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# Market and policy-oriented incentives to provide animal welfare: The case of tail biting

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# Market and policy-oriented incentives to provide animal welfare: The case of tail biting

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*Abstract*

*Modern animal production has been criticised for the lack of animal-friendly production practices. The goal of this paper is to examine how animal welfare could be improved in pig fattening by providing producers with extra incentives. The focus is on three preventive and one mitigative measures, viz. proving the pigs with plenty of straw as enrichment, solid-floor housing (vs. partly slatted flooring), extra pen space per pig, and mitigation of tail biting once the first case has been observed. Each measure is modelled under two different situations and different support policies. The results suggest that producers have incentives to adjust prevention policy when new information about the risk of tail biting is obtained. Moreover, the resources would be used more efficiently by promoting enrichments use (as such or with type) than extra space, but this requires markets or public policy to provide producers with extra incentives.*

*Keywords: Animal welfare, risk of tail biting, losses, subsidy*

*JEL classification: Q12, Q18*

## 1 INTRODUCTION

Modern animal production has been criticised for the lack of animal-friendly production practices. However, it is often costly to produce animal welfare. Blandford et al. (2002), for instance, reviewed several studies on animal-friendly production and found that the share of animal welfare-improving measures in these studies ranged from 3% to 22% of the total production costs. Besides increasing costs, enhanced animal welfare can improve the (partial) productivity of a livestock farm (e.g. Campos 2003), and there may be extra price premiums available to cover elevated production costs of animal-friendly production technology (cf. Bornett et al., 2003; Lagerkvist, 2006; Carlsson, 2007). However, the market premium is not always large enough to cover elevated production costs (e.g. Nilsson et al., 2006).

There are different approaches to ensure animal well-being in Europe. In some countries the minimum requirements set by national legislation are fairly tight whereas in some other countries national legislation is less demanding but there are market-driven welfare-standards and large variety of labelled production (Veissier et al., 2008). Both approaches have pros and cons. Tonsor et al. (2009) for instance argue for market-driven approach as it would provide more choice to match products with various types of consumers. A further complexification is that animal welfare has characteristics of a public good. Actions taken to improve animal welfare benefit all consumers, not just those who buy goods originating from animal-friendly production. Public policies to enhance animal welfare can be justified from the citizens viewpoint, because they consider securing adequate level of animal welfare in animal agriculture as one of the most important tasks of agricultural policy (Yrjölä and Kola, 2004). If society (the principal) desires to implement certain level of welfare in pig fattening, several important issues must be resolved. These include finding out measures which are profitable to be implemented by individual producers (agents) and measures which can be implemented by providing producers with extra economic incentives. Further issues include the question of what would be an efficient way for society to enhance animal welfare when resources are limited and there are competing measures to take.

Tail biting is considered as one of the most important animal welfare problems in the pig sector. It has been reported as the most common health disorder in finishing units in Finland (Heinonen et al., 2001). The magnitude of the problem however varies across Europe (EFSA, 2007). Zonderland et al. (2011) recently estimated losses due to tail biting at approximately €2400 per year for a typical finishing herd in the Netherlands, where 2% of pigs suffer from the problem. A higher economic impact has been estimated in the UK (Guy et al., 2011 *ref.* Edwards, 2012). In the early 2000's a tail damage was observed in 11% of pigs at a Finnish slaughterline (Valros et al., 2004). Keeling and Larsen (2004) observed 6% and 7% tail lesions in two Swedish slaughterhouses. Meat inspection records reported tail lesions in 1% of Danish (Schroeder-Petersen and Simonsen, 2001) and 4% of Norwegian (Fjetland and Kjaerstad, 2002) pigs. However, these records typically show much lower prevalence than observations from slaughter line or farms.

Farm management practices and housing conditions, such as inadequate access to enrichment, slatted floors, high stocking density, distortions in the ventilation, water or feed supply, mixing of animals and not removing the biter causing the problem, are known to affect the risk of tail biting (e.g. Bracke et al., 2004; EFSA, 2007). Enrichments are an important means to reduce the risk of tail biting (Hunter et al., 2001; Day et al., 2002).

