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Economic evaluation of high welfare indoor farrowing systems for pigs

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Abstract

New livestock housing systems designed to improve animal welfare will only see large-scale commercial adoption if they improve profitability, or are at least cost neutral to the farm business. Economic evaluation of new system developments is therefore essential to determine their effect on cost of production and hence the extent of any market premium necessary to stimulate adoption. This paper describes such an evaluation in relation to high welfare farrowing systems for sows where any potential system needs to reconcile the behavioural needs of the sow with piglet survivability, acceptable capital and running costs, farm practicality and ease of management. In the Defra-sponsored PigSAFE project, a new farrowing system has been developed which comprises a loose, straw-bedded pen with embedded design features which promote piglet survival. Data on this and four other farrowing systems (new systems: 360° Farrower and a Danish pen; existing systems: crate and outdoor paddock) were used to populate a model of production cost taking account of both capital and running costs (feed, labour, bedding etc). Assuming equitable pig performance across all indoor farrowing systems, the model estimated a higher production cost for non-crate systems by 1.6, 1.7 and 3.5%, respectively, for 360° Farrower, Danish and PigSAFE systems on a per-sow basis. The outdoor production system had the lowest production cost. An online survey of pig producers confirmed that, whilst some producers would consider installing a non-crate system, the majority of producers remain cautious about considering alternatives to the farrowing crate. If pig performance in alternative indoor systems could be improved from the crate baseline (eg through reduced piglet mortality, improved weaning weight or sow re-breeding), then the differential cost of production could be reduced. Indeed, with further innovation by pig producers, management of alternative farrowing systems may evolve to a point where there can be improvements in both welfare and pig production. However, larger data sets of alternative systems on commercial farms will be needed to explore fully the welfare/production interface before such a relationship can be confirmed for those pig producers who will be replacing their units in the next ten years.

Keywords: *animal welfare, economics, farrowing, housing systems, husbandry, pig*

Introduction

The farrowing crate is used widely for indoor-housed sows in the major pig-producing countries. For industry, it represents a cost-effective means of keeping sows peri-farrowing and up to the point of weaning (in Europe at a minimum of 28 days of age). The crate system is designed for ease of cleaning and requires a relatively modest amount of space, feed and slurry removal can be automated, sows can be fed individually, stockpersons can assist sows at farrowing without risk of injury and, because the crate provides a means of protection for the piglet as the sow lies down and allows targeted heat input during farrowing, piglet mortality, particularly as a result of crushing by the sow or hypothermia in an unbedded system, is minimised. Criticisms of the farrowing crate, however, have been reported widely (eg SCAHW 1997) given that it is a behaviourally and physically restrictive environment and may thus create stress for the sow (Baxter *et al* 2011).

Recently, the Defra-sponsored PigSAFE (Piglet and Sow Alternative Farrowing Environment) project has developed a prototype pen which better meets the welfare needs of the sow. The new farrowing system was developed, starting from a detailed review of scientific and technical literature (Baxter *et al* 2011, 2012) and consultation with international experts and stakeholder groups about both the welfare needs of the sow and piglet and past experience with alternative farrowing systems. The resulting PigSAFE prototype system comprises a loose pen including a straw-bedded nest with embedded design features which promote piglet survival (for example a pen layout which encourages the sow to farrow in a particular location promoting use of a readily accessible heated creep area, sloping walls to facili-

tate escape from crushing), whilst catering for safety of stockpersons (the sow can be confined in the feeding stall thus allowing personnel to undertake piglet tasks) and ease of cleaning (sides are fabricated from plastic panels which are easily cleaned and disinfected, the dunging area is slatted for automated manure removal). An improved prototype design has now been evaluated where data on 300 farrowings across two sites (Newcastle University and SAC, Edinburgh, UK) were recorded and matched with an equivalent number of contemporaries in standard farrowing crates (Edwards *et al* 2012). However, in the absence of legislation requiring change, large-scale commercial adoption of any system will only happen if the new system improves profitability, or at least is cost neutral to the farm business. Therefore, the aim of this paper was to evaluate the economics of pig production in the PigSAFE farrowing pen, and to specifically: i) identify the prevalent UK sow farrowing systems; ii) estimate the cost of production in different farrowing systems; iii) explore how sensitive these costs were to changes in outputs; and finally iv) estimate the likely uptake of high welfare farrowing systems by the UK pig industry.

