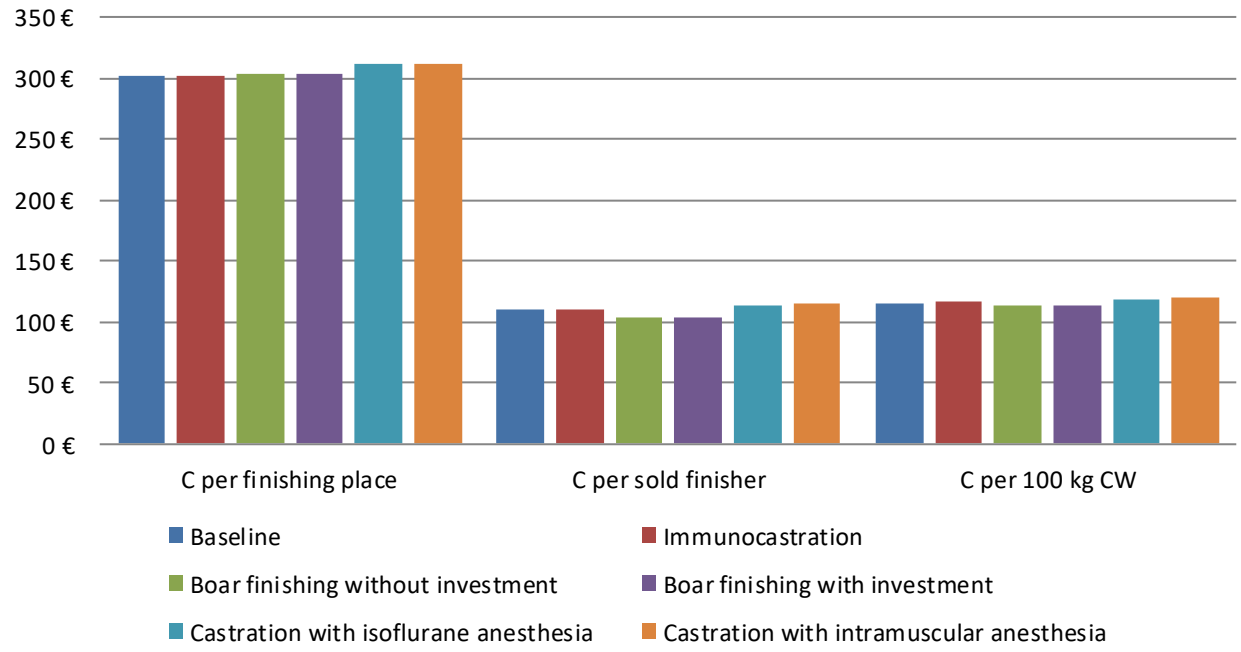
Source: own calculations.

The previous results have been presented separately by enterprises. Figures 7 und 8 present the results of the cumulated effects of the scenarios in a closed system (finishing of own piglets). Here, the higher costs of piglet production were added to the possibly higher costs in the pig finishing. Also, the piglet price was left out when changing from sow keeping to pig finishing. The results can be summarized as follows:

- The variable costs of the castration with Isofluran and injection anesthesia are the highest per finishing place, per finishing pig and per 100 kg carcass weight. This effect is due only to the increased costs of the above mentioned methods of castration in piglet production.
- The variable costs in the boar finishing show different results. On the other hand, the cost per finishing place is slightly increased by the purchase of the male reared piglets in comparison to the baseline. On the other hand, the cost per sold finishing pig is lower since the number of fattened animals is higher. Considering 100 kg carcass weight, this advantage is reduced because of the lower weight of the slaughter boars.
- The effect of the investment in feeding technology for boar finishing is marginal (building costs are not shown here, see appendix).
- The vaccination against boar taint has slightly higher variable costs than the baseline und thus lies between the baseline and the various castration methods with anesthesia.

- The scenarios of boar finishing have the lowest variable costs (EUR 113) per 100 kg carcass weight, whereas the surgical castration with injection anesthesia has the highest values (EUR 120 / 100 kg carcass weight).

Figure 7: Variable costs for the investigated scenarios in the imputed aggregation of the enterprises and different reference values



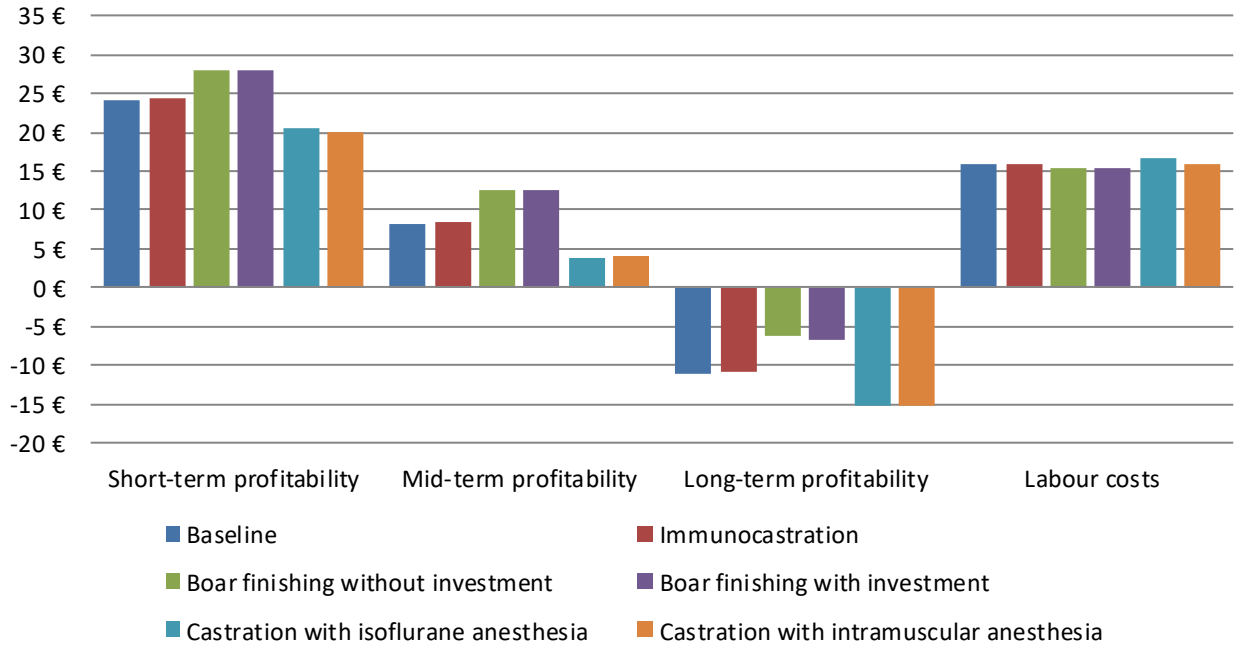
Source: own calculations.

Figure 8 shows the profitability and the additional costs per 100 kg carcass weight in a closed system.

- The boar finishing has to be considered favorable in terms of profitability. When the production rhythm of the boar finishing is adapted to the shorter finishing time and the lower carcass weight (increased number of finishing cycles), the long-term and short-term profitability is higher than in the baseline and all other scenarios.
- In the scenarios with the different anesthesia methods, the key performance indicators are the lowest, showing the effect of additional costs in the piglet production and the lower performance of the castrated male pigs during the finishing period till the moment when they are slaughtered.
- The labor costs per 100 kg of carcass weight are mostly on the same level as the baseline and slightly higher in the scenarios with vaccination against boar taint and castration with Isofluran. One exception is the boar finishing. Due to the shorter finishing time, the total of required workload per animal is lower, although a more intensive care of the boars is assumed.

- The vaccination against boar taint leads to the fact that all key performance indicators of these scenarios are close to the baseline and have to be considered as favorable. The additional workload of the vaccination is compensated by the better feed conversion.
- Concerning the long-term profitability, the calculations result in the following order of efficiency: boar finishing without invest – boar finishing with invest – immunocastration – baseline – anesthesia with injection – anesthesia with Isofluran.
- The differences between the scenarios are approx. EUR 9 per 100 kg carcass weight (EUR 0.09 per kg carcass weight).