Although tail biting decreases the performance of pigs and causes extra costs (e.g. Sinisalo et al, 2012), it may be suboptimal for a producer to tolerate the problem because it can be even more costly to eliminate the problem. The producer may also be able to reduce the costs by adjusting management patterns in situations where there is a risk of severe losses. This may compromise animal welfare if it enhanced welfare is associated with preventive rather than mitigative measures. Particularly extra labour costs due to providing enrichments and the risk of malfunctioning of the manure system when using straw are considered as problems. Mäki-Mantila (1998) for instance studied three alternative housing systems and found that a housing using plenty of enrichment (composting deep sawdust bedding) increased production costs per kilogram of pigmeat by 3 to 5% compared to a liquid-manure-based system.

The goal of this paper is to examine how animal welfare could be improved in pig fattening. We examine economic incentives associated with the enrichments use, housing, pen space per pig, and mitigation of tail biting once the first case has been observed, and how incentives could be strenghtened to enhance animal welfare and to reduce tail biting. The problem is analysed with a stochastic bio-economic model which simulates return on pig space unit and then solves the optimal "animal welfare policy" by maximising return on pig space.

The analysis is carried out under different situations (high and low risk,alternative support polivies) as shown in Section 2.3. The following section represents the model. Subsequent sections report results and discuss them.

## 2 THE MODEL

### *2.1 Objective function*

The model simulates the decision-making of an individual pig producer, and it consists of four major components. Firstly, there is a model which maximises the return on pig space by optimising the timing of slaughter, and measures to manage the risk of tail biting. The model is run under several policy scenarios. The optimal policy is conditional on the risk of tail biting faced by the farm. Because it is a stochastic model, exact tail biting status and input-output ratio is known for each pig only after slaughtering it, but not before starting to grow the animal. The approach is able to take into account uncertainty related to the occurrence of tail biting. Secondly, there is a stochastic model which simulates whether an individual pig becomes a victim of tail biting (see section 2.2). Thirdly, there is a pig growth model which simulates the weight gain of pigs on a daily basis by taking into account the feeding regime, whether the pig has been bitten and the current weight of the pig. Fourthly, there is an impacts assessment model which simulates economic and biological measures such as mortality rates, other health disorders, carcass condemnations, carcass value, feed and other costs and revenues associated with fattening of both bitten and non-bitten pigs.

The producer maximizes the expected net value of the current facility. The value is the discounted net income from selling pigs at harvest weight plus minus the price of weaned piglet, the feed costs and all costs associated with prevention, treatment and mitigation of tail biting in the pen a given planning horizon. More formally, the economic model follows the equation:

(1) $$V_1(\mathbf{x}_1) = E\left( \max_{\mathbf{u}_t(\mathbf{x}_t)} \left\{ \sum_{t=1}^{T} R_t(\mathbf{x}_t, \mathbf{u}_t) \beta^{\frac{t-1}{365}} \right\} \right)$$

subject to: $\mathbf{x}_{t+1} = g(\mathbf{x}_t, \mathbf{u}_t, \varepsilon)$ (transition equations)

$\mathbf{x}_1$ and $V_{T+1}(\mathbf{x}_{T+1})$ given (initial state and the terminal value given)

where $V_1(x_1)$ is the value of pig space as a function of the current state vector $\mathbf{x}_t = \{x_{t,j,w}, x_{t,j,TB}\}$ for all $j$; the subscript $t$ is the time index, the time unit being one day; $x_{t,j,w}$ is the live weight of the pig; $x_{t,j,TB}$ is the tail biting status of an animal; $\mathbf{u}_t = \{u_{t,cull}, u_{t,TB}\}$ is the control vector; $u_{t,cull}$ refers to the harvest rule and $u_{t,TB}$ to the rule to manage the risk of tail biting; $R_t(.)$ is the one-period return function; $\beta$ is the discount factor; $E(.)$ is the expectations operator; $V_{t+1}(x_{t+1})$ is the next-period value function; $g(.)$ represents the pig growth model, the harvesting decision and transition equation for tail biting; the "error" term ε refers to the variation in the pigs' carcass composition and growth; $V_{T+1}(\mathbf{x_{T+1}})$ is the value of pig space unit after the terminal period *T*, and $\mathbf{x}_1$ is the state at the beginning of the planning horizon (set at 25 kg piglet). The optimal management pattern is defined as a function of state variables. The model is normalised per pig space unit and solved using a policy iteration method (see e.g. Ljunqvist and Sargent 2000, 32-33, 633-635). The procedure utilises first-order conditions for model convergence (i.e. $V_t(\mathbf{x_t})= V_{t+1}(\mathbf{x_{t+1}})$).

