CASE STUDY

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Estimating the economic impact of the adoption of novel non-crate sow farrowing systems in the UK

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ABSTRACT

The majority of indoor sows in the UK (around 95 per cent) farrow in conventional farrowing crates. There is pressure from a number of quarters – EU and national regulators, supermarket buyers and consumers – to improve the welfare of sows by adopting "free" farrowing systems. A DEFRA-funded project (under the acronym PigSAFE) conducted by Newcastle University and the Scottish Agricultural College (SAC) has developed and tested such a non-crate farrowing system. The trial monitored the costs and pig performance of over 450 sows which farrowed in either PigSAFE pens or conventional farrowing crates. The data generated in this work were used to construct spreadsheet-based budgeting models and linear programming (LP) models to assess the comparative economic performance of the two systems and determine the likely uptake of the new system. The results suggest that the cost of production under the new farrowing system would be about 1.6% higher than the conventional farrowing crate while pig performance was comparable in the two systems. A survey showed that UK producers were prepared to consider the new systems when renewing their farrowing accommodation, although the modelling exercise suggests that a price premium would still be required to ensure the viability of the new systems.

KEYWORDS: farrowing sow; animal welfare; pig; housing system; cost of production

1. Introduction

One of the major factors affecting the profitability of breeding sow units is the number of piglets weaned per litter. In the case of indoor units, this has lead to the widespread use of farrowing crates as a system of controlling the movement of the sow and thereby safeguarding her piglets, particularly from crushing. It could be argued that in the design of this system, emphasis has been on the welfare (or at least survival) of the piglets rather than on the welfare of the sow. Crates prevent the sow from exhibiting many of her natural behaviours, such as freedom of movement and nest building at farrowing time. The regulatory framework at both national (DEFRA, 2007) and EU (Council of Europe, 2011) levels is moving away from the use of confined systems for gestating (or dry) sows. Also, in the UK in particular, there has been increasing interest from buyers of pigmeat, particularly supermarkets, in the development of non-crate farrowing systems.

This paper describes the economic evaluation of a novel free-farrowing system developed under a DEFRA-funded project run jointly by Newcastle University and the Scottish Agricultural College (SAC). This project, under the acronym PigSAFE, firstly designed and then tested a pen-based farrowing system and compared the results with those in conventional, crate-based systems. The data generated were used to populate a spreadsheet-based budgeting tool which compares the cost of weaner production through a wide variety of dry-sow and farrowing sow systems. Linear Programming (LP) models were then used to estimate the likely uptake of the PigSAFE system by the UK pig industry and to consider the conditions under which the adoption of the new system by producers would be cost-neutral.

2. Background – UK farrowing systems

A survey of producers was undertaken to establish the current types of indoor farrowing systems used in the UK and to investigate the intentions of producers with regards to likely replacement strategies. A web-based questionnaire was mounted on the National Pig Association (NPA) website, 'Pig World', in January, 2011.

A total of 45 replies were received from producers representing around 10,000 farrowing places which accounts for around 40–50,000 breeding sows or about 20% of the UK indoor breeding herd. The results showed that 96% of sows were farrowed in farrowing crates, 2% in a modified crate design and 2% in other systems. Sixty seven per cent of producers surveyed expected to replace part of their existing system over the course of the next 10 years. When replacing existing

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farrowing systems, 64% of producers reported that they would replace with the same housing design, with 27% considering replacing with a different system whilst 9% were unsure about which system they would choose as a replacement.

Of those producers considering replacing with a new system, one-third suggested they might adopt a fully-slatted opening pen that allowed the sow to turn around (a system developed and promoted by a commercial UK pig production company under the brand name '360°Farrower'). Another one-third of producers were considering a non-crated, part-bedded pen design such as the PigSAFE system. Finally, one-quarter of all producers who answered the questionnaire were thinking of trialling some form of non-crate farrowing system as a pilot.