Materials and methods

Survey of current farrowing systems and attitudes to system replacement

To determine the prevalent UK farrowing systems, a questionnaire was designed for pig producers to address specific questions about their current housing systems and their future plans for either replacement of the existing system or investment in an alternative system. UK pig producers were invited to complete the questionnaire online anonymously, through the PigWorld website (www.pigworld.co.uk) which represents the National Pig Association (NPA) (an organisation representing UK pig producers). The questionnaire was linked to a recent PigWorld article on the PigSAFE project and was available in January and February 2011.

Cost of production in different farrowing systems

To estimate the cost of production in different systems, an existing spreadsheet-based decision-support tool (DST) was updated and used to calculate the cost of producing pigs under different housing systems in a representative pig unit, taking account of any differences in physical performance of the pigs in that system. The method, including specifications of the seven gestating and ten farrowing-sow housing systems investigated, is described in full in Seddon *et al* (2012). Briefly, the DST has different modules for gestating sows, farrowing sows, weaners and grower/finishers and is populated with pig performance data, sourced where possible from the literature, augmented with industry values of capital and running costs (labour, bedding, feed etc). These physical/financial parameters are used to calculate the annual cost of keeping a sow in a particular gestation-farrowing housing combination and rearing the pigs to a defined weight. Results can be expressed on a £ per sow or £ per pig produced basis, or £ per kilogram of carcase sold.

The DST was modified to include the PigSAFE system and two other potential commercial free-farrowing systems, namely the Midland Pig Producers 360 Degree Farrower (360° Farrower) and a Danish free-farrowing system (Danish). The 360° Farrower was included since, although in this system the sow may be confined in a crate around farrowing and subsequently released and the amount of bedding may be minimal, it has generated much media interest and represents a compromise which could be adopted in countries where the use of the farrowing crate is limited to a period around farrowing. The Danish system has also drawn the attention of many farmers across Europe. As with PigSAFE, the Danish system provides an open pen and separate creep, but occupies a smaller pen area because of the absence of a separate lockable sow feeder. The building (capital) and repair costs for each system shown in Table 1 were estimated from information provided by UK pig building companies and farm management surveys/cost guides (eg Lewis 2010; Nix 2010). To estimate the annual repair cost per sow place, the annual repair cost per sow was converted to a percentage of the capital building costs known as the repair factor and, in the absence of published values for what the likely repair costs of alternative systems will be, the same repair factor was given to each system. Any differences in repair cost between different farrowing systems are then simply a reflection of higher initial capital cost. To generate an overall cost of production, costs for the farrowing stage were combined with a standard gestation sow cost (in this case assumed to be sows kept in either straw yards or yards with kennels).

An important input to the model is the level of pig performance achieved in a particular housing system. Although at Newcastle, the PigSAFE system has shown comparable performance to farrowing crates (Edwards *et al* 2011), there are as yet no large-scale datasets published for most non-crate systems. For that reason, pig performance (conception rate, numbers born alive, pre-weaning mortality etc) was assumed to be the same across all indoor farrowing systems and the national average values of BPEX, the UK levy body for pig production, for the year 2010 were adopted for indoor and outdoor systems accordingly (BPEX 2010).

Uptake of high welfare farrowing systems

To estimate the likely industry uptake of high welfare farrowing systems, a suite of linear-programming (LP) models was developed to test the conditions under which pig producers might adopt the PigSAFE pen. The model simulates a representative UK breeder/finisher unit consisting of 545 sows, with 4.5 full-time staff, 120 farrowing places and sufficient capacity for 3,600 finisher pigs at any one time (see Cain *et al* 2012 for full description). The main source of data is the cost of production estimates described previously so that the objective function is, for a given gestating-farrowing housing combination, to derive the value of pork (£ per kg carcase) necessary to meet the costs incurred in producing that pig, ie the break-even price. A number of different scenarios were considered, exploring the effect of changes in pig performance on break-even price.

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Table 1 Specification and building costs of different farrowing sow systems.

	Farrowing system				
Element	**Crate**	**PigSAFE**	**360° Farrower**	**Danish**	**Outdoor**
Area per sow and litter (m^2)	4.3[1]	8.9[1]	4.3[1]	6.0[1]	526.3
Floor/bedding if any[2]	FS	PS/ms	FS	PS/ms	E/sh
Capital cost (£ per place)	3,170	4,388	3,670	3,804	1,196
Lifetime (years)	20	20	20	20	10
Annualised capital cost (£ per £1,000 @8%)	102	102	102	102	149
Sow place cost (£ per year)	323	448	374	388	178
Repair factor (% of capital)	1.4	1.4	1.4	1.4	1.4
Repair cost (£ per sow place per year)	45	61	51	53	17
Total cost (£ per sow place per year)	368	509	425	441	195

[1] For ease of presentation, space required for each system is shown on a per sow and litter basis; additional space provided for the access passageway was accounted for in the DST model.
[2] FS: Fully-slatted floor; PS: Part-slatted; s: Straw; ms: Minimal straw; E/sh: Earth/straw in hut.