A number of parameters were specified for items such as one-period returns, the duration of impact on growth and veterinary treatments. Selection of parameters are shown in Table 1. The choice of parameter values is based on previous studies or synthesis of previous studies (Own elaboration) as much as possible. In selected items, such as the duration of veterinary treatment, assumptions based on research team's expertise have been made to facilitate the calculation of relevant parameters. Pig growth is modelled using a modified version of the model represented by Niemi and Sevón-Aimonen (2009). The impact of tail biting on pig growth is divided into typical and severe impacts according to the data by Niemi et al. (2011).

Market value of carcass is based on a scheme, which pays a premium or discounts per kg of meat according to the carcass weight and red meat percentage. However, condemned parts of carcass are not paid for, and a condemnation can result in an additional price discount.

Table 1. Parameters values used in the model to simulate the economic consequences of tail biting in the pen.

| **Parameter or item** | **Value** |
|---|---|
| Typical duration of treatment per bitten pig[1] | 5 days |
| Estimated duration of reduced growth of non-bitten pigs in the pen[1] | 7 days |
| Estimated duration of reduced growth in a typical case | 14 days |
| Days spent in the hospital pen[1] | Until harvest |
| Estimated duration of reduced growth in a severe case[1] | Until harvest |
| Share of bitten pigs moved to hospital pen and kept there until harvest[2] | 15% |
| Reduction in weight gain in a typical case (Sinisalo et al., 2012) | 7% |
| Permanent reduction in weight gain on a severe case[5] | 19% |
| Reduction in weight gain of non-bitten pigs in the pen with a biting[1] | 2% |
| Percentage of bitten pigs dead or disposed (Zonderland et al., 2011) | 2.4% |
| Percentage of bitten pig's meat mass lost due carcass condemnatios (Valros et al., 2004) | 0.7% |
| Extra carcass condemnations among bitten pigs (Valros et al., 2004) | 15% |
| Increase in the prevalence of treated leg disorders in bitten pigs (Niemi et al., 2012) | 240% |
| Increase in the prevalence of other treated disorders in bitten pigs (Niemi et al., 2012) | 660% |
| Discount rate $\beta$ (annual)[1] | 0.94 |
| Materials, medicine and veterinary fees, € per bitten pig[1] | 3.75 |
| Extra cost due to hospital pen , € per day per pig in a hospital pen[1] | 0.88 |
| Discount due to carcass condemnation, € per kg for 15% of bitten pigs[2] | 0.17 |
| Average costs of rendering one dead or removed animal, € per pig[1] | 30.00 |
| Fixed cost, € per pig space per year[1] | 45.73 |
| Cost of labour, € per hour[1] | 15.00 |
| Fixed cost of prevention (if applicable), € per day per pig[1] | 0.03 |
| Decoupled support - labour -fixed costs in the Basic option, € per year[1] | 40.81 |
| Price of pigmeat at slaughterhouse gate, € per kg | 1.55 |
| Price of a 25 kg piglet, € per piece | 55.00 |
| Price of barley, € per kg | 0.17 |
| Price of soybean meal, € per kg | 0.40 |

Source: Own elaboration unless otherwise mentioned.

### *2.2 Biological model of tail biting outbreak in the pen*

To characterise the number of tail bitten pigs in the pen, the probability of one or more biting incidents to occur in the pen was first simulated. Thereafter, the interval between successive biting incidents in the pen was simulated.