Figure 8: Profitability and other costs for the investigated scenarios in the imputed aggregation of the enterprises (EUR per 100 kg carcass weight)



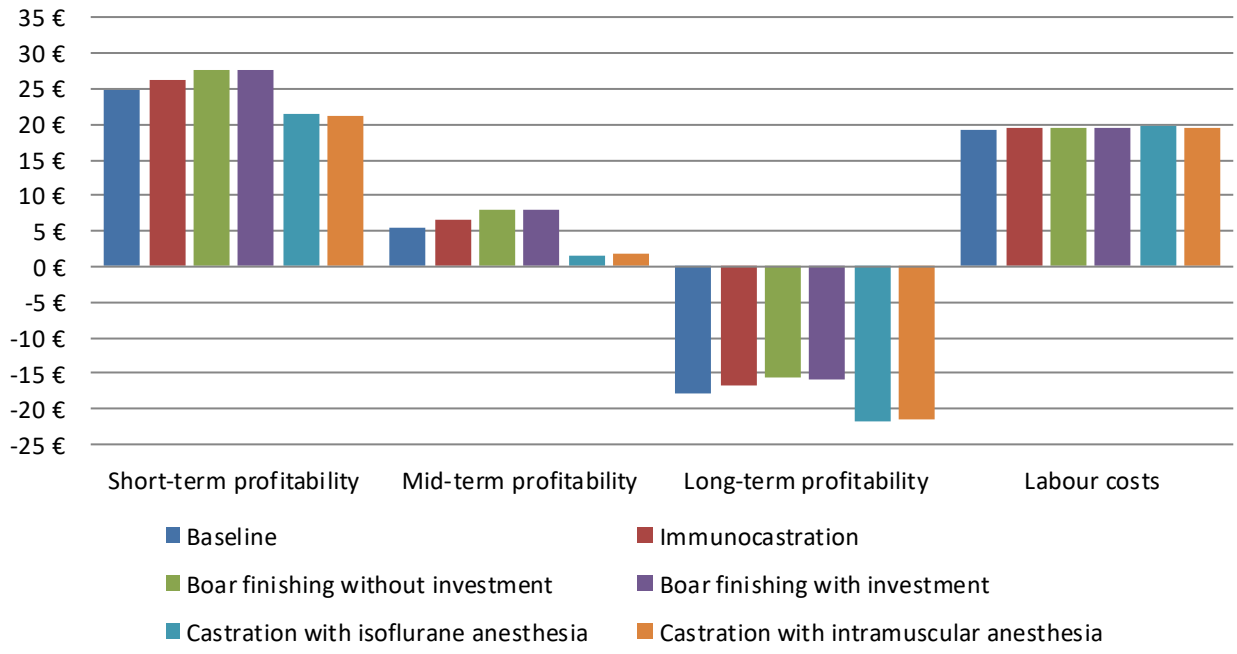
Source: own calculations.

Figure 9 shows the results of the imputed aggregation of the enterprises in reference to the Bavarian baseline. Profitability and other costs for the investigated scenarios refer to 100 kg carcass weight.

- Due to higher prices, the short-term profitability is above the values of the standard baseline. In all scenarios, even the contribution margin has lower values, which can be explained by a higher working time requirement per finishing place. Even the mid-term profitability of all scenarios already has lower values, which can be explained by the additional working time requirement per finishing place.

- Overall, a lower long-term performance level and a higher cost level can be observed in the Bavarian production. In the scenarios, the short-term profitability is up to EUR 9 per 100 kg carcass weight below the values of the standard baseline.
- The economic advantage of the immunocastration increases slightly in comparison to the baseline.
- Despite the different values in the baseline of the Bavarian farm with Bavarian indicators, the relative advantage of alternative methods to the piglet castration without anesthesia does not change.

Figure 9: Profitability and other costs in reference to the Bavarian baseline for the investigated scenarios in the imputed aggregation of the enterprises (EUR per 100 kg carcass weight)



Source: own calculations.

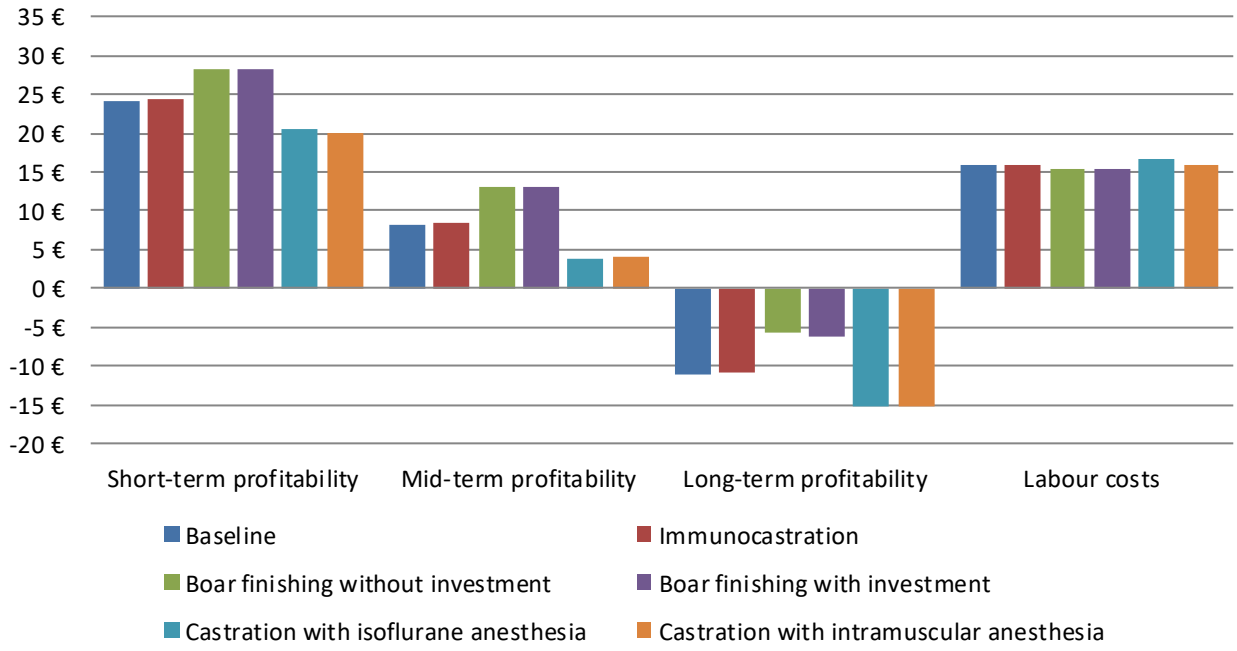
4.2 Variational calculations 1 for scenario 2 and 3: reduced carcass weight in the boar finishing

In other countries of the European Union, pork production with the method of boar finishing is already common practice, especially in Spain. A direct comparison or a direct transfer of the performance characteristics is not possible, since technologies like husbandry conditions, feeding methods and required genetic engineering have been established over a long time.

In these countries, the reduced carcass weight of boars is noticeable. In the following variational calculations, the final finishing weight in der boar finishing as a reference value for the Spanish

production of boar pork was reduced again from 115 kg to 110 kg live weight (Deblitz, 2016). This increases the number of finishing cycles in boar finishing to almost 3.4. In this case, the number of purchased male piglets sums up to 1163 und the average finishing time is reduced to only 89 days.