Table 2 Cost of production using different farrowing sow systems at three different levels of liveborn mortality (m).

			Farrowing system		
System	**Crate**	**PigSAFE**	**360° Farrower**	**Danish**	**Outdoor**
£ per sow[1]	776.29	803.65	788.44	789.33	670.59
£ per weaner (12% m)	34.03	35.23	34.57	34.60	31.12
£ per weaner (15% m)	35.23	36.48	35.79	35.83	32.22
£ per weaner (9% m)	32.91	34.07	33.43	33.46	30.10

[1] Total cost per sow includes all the costs in the farrowing stage and also costs in the gestation stage (average costs from two of the most common gestation sow housing systems, assumed to be the same housing system across all indoor systems, and an outdoor paddock system for the Outdoor option).

Results

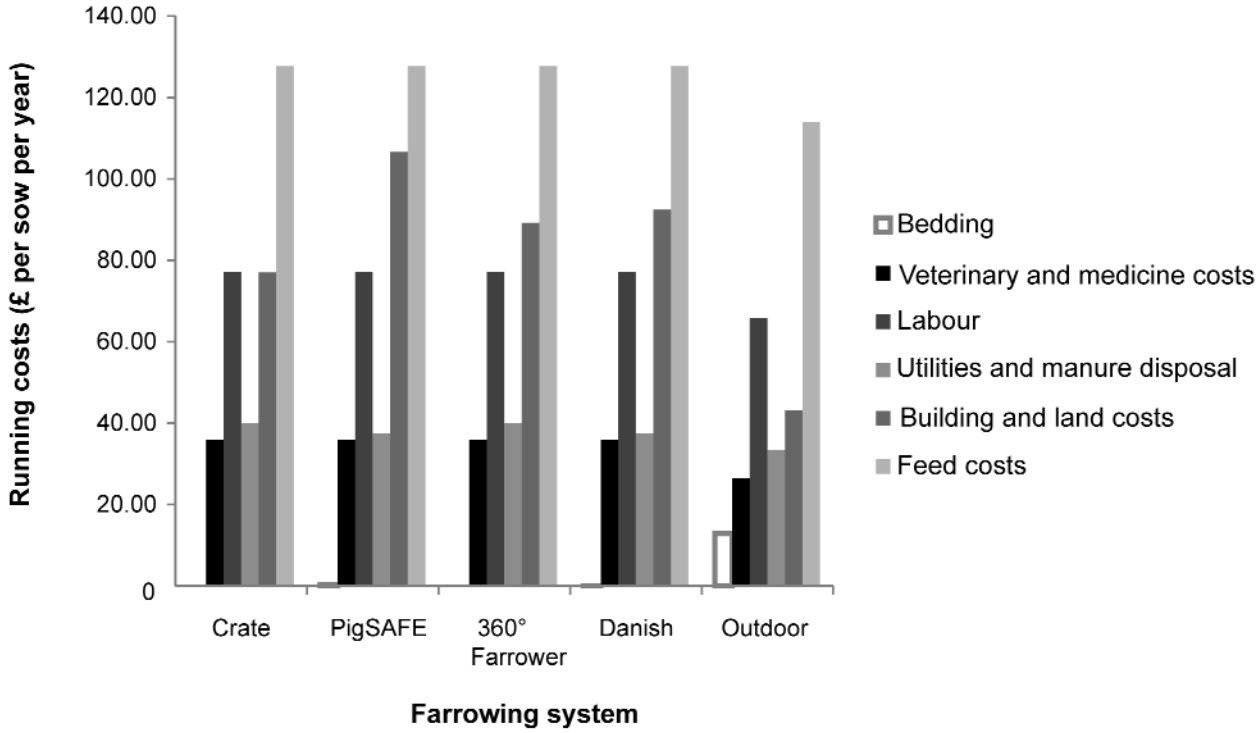
Distribution of current farrowing systems

A total of 45 questionnaires were completed, representing some 10,034 farrowing places which accounts for approximately 40,000–50,000 sows (~20% of the UK indoor herd). The questionnaire showed that 96% of indoor-housed sows farrowed in farrowing crates, 2% in a modified crate design and 2% in other systems. Out of the 45 responses, some 30 producers (67%) expect to replace part of their farrowing accommodation within the next 10 years. When considering future farrowing accommodation replacement, 29 of the 45 producers (64%) said they would keep the same farrowing system that they currently had, 4 (9%) were unsure about what to choose and 12 (27%) would consider replacing with a different system. Of the latter, four respondents (33%) indicated a preference for a fully slatted system that allows the sow to turn around (such as the 360° Farrower), four (33%) were considering a non-crate pen such as the PigSAFE system. The remainder were either undecided between these two systems, wanted to specify a completely different design or were simply unsure (number of respondents were 1, 1 and 2, respectively, or 8, 8 and 17%).