The occurrence of tail biting in the pen was simulated with Monte Carlo procedure as a dynamic process such that the probability of tail bting to occur in the pen depends on how many cases have been observed by the current moment. The probability of at least one more incidents to occur in the pen is:

$$(2) \qquad \Pr(n_{t,TB}) = \begin{cases} \alpha_1 & \text{if } n_{t,TB} \equiv 0 \\ \alpha_2 + \alpha_3 \ln(n_{t,TB} + 1) & \text{if } n_{t,TB} \geq 1 \end{cases},$$

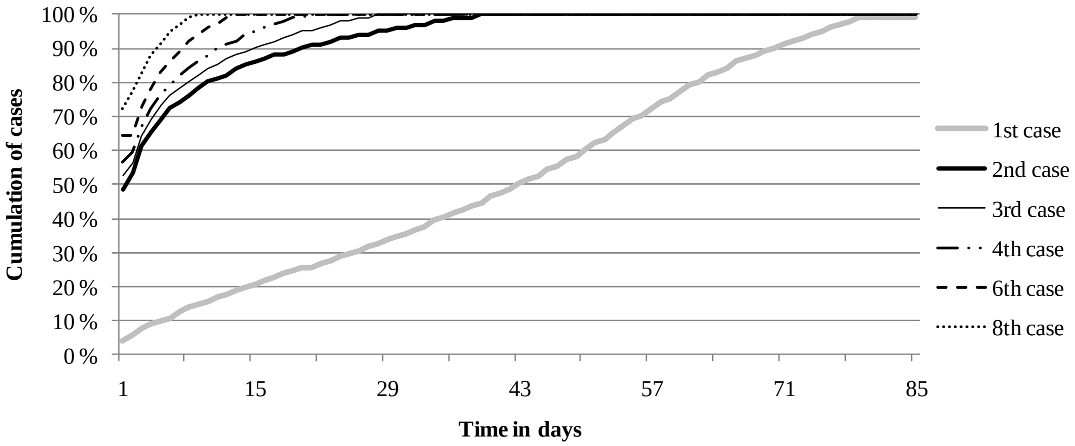
where parameters are as defined in Table 2.

The impact of different risk factors for tail biting which are assumed to be present at the farm are modelled by adjusting the parameter $\alpha_1$. Another key element of the model is that tail biting can emerge over time. Our data suggests that tail biting incidents are agglomerated in time, and that the time between successive cases of tail biting in the pen is the shorter the more cases there has been observed. According to the data obtained from the Finnish progeny test station, in 49% of incidents the second case was observed within one day after the first case of tail biting in the pen, whereas in 56% of incidents the fourth case is observed within one day after the third case of tail biting in the pen (Niemi et al., 2011). The distibution is shown visually for the first, second, third, fourth, sixth and eight case in Figure 1. Besides the risk of tail biting in the pig in general, also possible differences due to the genetic potential of pigs were taken into account.

Table 2. Parameters used in the model to simulate the occurrence of tail biting in the pen.

| Parameter | Description | Values |
|---|---|---|
| $t$ | Time index | [0,…, $T$] |
| $j$ | Index identifying an individual animal in the pen | [1,..,$n$] |
| $n_{\mathrm{t,TB}}$ | Number of bitten pigs in the pen since the arrival of pigs into the pen until current moment $t$ | [1,...,$n$] |
| $\Pr_j(n_{t,TB})$ | Probability that there will be $n_t$+1 tail biting incidents in the pen | [0,..,1] |
| $\alpha_1$ | Parameter of probability function | Varies by scenario |
| $\alpha_2$ | Parameter of probability function | 0.54 |
| $\alpha_3$ | Parameter of probability function | 0.11 |

Figure 1. Percentage of *n*th case of tail biting to have occurred by certain number of days after the observing *n*-1th case in the pen, and for the first case the number days from the arrival of pig into the pen until the occurrence of the first case in the pen.