Figure 10: Profitability and other costs in relation to the standard baseline in the imputed aggregation of the enterprises with reduced final finishing weight in the boar finishing (EUR per 100 kg carcass weight)

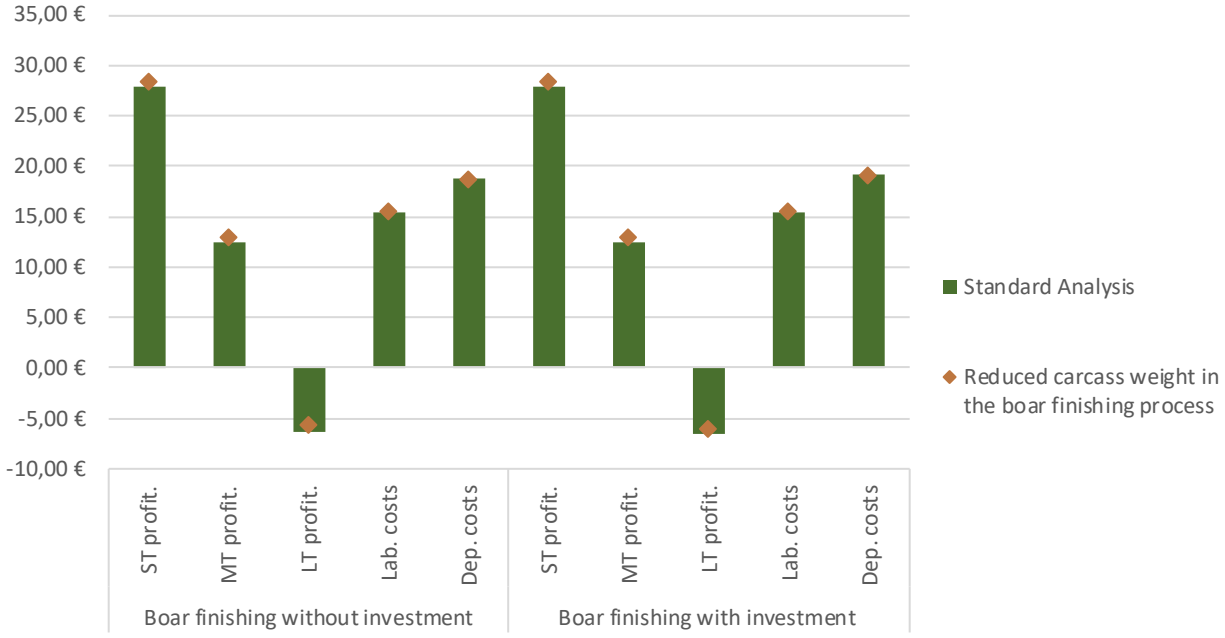


Source: own calculations.

Figure 11 shows the comparison of the results of profitability and other costs of the boar finishing scenarios with the variational calculations of reduced carcass weight. The effects of the earlier slaughtering are minimal.

- The costs per 100 kg carcass weight are almost identical.
- The key performance indicators (short-term profitability, mid-term profitability and long-term profitability) improve slightly with the reduction of the final finishing weight. The difference is about EUR 0.50 per 100 kg.

Figure 11: Comparison of profitability and other costs of boar finishing scenarios with variational calculations of reduced carcass weight (EUR je 100 kg carcass weight)



Abbreviations
ST profit. = short-term profitability; MT profit. = mid-term profitability; LT profit. = long-term profitability; Lab. costs = labour costs; Dep. costs = Depreciation costs (costs of buildings)

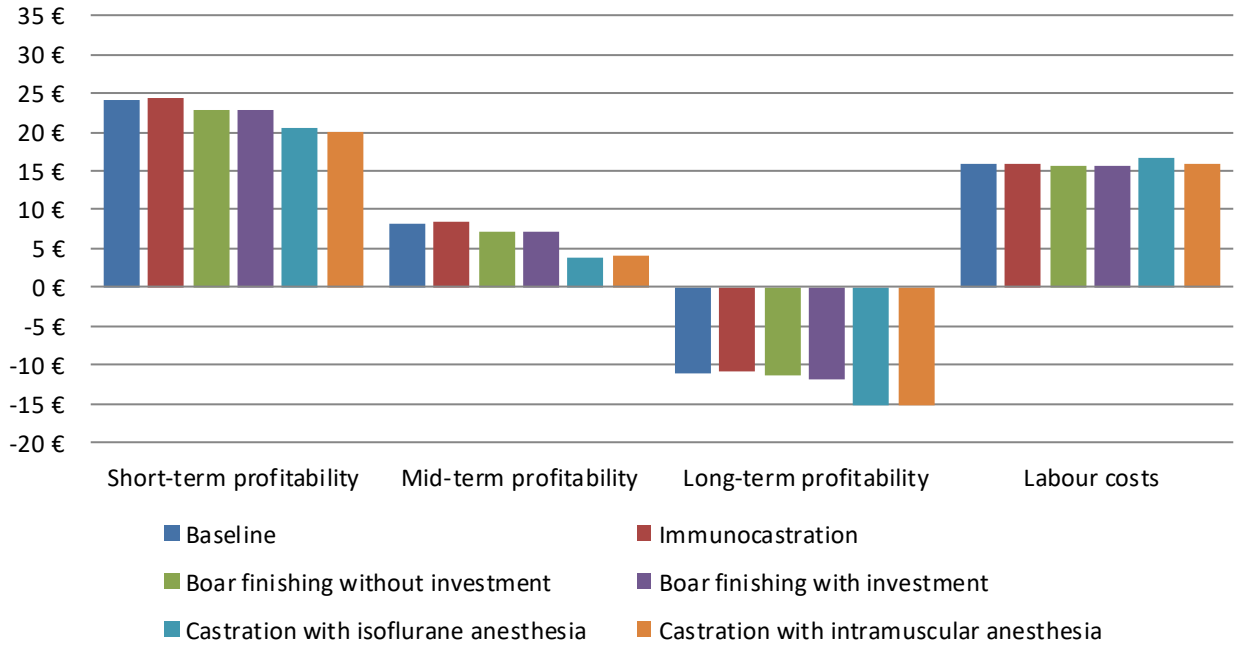
Source: own calculations.

4.3 Variational calculations 2 for scenario 2 and 3: same finishing time for sows and boars in the imputed aggregation of the enterprises

Farmers who finish own piglets and don´t purchase additional animals might decide to have the same finishing cycle for both sows and boars. (all in – all out). Thus, the stable can be filled respectively cleaned at the same time. In the variational calculations, a persistent selling weight weight of 121.5 kg (standard-baseline) is assumed. Due to the higher daily weight gain, the boars reach this weight after 102 days, which is 10 days quicker than the castrated pigs in the baseline. In the same time, the finishing sows reach a live weight of about 113 kg. Due to the shorter finishing time, the number of vacancy days rises from 18.5 to 28.6 per year when no animals are purchased additionally. Therefore, the number of finishing cycles does not raise with these variational calculations.

Figure 12 shows the results of the variational calculations with adapted finishing time for sows und boars in reference to the standard baseline in a closed system. Both boar finishing scenarios lose their preference, having worse results than the baseline and the immunocastration in the short und long term. The reason for this is that the reduced returns resulting from the decreased carcass weight of sows overcompensate the advantages from boar finishing.