Cost of production in different farrowing systems

The cost of producing a weaner pig using different farrowing systems on both a per sow and per weaner (8 kg) basis is shown in Table 2. There was a considerable range in cost of production between the lowest (outdoors) and the most expensive (PigSAFE) systems, representing a difference of £133 per sow or £4 per piglet. For indoor systems, keeping farrowing sows in PigSAFE pens rather than farrowing crates incurred a higher production cost; an increase of £27 per sow or £1 per piglet (approximately 3.5% higher). The Danish and 360° Farrower systems represented a more modest increase in cost of production compared to the farrowing crate — an increase of £13 and £12 per sow, respectively (1.7%).

Figure 1



Variable running costs of the farrowing sow phase (£ per sow per ear) in different systems.

Data shown in Table 2 also illustrate the impact of piglet mortality on the cost of pig production. If liveborn mortality were increased from 12 to 15%, then the cost of production per piglet would be increased by between £1.11 and £1.25 depending on the system. The converse is true for reducing piglet mortality, namely the potential to reduce cost of production from having more piglets to sell. Comparisons can also be made for a given level of mortality in a given farrowing system. For example, as producers become more proficient at operating a system, such that liveborn mortality in PigSAFE pens could be reduced to 9%, then the cost of production becomes much more comparable to the other alternative systems and indeed to average producers using farrowing crates (with 12% liveborn mortality). Considering the components of production costs, Figure 1 shows that in outdoor farrowing the bedding costs are relatively important, but labour and building/land costs are considerably lower than in indoor systems. Differences between the farrowing crate and alternative farrowing systems were accounted for mainly by higher building/land costs, particularly for the PigSAFE pen which can be attributed primarily to a greater space allowance (38% higher than a part-slatted farrowing crate) although pen furniture is also slightly more expensive due to higher pen divisions and some additional metalwork.

Uptake of high welfare farrowing systems

LP model results in Table 3 demonstrate the higher break-even price required for pork produced through the PigSAFE system. Compared to conventional production using part-slatted farrowing crates, the price of pork would need to be 2.3 p kg^{-1} carcase weight (cwt) higher (1.6% premium) for PigSAFE-produced pork to allow producers to break even. The results also demonstrate the sensitivity of this premium to changes in pig performance. Improvements in management of the PigSAFE system, through better management of the sow and increased exercise and appetite, for example, might lead to higher piglet weaning weights. An increase in piglet weaning weight of 0.3 kg, as found in the current project, would reduce the premium required in PigSAFE pens to just 1.3 p kg^{-1} carcase weight (0.9% extra). However, under less-skilled standards of stockmanship, if 0.5 fewer piglets were weaned per litter (thus 9.6 instead of 10.0 piglets) then the premium required would increase to 4.7 p kg^{-1} cwt.

Discussion

Cost of production in different farrowing systems

This study has demonstrated that a move to alternative non-crate farrowing systems would result in an increased cost of production, ranging from 1.7% in the 360° Farrower, about which there remains a degree of concern as to whether this fully meets the needs of the sow, to 3.5% in the PigSAFE system which is designed to match the needs of sow, piglet and stockperson. When considered across the rearing of the finished pig, the increase in cost of production was diluted somewhat to just 1.6% extra compared to using farrowing

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Table 3 Effects of variations in pig performance on the cost of finished pig production[1].

Model run	PigSAFE cost	Difference compared to production cost using a farrowing crate (145.0 p kg^{-1} cwt)	
	p kg^{-1} cwt	p kg^{-1} cwt	% difference
Base	147.33	+2.3	1.6
Fewer piglets weaned (–0.5 per litter)	152.70	+4.7	3.2
Higher weaning weight (+0.3 kg)	146.30	1.3	0.9

[1] Includes all costs to produce a finished pig (ie gestation and farrowing stages and rearing of piglets from weaning to sale weight) expressed as UK p kg^{-1} carcase weight (p kg^{-1} cwt).

crates. However, whilst these values may appear a very small price to pay for greater freedom of movement, the opportunity for the sow to build a nest and the reduction in stress that this brings, it is worth remembering that pig production is characterised by very small margins. Thus, for the 545-sow farm modelled in this study, an increase in cost of production of 1.6% factored across the whole farm would equate to an annual cost of almost £20,000, clearly something which would have a significant effect on the financial sustainability of the business. In a Danish study investigating the implications for pig farmers of changing housing systems, Lund *et al* (2010) reported that a move to free farrowing would result in a 9.5% increase in the cost of pig production which, under the prevailing relatively poor market price for pork and high input costs, meant that a loss of DKK 435 per sow was increased to DKK 1,073 (a 146% increase in the loss made per sow).