### *2.3 Scenarios*

There are different strategies to manage the risk of tail biting. In this paper we focus on the prevention of tail biting and on the mitigation of the consequences of tail biting at the farm level, and on policies which might promote animal welfare. Based on previous empirical studies, we specified four *hypothetical* scenarios to analyse measures to reduce the risk of tail biting. Table 3 represents the basic preventive management options considered in this study. In addition, we consider the option not to take reactive measures to prevent further cases of tail biting after the first case has occurred. This option is assumed to increase parameter $\alpha_2$ from 0.56 to 0.76, but to save two-thirds of costs due to enrichment provision and hospital pens after observing tail biting in the pen. If it is a solid-floor straw-based bedding, it is assumed to reduce the costs of capital and to increase labour and annual material costs.

We examine economic incentives of producers under two different scenarios, viz. high risk and low risk of tail lesions. The high risk of tail lesions is assumed to represent a farm which doesn’t apply tail docking, and the low risk of tail lesions which is assumed to represent a situation where tail docking is applied (i.e. the docking is continues as a special case). Biological studies show mixed evidence about whether tail docking is a risk factor for tail biting (e.g. Hunter et al., 2001; Moinard et al., 2003). There are studies showing that a lower prevalence of tail biting is observed in farms using tail docking as opposed to farms not docking the tails (e.g. Hunter et al., 2001). This does not imply that there would be a difference in the level of animal welfare between these two cases, because the docking may just hide the problem. However, if the economic rationality of reducing tail biting is related to the prevalence of tail biting, then it may imply that farms using tail docking may have less to gain by using preventive measures. Tail docking is prohibited in Finland, and in principle in the whole EU, but many member states allow it under special circumstances.

Three policy measures to combat tail biting are examined:

1) animal welfare-improving measures in Table 3 are not paid a premium or a subsidy
2) a price premium is offered for a farm which complies with “Enriched”, “Solid floor” of “Extra space” policy reported in Table 3

3) an animal welfare support (shown in Table 3) which is paid once a year to a farm which complies with “Enriched”, “Solid floor” or “Extra space” policy, and requires a farm to be committed to use specific management. The parameter values for each scenario were determined based on EFSA (2007) and literature referred to therein, and complemented by other studies (e.g. Zonderland et al., 2010; Niemi et al., 2011). According to Zonderland et al. (2010), a small amount of straw provided twice per day was able to reduce the number of pens where there were tail wounds by approximately 75% (from 29% to 8% or from 75% to 16%) when compared to very small amounts of straw provided from a rack.

Table 3. Hypothetical scenarios for tail-biting prevention options investigated in this study and assumed probability of tail-biting outbreak (parameter $\alpha_1$ except in the event of mitigation parameter $\alpha_2$) in the pen under low risk of tail lesions (low) and high risk of tail lesions (high) scenarios[1].

| Option | Description | High | Low |
|---|---|---|---|
| Basic | Production facility with partly slatted flooring and using a minimal amount of straw as enrichment and 0.9 $m^2$ pen space per pig | 0.45 | 0.30 |
| Enriched | As basic but assumed to use of straw as enrichment | 0.10 | 0.07 |
| Solid floor | Straw-based bedding with solid flooring and plenty of straw and 0.9 m2? | 0.05 | 0.03 |
| Extra space | As basic, but assumes the pig has 35% more pen space allowance | 0.40 | 0.27 |
| No mitigation | Optionally can reduce the effort to mitigate tail biting after observing the first biting in the pen (this option can is used in combination with three others) | 0.76 | 0.56 |

1) The analysis assumes that the relative difference between management options is the same in low and high risk scenario.

## 3 RESULTS

The results suggest that in the current situation the markets do not provide the producer with incentives to choose any of the three preventive options with reduced risk of tail biting. By contrast, the producer would choose basic option (Table 4). In addition there are incentives to choose mitigation if tail biting occurs in the pen. Mitigation measures are an option that the producer can choose in order to reduce the losses of an animal welfare problem should it occur. Having this option is important because the marginal benefit from using preventive measures is significantly increased once the problem occurs when compared to the case of continuous application of preventive measures. This aspect is because once a case of tail biting has occurred, it can escalate into an epidemic where several animals are suffering from the problem. Hence, the results suggest that producers have incentives to adjust prevention policy when new information about the risk of tail biting is obtained. However, this compromises animal welfare, because incentives for continuous prevention are inadequate.