Figure 12: Profitability and other costs related to the standard baseline in the imputed aggregation of the enterprises with the same finishing time for sows und boars (EUR per 100 kg carcass weight)



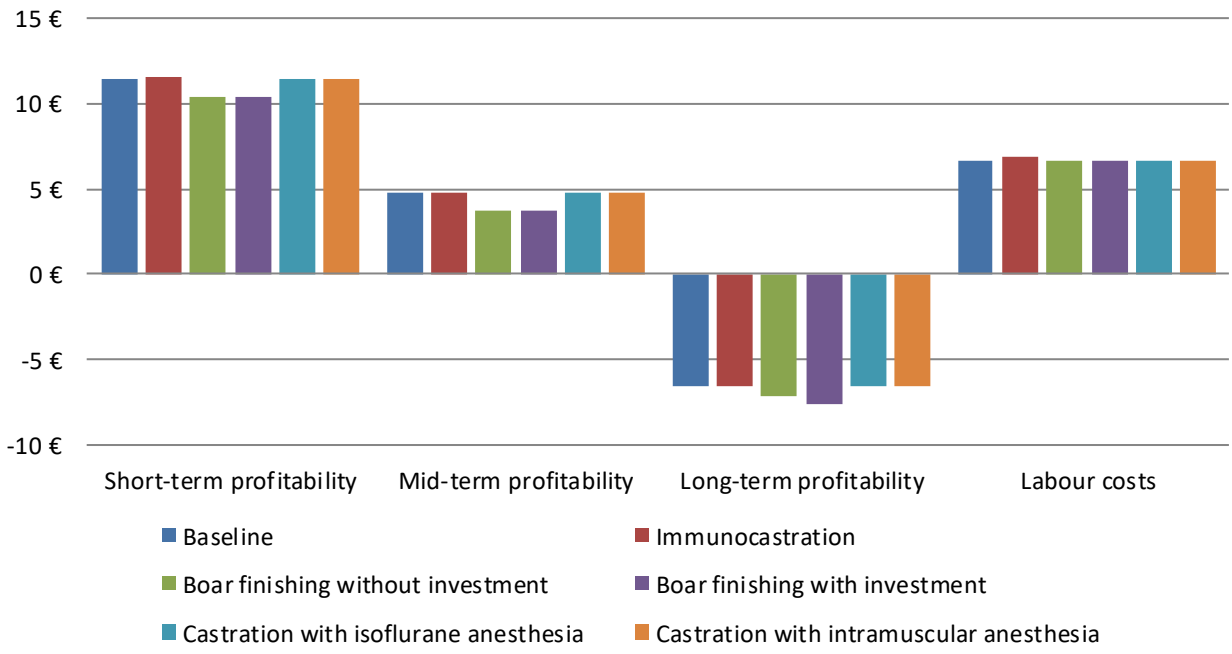
Source: own calculations.

4.4 Variational calculations 3 of scenario 2 und 3: same finishing time and increased number of finishing cycles

Finishing enterprises generally purchase their piglets. Provided an adapted finishing time of 102 days, the enterprises can raise the number of finishing cycles and buy the number of animals in equal shares that is additionally required für die utilization of the sty capacity. The final finishing weight for the adapted duration of the finishing is therefore 121.5 kg live weight für boars and 113 kg for sows. The number of the finishing cycles increases in this variational calculations from 2.8 to 3.0.

Figure 13 shows the results of the profitability and other costs in reference to the standard baseline in the finishing enterprise with the same finishing time for sows and boars in EUR per 100 kg carcass weight. The figures for the anesthetic procedures and for the baseline are the same, as the costs for the piglet castration with anesthesia accrued already in the piglet production.

Figure 13: Profitability and other costs related to the standard baseline in the finishing enterprise with the same finishing time for sows und boars (EUR per 100 kg carcass weight)



Source: own calculations.

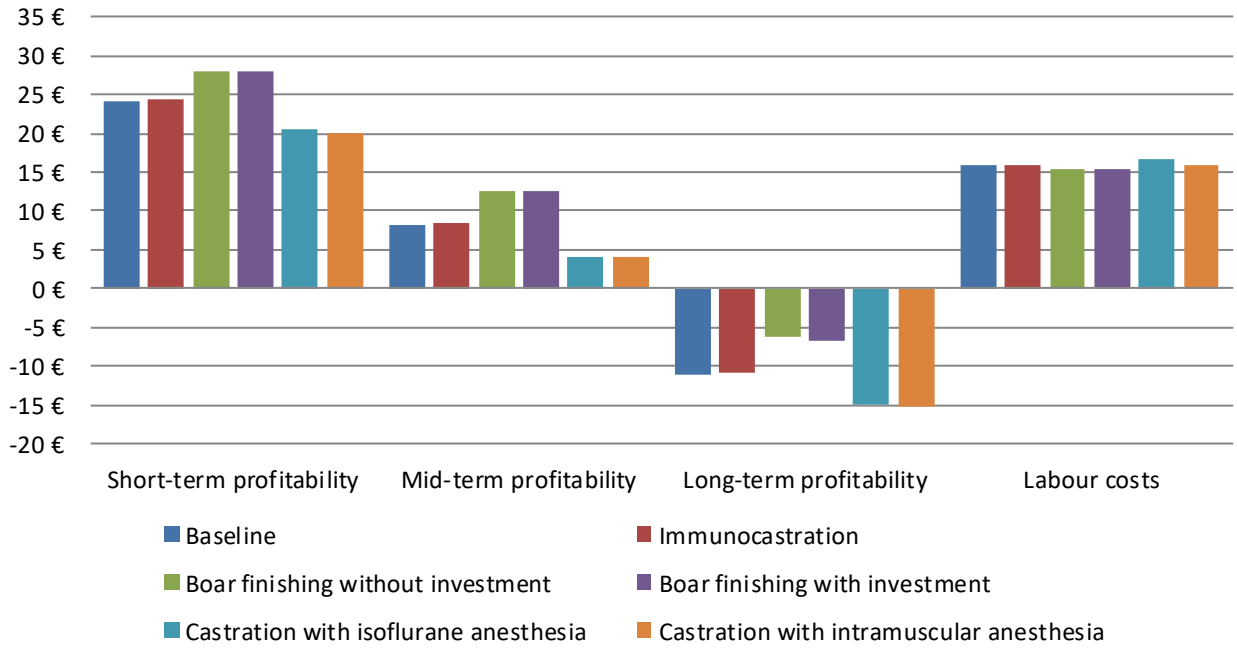
An increased number of finishing cycles in the boar finishing scenarios and the higher number of sold animals involved means a minimal short-term advantage in comparison to the baseline. In the long term, the boar finishing draws level with other methods. Possible investments in the finishing enterprises with intended boar finishing add up to the negative effects.

4.5 Variational calculations 4 of scenario 4: shared use of the anesthesia equipment

The application of the inhalation anesthesia with isoflurane requires an anesthetic device. The price for the purchase is about EUR 7200. The annual depreciation is determined by the useful life, which is assumed to be 6 years in the basic scenario. Together with the annual maintenance costs, everything sums up to the annual equipment costs. In the basic scenario, these costs are estimated at EUR 0.43 per anesthesia. Assuming the use of the device in only one farm with 5000 to 6000 castrations per year, the anesthetic device wouldn´t be working to capacity.

A shared use of the anesthesia equipment is therefore conceivable, as it minimizes the equipment costs. In the case of a full utilization of the equipment on farms with similar numbers of cattle as in the baseline, it would theoretically be possible to operate 9 plants with one device. This would reduce equipment costs from EUR 0.43 to EUR 0.05 per anesthesia. We must point out that a shared use of anesthesia equipment entails a high risk of infection for the piglets.

Figure 14: Profitability and other costs related to the standard baseline in the imputed aggregation of the enterprises with shared use of the anesthesia equipment (EUR per 100 kg carcass weight)



Source: own calculations.

The results of the variational calculations concerning the shared use of the anesthesia equipment only show minimal changes. Investigating the contribution margin and the long-term profitability, there is no more difference between both anesthesia scenarios. Nevertheless, procedures with anesthesia stay those with the worst economic results in all investigated scenarios.

5 Conclusions

In the investigated scenarios, the results show - related to the long term profitability - differently pronounced economic long-term advantages and disadvantages of the renouncement from castration without anesthesia. This means that there is no general answer to the question about the effects, so different scenarios and their results have to be considered individually.