3. The PigSAFE project

In the first stage of the project, a wide-ranging review of the literature on free-farrowing systems was undertaken to examine the principal features which contribute to the welfare of both the sow and her piglets (Baxter *et al*., 2011a), and to consider the design and management factors affecting the performance of those systems (Baxter *et al*, 2012). From these reviews and from an LP-based optimisation exercise (Ahmadi *et al*, 2011), a prototype pen-based farrowing system was designed. The PigSAFE pen has been developed to optimise welfare and economic performance, with the design intended to meet biological needs of sows and piglets, as well as requirements for stockperson safety and management ease. Following the review of more than 350 articles in the scientific, technical and industry literature, and extensive discussions with a wide range of scientists and stakeholders, a prototype pen was designed as shown in the Figure 1 below (Anon, 2010a and Anon, 2010b). The pen involves a basic nest area, with solid flooring to allow provision of nesting material and sloping walls against which the sow can slide more slowly to ground level for suckling, to lower the risk of piglets being trapped and killed. A heated creep area has easy access from the nest. A separate slatted dunging area is bounded by walls with barred panels to adjacent pens to discourage farrowing outside the nest. A feeding crate for the sow is included at one side of the pen, where the sow can be locked in to allow safe inspection or treatment of the piglets.

The resulting PigSAFE system then has embedded design features to promote piglet survival and ease of management. The pen layout encourages the sow to farrow in a particular location promoting the use of a readily accessible heated safe creep area by the piglets and incorporates sloping walls to facilitate their escape from crushing. It also provides a safe environment stockpersons as the sow can be confined in a feeding stall thus allowing personnel to undertake piglet tasks. The pen is easily cleaned between batches as the sides are fabricated from plastic panels which are easily cleaned and disinfected, and the slatted dunging area has automated manure removal.

This design, with some variations to test specific alternative design features, was piloted at Newcastle University's Cockle Park farm (Edwards *et al*., 2012a) and SAC's Bush Estate (Baxter *et al*., 2011b), using 150 litters at each site. Analysis of pig performance of this pilot stage was used to finalise a design for the new system which was then run for a further year at both sites under commercial conditions. The building space occupied by the pen is approximately 20% more than that occupied by a conventional farrowing crate.