Producer does not have economic incentives to invest in extra space or completely solid floors unless the risk of tail biting in the farm is particularly high. For instance, allowing tails to be docked reduced both the risk of tail biting and producer's incentives to invest in animal-friendly facilities. Hence, there is a room for public policy to promote animal welfare. If the producer is offered an animal welfare support on the condition that s/he will comply "Enriched", "Solid floor" or "Extra space" policy, then €10 per pig space per year would enable "Solid floor" option to be preferred over "Basic" option in the high risk scenario but not in the low risk scenario. By contrast, €15 per pig space per year would allow "Solid floor" to be preferred in also the event of low risk scenario.

Figure 2 reports the support payments and market price premiums which would allow three options to be preferred over the basic option. It illustrates the region where the results would be unchanged in the current situation. If large enough support would be available to any of three options, then Solid floor would be preferred over other alternatives because their ranking is not affected by support and support has quite similar relative impact on return on these options. The same applies to a market price premium which is paid on per kg basis.

However, our results are very sensitive to assumptions on parameters regarding the risk of tail biting and the costs of measures "Enriched", "Solid floor" or "Extra space", in particular assumptions regarding the cost of extra work associated with these options. The "Solid floor" scenario is assumed to have a rather large impact of the probability of tail biting outbreak. If this impact would be reduced by 4 to 5 percentage points, then "Enriched" would be preferred over "Solid floor" particularly in the event of low risk scenario. Sensitivity analysis illustrated that 10% reduction in the material and labour costs of enrichments use would change the optimal solution so that at "Enrichment" would be preferred over other alternatives at support level €10 per pig space per year in high risk scenario and at €15 per pig space per year in low risk scenario.

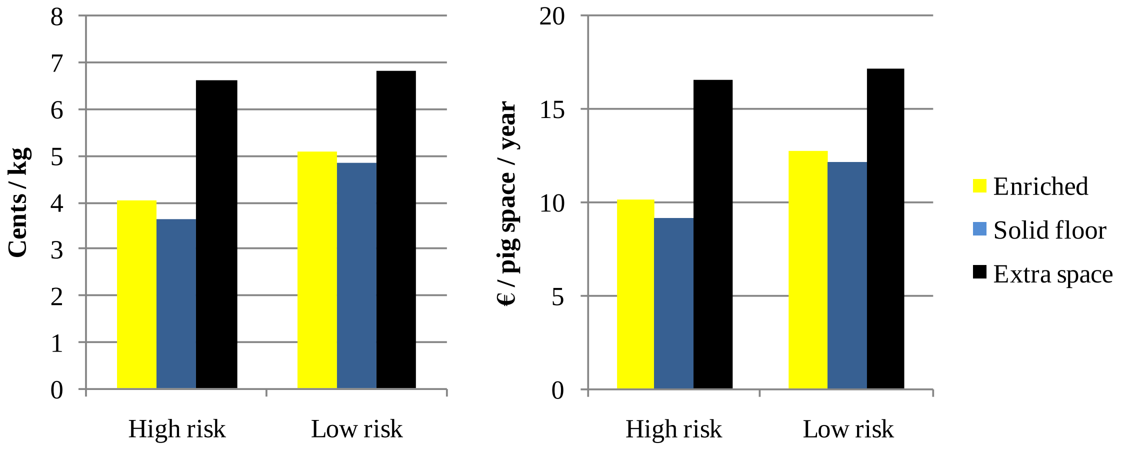
The results suggest that producers have incentives to adjust their policy of prevention when new information about the risk of tail biting is obtained. However, this compromises animal welfare, because incentives for continuous prevention are inadequate, particularly if the risk of tail biting is low. The costs of reducing tail biting prevalence by one percentage points is quite similar between Enriched and Solid floor options, whereas the costs of reducing the prevalence of tail biting through "Extra space" is much higher (Figure 3). If the public policy is to enhance animal welfare primarily by reducing tail biting, the resources would be more efficiently allocated if the effort would be focused on "Enriched" and "Solid floor" measures that providing the pigs with "Extra space". Results therefore suggest that there are differences between studied policy options in their efficiency to enhance the welfare of pigs. Hence, it matters how public policy measures are targeted.