For the analysis presented in this paper, the following statements can be made:

- The economic results are already negative as a result of the particularly low pig meat prices in 2015 (baseline). The difference between the baseline and the scenarios would, however, remain as well with other price conditions.
- If the reported economic disadvantages of castration with general anesthetic persist, the implementation of the ban on anesthesia in 2019 will require price compensations for pig farmers if the existing efficiency standard is to be maintained.
- The boar finishing has certain economic advantages as long as the sale of the pigs is guaranteed and there are no financial deductions for odor polluted boars.
- Under the differentiated considerations of different reference situations (standard baseline and Bavarian baseline), the relative effects of the scenarios are the same. Consistent additional costs (e.g. for medicinal products) carry more weight when the performance level or the enterprise size is low.
- In both investigated scenarios, the surgical castration with general anesthetic proves to be less favorable compared to the other methods. The best results were achieved with methods of boar finishing – regardless of the necessity to invest in an adapted feeding technology.
- Individual variations in the assumptions (reduced final finishing weight in the boar finishing, shared use of the anesthesia equipment when using inhalation anesthesia) have no effect on the order of efficiency of the alternatives compared to the reference situation. Also, the economic benefit of the examined scenarios only changes slightly.

The results of the profit and loss account of the investigated scenarios are presented in table 10. The colors symbolize the change in the calculatory gain of the scenarios compared to the baseline (green = advantageous, red = disadvantaged, gray = neutral effect).

Table 10: Changes in the calculatory profit of the enterprises compared to the baseline in the overview

	Piglet production Calculatory profit in EUR per reared piglet	**Pig finishing** Calculatory profit in EUR per 100 kg CW	**Imputed aggregation of both enterprises** Calculatory profit in EUR per 100 kg CW
Scenarios			
Immunocastration	0,12 € 	-0,04 € 	0,06 € 
Boar finishing without investment	0,12 € 	0,78 € 	4,79 € 
Boar finishing with investment	0,12 € 	0,39 € 	4,37 € 
Castration with Isofluran	-4,04 € 	0,00 € 	-4,32 € 
Castration with injection anesthesia	-3,82 € 	-0,04 € 	-4,12 € 

Source: own calculations.

- *Piglet production*: Compared to the baseline, the returns in the piglet production don´t change while in the scenarios without castration, production costs decrease. A considerable increase of the total costs in the piglet production is caused by surgical castration with general anesthetic, with costs for inhalation anesthesia exceeding those for the injection.
- *Pig finishing*: In this enterprise, additional returns resulted in the boar finishing scenarios and in the scenarios of boar finishing (with vaccination). The additional costs for the immunocastration resulting from the vaccination and the additional workload were compensated by an increased performance. The costs of the meat production with boar finishing were reduced. In these two scenarios, the result is a higher return per 100 kg carcass weight for the *pig finishing enterprise*.
- *Imputed aggregation of the enterprises:* This approach makes it possible to compare the effects of all scenarios with regard to the additional costs and changes in revenues, and thus the change in the calculated profits within a company.
- The advantages of the boar finishing are clear: reduced costs for piglet production due to the omission of castration, decreasing costs and higher productivity in the finishing lead to a significantly higher profit per 100 kg of carcass weight.

- In the case of immunocastration, the cost savings in the piglet production and the higher productivity in the finishing process are offset by the additional costs for the vaccination, so this scenario does not mean a monetary change for the company.
- Compared to the baseline, the revenue structure of anesthetic procedures does not change, but additional costs for the castration arise that have a considerable effect (per 100 kg carcass weight). However, a further reduction in the costs of surgical castration does not lead to a better position of these procedures compared to the other alternatives.

Table 11 shows the price required per reared piglet respectively per kg carcass weight to achieve the same profitability as in the baseline.

- *Piglet production*: Under the assumptions made, price increases of 7 to 8 percent are necessary to compensate the surgical castration under anesthesia.
- *Pig finishing*: compared with the baseline, the ratio of the key performance indicators to the basic price per kilogram of carcass weight in relation to the performance per 100 kg of carcass weight does not change in the scenarios of the application of surgical castration under anesthesia.
- Pig finishing: in the case of the boar finishing and the finishing of vaccinated boars, there is no need for compensation in the basic price per kilogram. The vaccination costs and the working time required are therefore not significant in the finishing enterprises.

Imputed aggregation of the enterprises: The boar finishing increases the profitability of the enterprises. The vaccination against boar taint does not lead to compensation entitlements since profitability remains the same at given prices. Only anesthesia methods have an economic disadvantage which would have to be compensated for with up to 3 percent of the basic price.

Table 11: Pigs and slaughter pigs required to achieve the profitability of the baseline

	Basic price per piglet (in EUR) in the sow enterprise: 48,16					
	Short-term profitability		**Mid-term profitability**		**Long-term profitability**	
Scenarios						
Castration with Isofluran	51,57 €	7,08%	52,20 €	8,39%	52,20 €	8,39%
Castr. with injection anesthesia	51,91 €	7,79%	51,96 €	7,89%	51,98 €	7,93%
	Basic price per kg CW (in EUR) in the finishing enterprise: 1,40					
	Short-term profitability		**Mid-term profitability**		**Long-term profitability**	
Scenarios						
Immunocastration	1,40	0,00%	1,40 €	0,00%	1,40 €	0,00%
Boar fin. without investment	1,40	0,00%	1,40 €	0,00%	1,39 €	-0,71%
Boar finishing with investment	1,40	0,00%	1,40 €	0,00%	1,40 €	0,00%
	Basic price per kg CW (in EUR) in imputed aggregation of both enterprises: 1,40					
	Short-term profitability		**Mid-term profitability**		**Long-term profitability**	
Scenarios						
Immunocastration	1,40 €	0,00%	1,40 €	0,00%	1,40 €	0,00%
Boar fin. without investment	1,36 €	-2,86%	1,36 €	-2,86%	1,35 €	-3,57%
Boar finishing with investment	1,36 €	-2,86%	1,36 €	-2,86%	1,36 €	-2,86%
Castration with Isofluran	1,44 €	2,86%	1,44 €	2,86%	1,44 €	2,86%
Castr. with injection anesthesia	1,44 €	2,86%	1,44 €	2,86%	1,44 €	2,86%

Source: own calculations.

Table 12 shows the results of the variational calculations 2 and 3. Furthermore it shows the changes of the calculatory profit compared to the standard baseline in case of the finishing time for male and female pigs staying the same and accordingly the final weight of the sows being lower than the weight of the boars.

- If there is no increase in the number of finishing cycles and therefore no additional purchase of boars (variational calculation 2), the calculatory profit gets negative when the enterprises are aggregated. Here, the scenario “investment in feeding technology” shows a significantly poorer performance than the scenario without investment.
- If the number of finishing cycles is increased (variational calculations 3), this can compensate for some of the decreasing returns (due to the lower weights of the sows) and leads to the same result as the baseline. If additional investments are made in feeding technology, the compensating effect is not sufficient and the calculatory profit is negative.

Table 12: Changes in the calculatory profit of the enterprises compared to the standard baseline with variational calculations in the boar finishing

	Basic price per piglet (in EUR) in the sow enterprise: 48,16					
	Short-term profitability		**Mid-term profitability**		**Long-term profitability**	
Scenarios						
Castration with Isofluran	51,57 €	7,08%	52,20 €	8,39%	52,20 €	8,39%
Castr. with injection anesthesia	51,91 €	7,79%	51,96 €	7,89%	51,98 €	7,93%
	Basic price per kg CW (in EUR) in the finishing enterprise: 1,40					
	Short-term profitability		**Mid-term profitability**		**Long-term profitability**	
Scenarios						
Immunocastration	1,40	0,00%	1,40 €	0,00%	1,40 €	0,00%
Boar fin. without investment	1,40	0,00%	1,40 €	0,00%	1,39 €	-0,71%
Boar finishing with investment	1,40	0,00%	1,40 €	0,00%	1,40 €	0,00%
	Basic price per kg CW (in EUR) in imputed aggregation of both enterprises: 1,40					
	Short-term profitability		**Mid-term profitability**		**Long-term profitability**	
Scenarios						
Immunocastration	1,40 €	0,00%	1,40 €	0,00%	1,40 €	0,00%
Boar fin. without investment	1,36 €	-2,86%	1,36 €	-2,86%	1,35 €	-3,57%
Boar finishing with investment	1,36 €	-2,86%	1,36 €	-2,86%	1,36 €	-2,86%
Castration with Isofluran	1,44 €	2,86%	1,44 €	2,86%	1,44 €	2,86%
Castr. with injection anesthesia	1,44 €	2,86%	1,44 €	2,86%	1,44 €	2,86%

Source: own calculations.