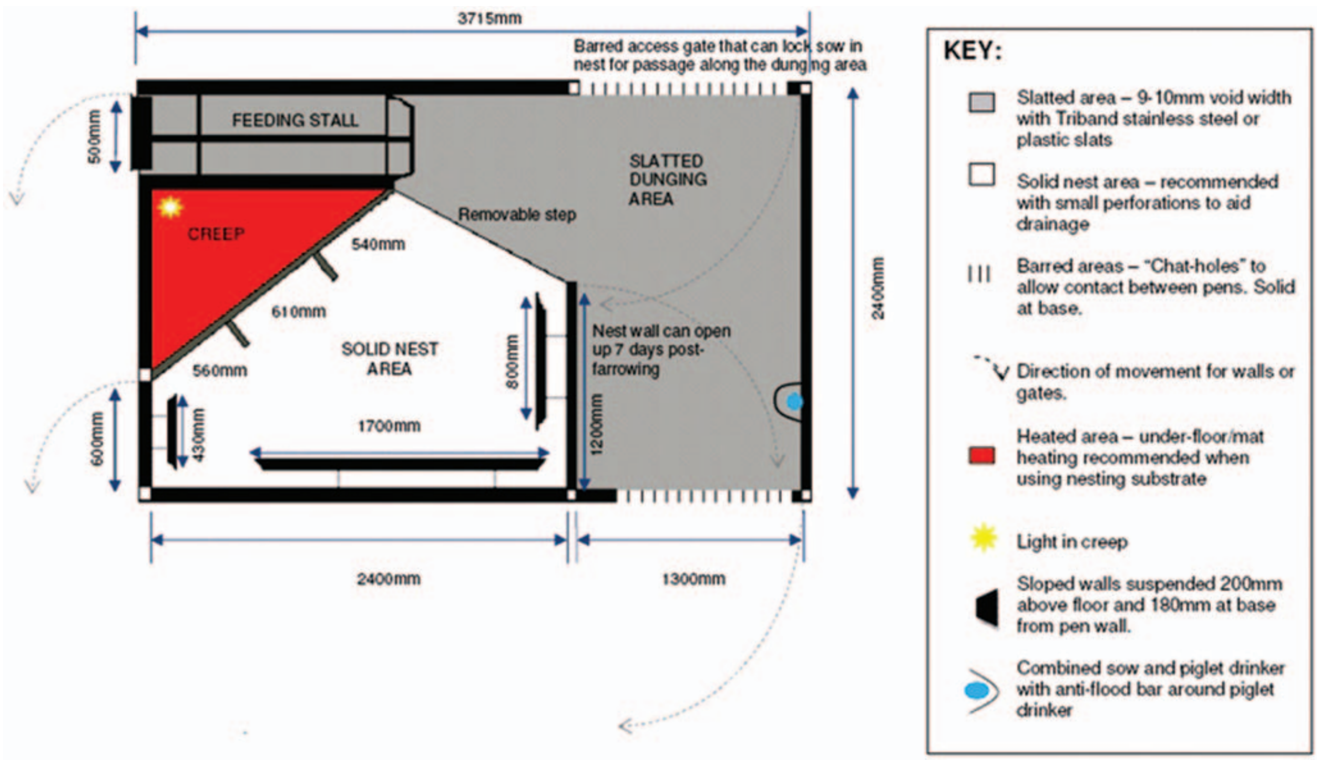

Figure 1: Prototype pen, PigSAFE

Table 1: Base model unit parameters

Parameter	Unit value
Breeding sows	540
Staff (FT equivalent)	4.5
Farrowing places	120
Weaner places	1,200
Finisher places	3,600

4. Method of economic analysis

A suite of linear programming (LP) models was developed to test the economic conditions under which pig producers might adopt new farrowing systems. The alternative farrowing systems considered were the PigSAFE system, the 360 Farrower described previously and a Danish free farrowing pen. The latter consists of a minimally bedded pen with a slatted dunging area but without walls dividing functional areas and having a smaller area than the PigSAFE system (Vivi Aarestrup Moustsen, Pers. Com., 2011). A common dry-sow system was assumed for cost purposes, by taking a weighted average of the two most prevalent UK systems, namely kennels with individual feeders and large straw yards with electronic sow feeding.

The base LP model was constructed to simulate the representative UK breeder/finisher unit of 540 sows according to national statistics (BPEX, 2010). Larger (1000-sow) and smaller (200-sow) units were also considered. Table 1 shows the physical parameters of the basic representative unit model. In each case the new farrowing systems were tested against the conventional part-slatted farrowing crate-based system and conditions under which producers were likely to adopt the new system tested. To evaluate the sensitivity of the results, costs, resource use and animal physical performance were varied and the models re-run.

5. Data

To populate the models, in addition to data generated from the farm trials of PigSAFE, data were collected from industry and further supplemented with that from the scientific literature.

Animal performance

Because of the lack of large scale reliable published data on the performance of pigs in non-crate systems, sow performance parameters (e.g. litters per sow per year, numbers born alive, pre-weaning mortality), initially were assumed to be equal for all systems and were taken from the average technical performance data for UK indoor herds (BPEX, 2010). Thus farrowing performance was assumed initially to be 2.25 litters per sow per year and 10 piglets weaned per litter.

In the trial, sow performance in the crates and in the commercial PigSAFE phase were not significantly different (Edwards *et al*, 2012b) and the number of piglets weaned per litter were the same under both systems. This is contrary to the results of many previous investigations into free-farrowing systems. Also, at the Edinburgh site weaning weights were about 0.3 kg higher in the PigSAFE system than in the crate system.

Cost data

Cost data used included the costs of building construction, level of resource use (labour, power etc.) in operating the various housing systems and the unit costs of these resources. Estimates of building construction and repair costs were provided by a number of UK commercial pig building companies, assuming new build construction costs and provision of a building frame in which the farrowing system will be located. The PIGSafe system proved the most expensive to construct at £4,388 per unit compared with £3,170 for the conventional farrowing crate system. The annual building costs per sow place were estimated based on the expected lifespan and repair costs of the various housing systems as shown in Table 2.

Standard unit prices were collated for feedstuffs, labour cost per hour and machinery. Average electrical power use for farrowing systems was calculated from data collected on UK farms by Farmex Ltd (Reading, UK). Stockperson labour hours for farrowing and weaner phases were calculated from industry labour studies for indoor pig systems (Webster and Harper, 2008), along with data from the Newcastle PigSAFE trial. Bedding use was estimated from trial results and information provided in literature (Vieuille *et al*., 2003; MAFF, 1993). Machinery use for general sow husbandry, slurry and solid manure disposal were adapted from standard farm management data (Nix, 2010 and SAC, 2010). The unit input prices used are shown in Table 3.