Consistency in performance is another factor which has a major effect on profitability of any pig enterprise. When pre-weaning piglet mortality varied, the cost of production showed a direct response, adding a cost of approximately £1.20 per weaner for every additional 0.5 piglet death. Clearly, any alternative farrowing system offered in place of the crate must have the potential to achieve at least comparable levels of piglet survival. At the Newcastle site, the PigSAFE system has shown comparable levels of piglet mortality compared to a conventional crate system managed by the same stockperson (Edwards *et al* 2011) but, whilst this is a very positive outcome, the result may not be replicated elsewhere under different conditions of management, subtle differences in pen design etc. Taking the most optimistic view, however, if the PigSAFE system could deliver liveborn mortality of just 9% and if piglet weaning weights were consistently higher (currently the system reports a non-significant increase of 0.3 kg), then there could be potential for reduced cost of production with more piglets to sell and savings on feed and housing costs from a shorter finishing period. However, without large-scale datasets from the PigSAFE system in commercial conditions, this potential cannot be confirmed and producers require above all a system which gives consistent performance. Thus, whilst outdoor production appears to be a very attractive, low cost system, it does have an inherent risk of higher piglet mortality during adverse weather conditions (NADIS 2011), as happened in the UK during the winter of 2010/2011 with record levels of snowfall and temperatures remaining substantially below zero for an extended period of time. Despite these risks, in the UK there has been a considerable increase in outdoor production, so that now over 40% of the national sow herd is outdoors.

Uptake of high welfare farrowing systems

This study has reported important increases in production costs when using the PigSAFE system compared to crates, under various financial and physical conditions. These results could be turned around to illustrate the conditions under which adoption of the PigSAFE system would be cost neutral. The simplest of these would be the receipt of a premium of 2.3 p kg^{-1} cwt to cover the additional associated capital and running costs. However, there is some concern as to which part of the pigmeat supply chain should pay for this. Whilst the consumer may express an interest and concern for animal welfare, this does not always translate into purchase of high welfare products: the conflict between citizen and consumer (eg Christensen *et al* 2012). Alternatively, were producers able to reduce capital costs and at the same time improve pig performance, then the requirement for a premium might be removed or at least reduced. For example, when an increase in piglet weaning weight was factored into the model, the premium required to break even was reduced to just over one pence, and this would be soon offset if an improvement in re-breeding efficiency of the sow was also to occur as a result of better lactation food intake. However, the same points regarding variability in pig performance remain, so that a drop in performance may quickly result in a cost-neutral system becoming financially unsustainable.

The producer online questionnaire confirmed, however, that in the UK, indoor farrowing systems are dominated by the farrowing crate. When asked what system would be chosen when it comes to replacement of existing farrowing systems, the majority of producers said that they would use farrowing crates again, although a significant minority would consider non-crate options. There remain then two

significant obstacles to the uptake of non-crate farrowing systems, namely the hesitation of pig producers to invest in alternative free-farrowing systems given estimates of higher cost of production and the lack of sufficient data of commercial-scale pig performance in free-farrowing systems to provide reassurance about their robustness.

Animal welfare implications

Whilst the PigSAFE project has successfully developed a system design that meets the needs of both the peri-parturient sow and her litter, and thus has the potential to improve the welfare of indoor-housed pigs, it is the economic aspects of this system which may yet limit its impact on the pig industry. Non-crate farrowing continues to attract the interest of various stakeholders including NGOs and government, but without either unilateral legislation in Europe, or a willingness by consumers to pay the premium required for non-crate farrowing, pig producers are cautious about investing in housing systems that will increase their cost of production without a guaranteed premium from the market.

Conclusion

In the UK, current indoor farrowing systems are dominated by the farrowing crate. Assuming comparable pig performance, the cost of pig production will be higher when using free-farrowing systems such as the PigSAFE pen. Pig producers may seek a premium to encourage them to invest in alternative farrowing systems, but they remain cautious about large-scale investment in these systems, despite the reported welfare advantages for the sow.

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