For a further economic analysis of the consequences of the avoidance of castration without anesthesia, the evaluation of different farm sizes is necessary. Also, regional differences in the sales opportunities for boar meat and the influence of piglet imports from neighboring countries have to be considered. Other aspects that can limit the possibilities of the farms are:

- Lack of consumer acceptance for meat of vaccinated boars.
- Increasing price disparity in the marketing of female and male finishing pigs.
- When boar finishing with an increased number of finishing cycles is implemented to a greater extent, rising prices for male piglets due to an increasing demand are to be expected.
- For epidemic reasons, farms with a closed system would not necessarily purchase male piglets and raise the number of finishing cycles. This would considerably reduce the benefits of boar finishing.

In the long term, the measurement of the fat quality in applications like AutoFOM III could be possible. The individual fat quality is measurable in the slaughterhouse and can be attributed to feeding and genetics.

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Annex

Table A. 1: Baseline – key performance indicators for the sow enterprise

		Sow enterprise
Production system		
Number of places	No. place	400
Livestock		
Number of sows	No. heads	400
Number of boars	No. heads	2
Performance		
Born piglets per sow	piglet/sow/year	33,49
Litters per sow and year	litters/sow/year	2,34
Lactation time per litter	days	24,5
Weaning weights	kg LW	6,8
Cull rate sows	%	39,40
Cull rate boars	%	50,00
Fraction of own replacement	%	100,00
Sow mortality	%	7,00
Boar mortality	%	7,00
Piglet mortality (lactation period)	%	15,50
Piglet mortality (rearing)	%	2,60
Weaner	piglet/sow/year	28,63
Average piglet rearing time	days	54
Reared piglets	piglet/sow/year	27,89
Selling weight		
Selling weight sow	kg CW	175
Selling weight boar	kg CW	220
Selling weight weaned piglet	kg LW	6,8
Selling weight reared piglet	kg LW	29,9

Source: agri benchmark, InterPIG, KTBL.

Table A. 2: Baseline - Prices and variable costs for the sow enterprise

		Prices
Purchase		
Gilts	EUR/unit	290
Boars	EUR/unit	500
Sale		
Sows	EUR/kg CW	1,08
Boars	EUR/kg CW	1,08
Reared piglets	EUR/unit	48,16
		Variable costs
Veterinarian, medicine, veterinarian equipment	EUR/unit	137,26
Insemination	EUR/unit	26,02
Energy	EUR/unit	75,24
Costs for liquid manure	EUR/unit	21,94
Transportation costs	EUR/unit	1,79
Rendering costs	EUR/unit	1,04
Others	EUR/unit	33,37

Source: agri benchmark, InterPIG, KTBL

Table A. 3: Baseline - feeding in the sow enterprise

		Feeding
Sows (feed - fresh weight)		
Gestation feed	kg/pig/year	1.285
Piglets (feed per period - fresh weight)		
Piglet feed I	kg/pig	39,4

Source: agri benchmark, InterPIG.

Table A. 4: Baseline – factor costs in the sow enterprise

		Factor costs				
		Cash costs per place				
		Total	Depreciation	Maintenance	Total Dep. + Maintenance	Economic lifetime
Sows						
Buildings	EUR/year	1.753,72	70,15	17,54	87,69	25
Facilities incl. feeding systems	EUR/year	1.074,86	89,57	10,75	100,32	12
Liquid manure	EUR/year		0,00	0,00	0,00	25
Total	EUR/year		159,72	28,29	188,01	
Interest payments	EUR/year		76,37	0,03		
Current Interest Rates				*Excluded*		
Total	EUR/year		76,37			
Rearing						
Buildings	EUR/year	177,44	7,10	1,77	8,87	25
Facilities incl. feeding systems	EUR/year	108,75	9,06	1,09	10,15	12
Total	EUR/year		16,16	2,86	19,02	
Interest payments	EUR/year		7,73	0,03		
Current Interest Rates				*Excluded*		
Total	EUR/year		7,73			
Labour			**Number of hours**		**Wages per min.**	
Total	Min./year		720		0,33	
Land						
Lease payments	EUR/year			*Excluded*		
Rent Price				*Excluded*		
Total	EUR/year			*Excluded*		

Source: agri benchmark, InterPIG, KTBL.

Table A. 5: Baseline – key performanec indicators in the finishing enterprise

		Finishing enterprise
Livestock		
Places	No. places	3990
Number of sold animals (female & castrated)	No. heads	10.864
Share of female pigs	%	50
Performance		
Stalling-in weight	kg LW	29,90
Stalling-in weight (boar piglets)	kg LW	29,90
Average finishing time	days	112,00
Days without animals in stable	days	18,50
Mortality	%	3,00
Average selling weight (alive)	kg LW	121,50
Carcass yield	%	79,00
Share of fat free lean	%	58,00
Carcass weight	kg CW	96,00
Average daily weight gain	g/d	817,86
Feed conversion	kg/kg	2,82
Number of fattening cycles		2,80

Source: agri benchmark, InterPIG, KTBL.

Table A. 6: Baseline - prices in the finishing enterprise

		Prices
Purchase		
Female piglets and castrated boars	EUR/piglet	48,16
Male piglets	EUR/piglet	48,16
Sale		
Finishing pigs (female and castrated)	EUR/kg CW	1,40
		Variable costs
Veterinarian, medicine, veterinarian equipment	EUR/unit	0,76
Energy	EUR/unit	2,18
Costs for liquid manure	EUR/unit	2,15
Rendering costs	EUR/unit	0,04
Others	EUR/unit	2,75

Source: agri benchmark, InterPIG.

Table A. 7: Baseline - feeding in the finishing enterprise

		Feed (per finishing cycle)
Finishing feed I		
Share of the finishing	%	100,00
Amount of feed	kg/year	260,55

Source: agri benchmark, InterPIG.

Table A. 8: Baseline – factor costs in the finishing enterprise

		Factor costs				
		Cash costs per place				
		Total	Depreciation	Maintenance	Total Dep. + Maintenance	Economic lifetime
Sows						
Buildings	EUR/year	275,09	11,00	2,75	13,75	25
Facilities incl. feeding systems	EUR/year	168,61	14,05	1,69	15,74	12
Total	EUR/year		25,05	4,44	29,49	
Interest payments	EUR/year		11,98	0,03		
Current Interest Rates				*Excluded*		
Total	EUR/year		11,98			
Labour			**Number of hours**		**Wages per minute**	
Wage labour	min/year				0,33	
Family labour	min/year				0,33	
Total	min/year		19,20		0,33	
Land						
Lease payments	EUR/year			*Excluded*		
Rent Price				*Excluded*		
Total	EUR/year			*Excluded*		

Source: agri benchmark, InterPIG, KTBL.

Table A. 9: Baseline – feed prices

		Purchase feed prices
Finishing feed I	EUR/t	226,70
Finishing feed II	EUR/t	238,85
Gestation feed	EUR/t	239,10
Piglet feed I, II, III	EUR/t	351,80

Source: agri benchmark, InterPIG, AMI.