Table 4. Characterisation of the management option chosen[1] by the producer under four different animal welfare support scenarios and under tail docking and no tail docking scenarios.

| Policy scenario | High risk | Low risk |
|---|---|---|
| No subsidy | Basic | Basic |
| Annual support €5 per pig space | Basic | Basic |
| Annual support €10 per pig space | Solid Floor | Basic |
| Annual support €15 per pig space | Solid Floor | Solid Floor |

1 In addition, mitigation measures are chosen to reduce the risk of further economic losses whenever tail biting is observed.

Figure 2. Estimated price premium (cents per kg pigmeat, on the left) and subsidy payment (€ per pig space per year, on the right) required for animal welfare improvements to become implemented by the producer in the current situation.

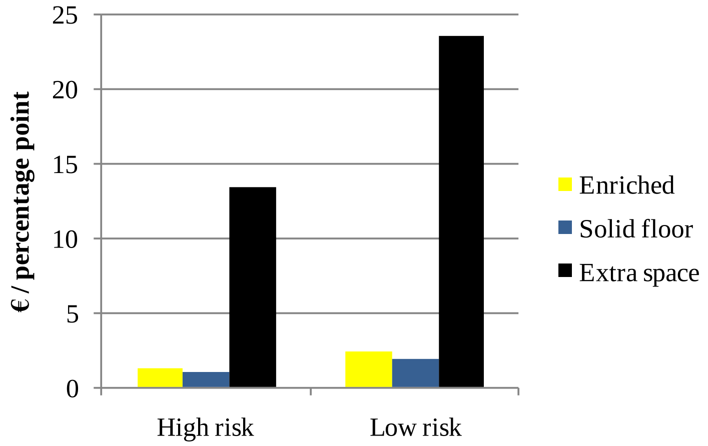



Source: Own simulations

Economic effects of tail biting estimated in this study are little larger than those estimated by Zonderland et al. (2011), and quite similar to estimates by Guy et al. (2011, *ref.* Edwards, 2012). Moreover, our results are in line with those of Mäki-Mantila (1998) in the sense that welfare-improving measures were found unprofitable to be implemented unless extra economic incentives are provided to producers.

This paper has neither considered consumer's willingness to pay for animal welfare improvements, nor analysed asymmetric information as an issue. Hence, further studies could combine information about market price premiums available compared to increases in the production costs and to address the costs associated with controlling the problem of asymmetric information in this context. Because of limited space, this paper has not analysed in detail how much animal welfare would be increased in general with different measures. For instance, pen space per pig vs. enrichments use may have different impact on animal welfare and not all these impacts are reflected by the prevalence of tail biting. However, there are indicators to quantify the effects of different measures on animal welfare. Combining these indicators with our results would be an interesting topic for a further study.

Figure 3. The cost of reducing the prevalence of tail biting by one percentage point with a targeted payment under two risk levels for a farm which chooses a specific management option. The comparison is made to the Basic option.




Source: Own simulations

## 4 CONCLUDING REMARKS

In the current situation, markets or public policy provide very limited incentives to reduce the risk of tail biting in pigs. The results suggest that producers have incentives to adjust prevention policy when new information about the risk of tail biting is obtained. Results suggest that the resources would be more efficiently used if the effort would be allocated to promote the use of enrichments rather than providing the pigs with extra space. Animal welfare could be improved by policies supporting investments in animal-friendly housing or consumers paying a price premium for animal-friendly housing and management. The introduction of novel production technologies is also important possibility, because some animal welfare-enhancing measures are labour-intensive.

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