Table A. 10: Bavarian baseline - prices and variable costs in the sow enterprise

		Prices
Purchase		
Gilts	EUR/unit	317,90
Boars	EUR/unit	500,00
Sale		
Sows	EUR/kg CW	1,07
Boars	EUR/kg CW	1,07
Reared piglets	EUR/unit	50,52
		Variable costs
Veterinarian, medicine, veterinarian equipment	EUR/unit	126,10
Insemination	EUR/unit	23,50
Energy	EUR/unit	88,20
Costs for liquid manure	EUR/unit	22,60
Transportation costs	EUR/unit	1,79
Animal diseases fund	EUR/unit	13,45
Other	EUR/unit	33,61

Source: LfL (2016)

Table A. 11: Bavarian baseline - feeding in the sow enterprise

		Feeding
Sows (feed - fresh weight)		
Gestation feed	kg/pig/year	1.310
Piglets (feed per period - fresh weight)		
Piglet feed I	kg/pig	38,7

Source: LfL (2016)

Table A. 12: Bavarian baseline – factor costs in the sow enterprise

		Factor costs				
		Cash costs per place				
		Total	Depreciation	Maintenance	Total Dep. + Maintenance	Economic lifetime
Sows						
Buildings	EUR/year	1.746,00	70,00	17,00	87,00	25
Facilities incl. feeding systems	EUR/year	1.678,00	140,00	17,00	157,00	12
Liquid manure	EUR/year		0,00	0,00	0,00	25
Total	EUR/year		210,00	34,00	244,00	
Interest payments	EUR/year		92,00	0,03		
Current Interest Rates				*Excluded*		
Total	EUR/year		92,00			
Rearing						
Buildings	EUR/year	177,44	7,10	1,77	8,87	25
Facilities incl. feeding systems	EUR/year	108,75	9,06	1,09	10,15	12
Total	EUR/year		16,16	2,86	19,02	
Interest payments	EUR/year		7,73	0,03		
Current Interest Rates				*Excluded*		
Total	EUR/year		7,73			
Labour			**Number of hours**		**Wages per minute**	
Wage labour	min/year				0,29	
Family labour	min/year				0,29	
Total	min/year		960		0,29	
Land						
Lease payments	EUR/year			*Excluded*		
Rent Price				*Excluded*		
Total	EUR/year			*Excluded*		

Source: LfL (2016)

Table A. 13: Bavarian baseline - prices and variable costs in the finishing enterprise

		Prices
Purchase		
Female piglets and castrated males	EUR/pig	50,52
Male piglets	EUR/pig	50,52
Sales		
Fattening pig (female and castrated males)	EUR/kg CW	*see Text*
		Variable costs
Veterinarian, medicine, veterinarian equipment	EUR/unit	1,10
Energy	EUR/unit	2,52
Animal diseases fund	EUR/unit	0,97
Other	EUR/unit	2,75

Source: LfL (2016)

Table A. 14: Bavarian baseline - feeding in the finishing enterprise

		Feed (per finishing cycle)
Finishing feed I		
Share of the finishing	%	100,00
Amount of feed	kg/year	262,60

Source: LfL (2016)

Table A. 15: Bavarian baseline – factor costs in the finishing enterprise

		Factor costs				
		Cash costs per place				
		Total	Depreciation	Maintenance	Total Dep. + Maintenance	Economic lifetime
Sows						
Buildings	EUR/year	231,00	9,00	2,00	11,00	25
Facilities incl. feeding systems	EUR/year	189,00	16,00	2,00	18,00	12
Total	EUR/year		25,00	4,00	29,00	
Interest payments	EUR/year		11,00	0,03		
Current Interest Rates				*Excluded*		
Total	EUR/year		11,00			
Labour			**Number of hours**		**Wages per minute**	
Wage labour	min/year				0,29	
Family labour	min/year				0,29	
Total	min/year		21,35		0,29	
Land						
Lease payments	EUR/year			*Excluded*		
Pachtansatz				*Excluded*		
Total	EUR/year			*Excluded*		

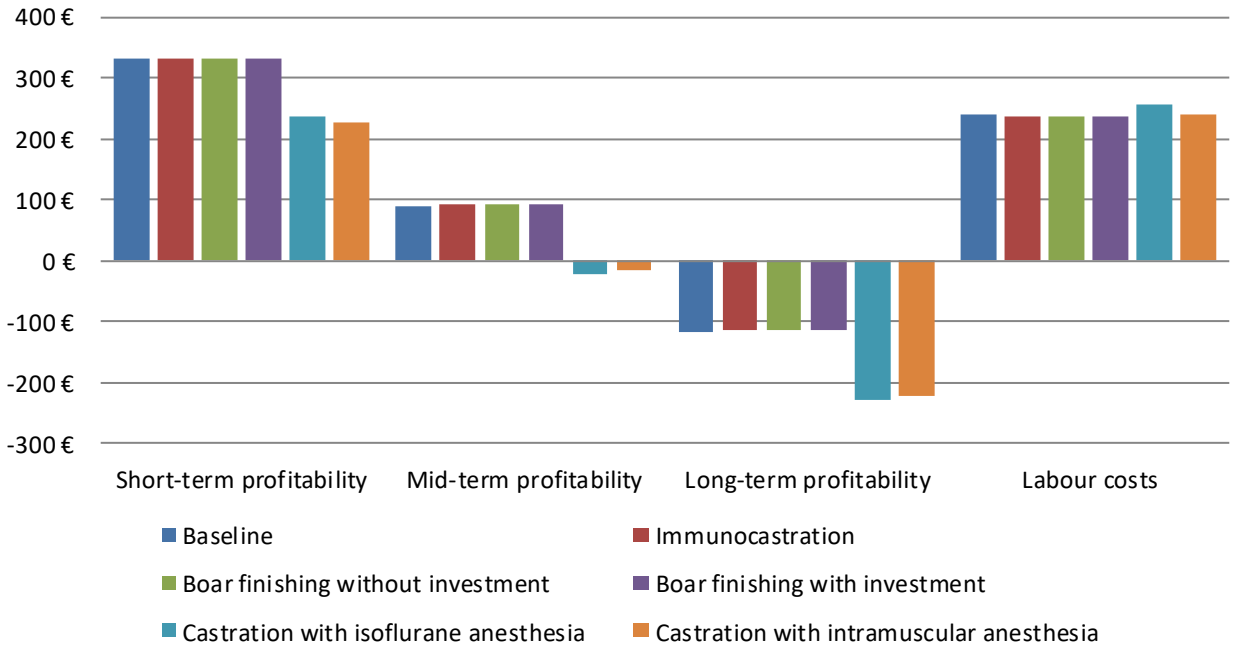
Source: LfL (2016)

Table A. 16: Bavarian baseline – feed prices

		Purchase feed prices
Finishing feed I	EUR/t	212,10
Finishing feed II	EUR/t	223,47
Gestation feed	EUR/t	213,80
Piglet feed I, II, III	EUR/t	312,60

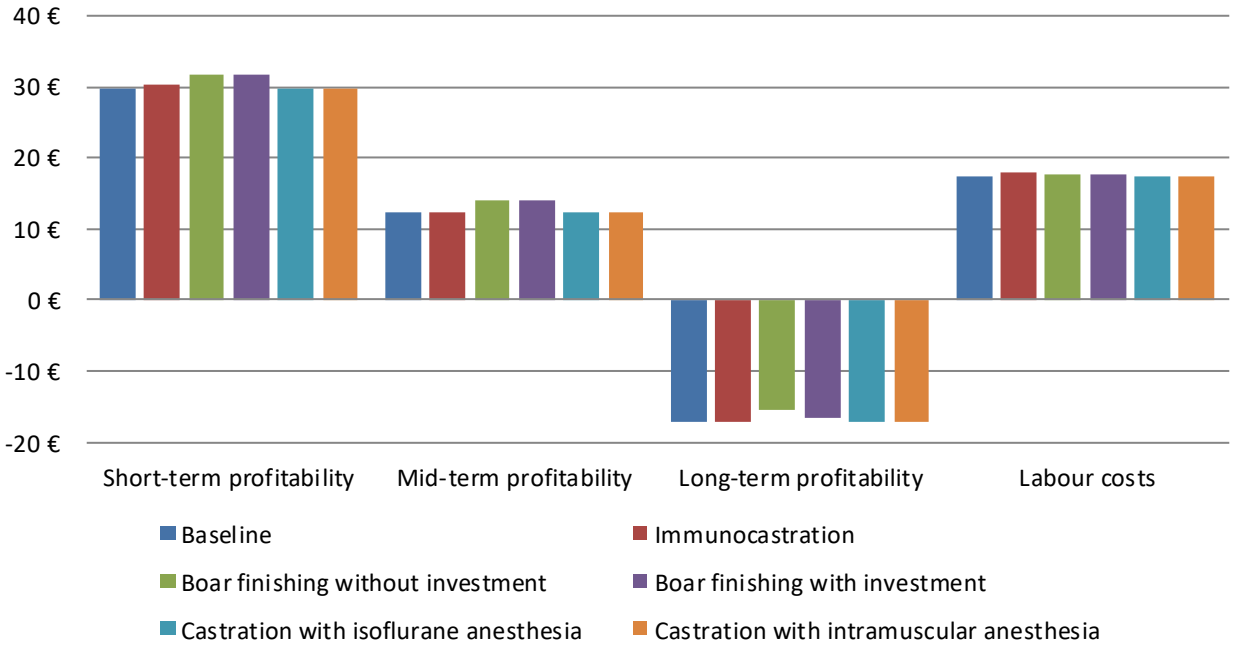
Source: LfL (2016)

Figure A. 1: Comparison of the results for the investigated scenarios (EUR per sow place)



Sorce: own calculations

Figure A. 2: Key performance indicators of the results for the investigated scenarios (EUR per finishing place)



Source: own calculations

Table A. 17: Key performance indicators in € per sow place

	Baseline	Immuno-castration	Boar finish. without investment	Boar finish. with investment	Castration with Isofluran	Castration with injection anesthesia
Performance and result						
Short-term profitability	330 €	331 €	331 €	331 €	235 €	225 €
Mid-term profitability	90 €	94 €	94 €	94 €	-22 €	-16 €
Long-term profitability	-117 €	-113 €	-113 €	-113 €	-229 €	-223 €
Costs						
Labour costs	240 €	237 €	237 €	237 €	258 €	241 €
Building costs	207 €	207 €	207 €	207 €	207 €	207 €

Table A. 18: Key performance indicators in € per finishing place

	Baseline	Immuno-castration	Boar finish. without investment	Boar finish. with investment	Castration with Isofluran	Castration with injection anesthesia
Performance and result						
Short-term profitability	30 €	30 €	32 €	32 €	30 €	30 €
Mid-term profitability	12 €	12 €	14 €	14 €	12 €	12 €
Long-term profitability	-17 €	-17 €	-16 €	-17 €	-17 €	-17 €
Costs						
Labour costs	17 €	18 €	18 €	18 €	17 €	17 €
Building costs	29 €	29 €	29 €	31 €	29 €	29 €

Table A. 19: Key performance indicators in € per raised piglet

	Baseline	Immuno-castration	Boar finish. without investment	Boar finish. with investment	Castration with Isofluran	Castration with injection anesthesia
Performance and result						
Short-term profitability	12 €	12 €	12 €	12 €	8 €	8 €
Mid-term profitability	3 €	3 €	3 €	3 €	-1 €	-1 €
Long-term profitability	-4 €	-4 €	-4 €	-4 €	-8 €	-8 €
Costs						
Labour costs	9 €	8 €	8 €	8 €	9 €	9 €
Building costs	7 €	7 €	7 €	7 €	7 €	7 €

Source: own calculations

Table A. 20: Key performance indicators in € per sold finishing pig

	Baseline	Immuno-castration	Boar finish. without investment	Boar finish. with investment	Castration with Isofluran	Castration with injection anesthesia
Performance and result						
Short-term profitability	11 €	11 €	11 €	11 €	11 €	11 €
Mid-term profitability	5 €	5 €	5 €	5 €	5 €	5 €
Long-term profitability	-6 €	-6 €	-5 €	-6 €	-6 €	-6 €
Costs						
Labour costs	6 €	7 €	6 €	6 €	6 €	6 €
Building costs	11 €	11 €	10 €	10 €	11 €	11 €

Table A. 21: Key performance indicators in € per 100 kg live weight (sow enterprise)

	Baseline	Immuno-castration	Boar finish. without investment	Boar finish. with investment	Castration with Isofluran	Castration with injection anesthesia
Performance and result						
Short-term profitability	37 €	37 €	37 €	37 €	26 €	25 €
Mid-term profitability	10 €	10 €	10 €	10 €	-2 €	-2 €
Long-term profitability	-13 €	-13 €	-13 €	-13 €	-25 €	-25 €
Costs						
Labour costs	27 €	26 €	26 €	26 €	29 €	27 €
Building costs	23 €	23 €	23 €	23 €	23 €	23 €

Table A. 22: Key performance indicators in € per 100 kg slaughter weight (finishing)

	Baseline	Immuno-castration	Boar finish. without investment	Boar finish. with investment	Castration with Isofluran	Castration with injection anesthesia
Performance and result						
Short-term profitability	11 €	12 €	12 €	12 €	11 €	11 €
Mid-term profitability	5 €	5 €	5 €	5 €	5 €	5 €
Long-term profitability	-7 €	-7 €	-6 €	-6 €	-7 €	-7 €
Costs						
Labour costs	7 €	7 €	7 €	7 €	7 €	7 €
Building costs	11 €	11 €	11 €	11 €	11 €	11 €

Source: own calculations

Table A. 23: Variable costs of the scenarios (comparison)

	Baseline	Immuno-castration	Boar finish. without investment	Boar finish. with investment	Castration with Isofluran	Castration with injection anesthesia
Variable costs per						
Sow place	1.075 €	1.075 €	1.075 €	1.075 €	1.170 €	1.176 €
Reared piglet	39 €	39 €	39 €	39 €	42 €	42 €
Fattening place	329 €	329 €	340 €	340 €	329 €	328 €
Sold finisher	121 €	121 €	117 €	117 €	121 €	121 €
100 kg total LW (sow enterprise)	119 €	119 €	119 €	119 €	129 €	130 €
100 kg CW (finishing)	126 €	127 €	127 €	127 €	126 €	126 €

Source: own calculations

Table A. 24: Performances of the scenarions (comparison)

	Baseline	Immuno-castration	Boar finish. without investment	Boar finish. with investment	Castration with Isofluran	Castration with injection anesthesia
Variable costs per						
Sow place	1.405 €	1.406 €	1.406 €	1.406 €	1.405 €	1.402 €
Reared piglet	50 €	50 €	50 €	50 €	50 €	50 €
Fattening place	359 €	359 €	372 €	372 €	359 €	358 €
Sold finisher	132 €	132 €	128 €	128 €	132 €	132 €
100 kg total LW (sow enterprise)	156 €	156 €	156 €	156 €	156 €	156 €
100 kg CW (finishing)	137 €	138 €	139 €	139 €	137 €	137 €

Source: own calculations

Table A. 25: Variable costs of the scenarios in the imputed overview of the enterprises

	Baseline	Immuno-castration	Boar finish. without investment	Boar finish. with investment	Castration with Isofluran	Castration with injection anesthesia
Variable costs per						
Fattening place	302 €	302 €	303 €	303 €	311 €	312 €
Sold finisher	111 €	111 €	104 €	104 €	114 €	115 €
100 kg CW (finishing)	116 €	116 €	113 €	113 €	119 €	120 €

Source: own calculations

Table A. 26: Key performance indicators in € per 100 kg slaughter weight (finishing) in the imputed overview of the enterprises

	Baseline	Immuno-castration	Boar finish. without investment	Boar finish. with investment	Castration with Isofluran	Castration with injection anesthesia
Performance and result						
Short-term profitability	24 €	24 €	28 €	28 €	20 €	20 €
Mid-term profitability	8 €	8 €	12 €	12 €	4 €	4 €
Long-term profitability	-11 €	-11 €	-6 €	-7 €	-15 €	-15 €
Costs						
Labour costs	16 €	16 €	15 €	15 €	17 €	16 €
Building costs	19 €	19 €	19 €	19 €	19 €	19 €

Source: own calculations