Building space requirement and labour use for each stage of pig production are shown in Table 4.

Production costs incurred for each stage of pig production, excluding resources included within the LP model matrices (principally buildings and labour),

Table 2: Building costs of farrowing sow systems

	Farrowing system			
Element	Crate	PigSAFE	360 Farrower	Danish
Capital cost (£/place)	3,170	4,388	3,670	3,804
Lifetime (Years)	20	20	20	20
Annualised capital cost (£ per £1,000 @8%)	102	102	102	102
Sow place cost (£/year)	323	448	374	388
Repair cost (£/sow place/yr)	45	61	51	53
Total cost (£/ sow place/yr)	368	509	425	441

[5] In mid-December 2012, £1 was approximately equivalent to $US 1.63 and €1.23

Table 3: Standard unit input prices

Resource	Description	Unit	Cost/unit (£)
Feed	Lactating sow diet	Kg	0.21
	Creep feed	Kg	0.74
Vet. and Med.	Farrowing sow	Per sow per year	41.78
Machinery	Tractor hour	Hour	14.55
	Slurry disposal	M^3	2.4
	Farm Yard Manure disposal	Tonne	3.2
Bedding	Straw	Tonne	60
Labour	Stockperson	Hour	13.08
Water	Mains water	M^3	1.3
Power	Electrical energy	KW/h	0.10

Table 4: Building space use and labour requirement

Phase	Pig space use (annual proportion of a place)	Labour (hours per animal)
Dry sows	0.78/year	4.7
Farrowing sows	0.1/farrowing	2.6
Weaners	0.1/year	0.32
Grower/finishers	0.3/year	0.08

Table 5: Production costs for each stage of pig production (£/animal)

Stage of pig production	System	Cost £/animal
Dry sow	Kennels/Straw yards	£357[1]
Farrowing sow	Crate	£95[2]
	PigSAFE	£95[2]
	360 Farrower	£95[2]
	Danish	£94[2]
Weaner	Fully-slatted	£17[3]
Grower/finisher	Fully-slatted	£54[3]

Notes:
1. Dry sow costs are annual total costs excluding labour and weighted 50/50 for the two systems.
2. Farrowing sow costs are per farrowing and exclude building and labour costs.
3. Weaner and finisher costs are per pig excluding labour.

Table 6: Variations applied to the PigSAFE base model

Parameter varied	System	Base model	Variation	Value
Building cost - new	PigSAFE	£509/place	−10%	£458/place
	Crates	£337/place		
No. piglets weaned	PigSAFE	10 pigs/litter	−5%	9.5 pigs/litter
			−10%	9.0 pigs/litter
Building renovation	PigSAFE	£509/place	renovation	£365/place
	Crates	£368/place	renovation	£249/place
Piglet weaning weight	PigSAFE	7 kglwt	+ 0.3kglwt	7.3 kglwt

were calculated in the spreadsheet budgeting models to be used as objective function values in the LP models (see Table 5).

6. Model Runs

Using the data described above, the base models were run allowing the optimisation process to select between the farrowing crate system and one of the new farrowing systems. In the first instance the farrowing systems were assumed to be new-build. The models were used in three ways. Firstly by applying a variable premium to sales from the free farrowing systems it was possible to simply calculate the differences in production costs between the systems as the premium required to promote a switch between systems. The models were then re-run for the PigSAFE system to determine the effects on these differences in costs of production of variations in some of the principal costs and of changes in the performance parameters. Table 6 shows the variations which were applied and, as can be seen, one of these was to include the renovation of existing farrowing facilities rather than simply allowing the new-build option. Finally, the models were used to test the economic conditions under which the optimum solution would select the free farrowing system.

Table 7: Effects of variations on production costs

Model run	PigSAFE cost (pence/kgcwt)	Difference compared to farrowing crate production costs (145.0 pence/kgcwt)	
		p/kgcwt	%
Base	147.3	2.3	1.6
Reduced numbers weaned	152.7	4.7 (−0.5 pig)	3.2
		7.7 (−1 pig)	5.3
Reduced building cost	146.5	1.5	1.0
Renovated buildings	145.3	1.8	1.2
Higher weaning weight	146.3	1.3	0.9

7. Results

The results were firstly expressed as differences in cost of production per kg carcass of pigmeat (p/kg cwt). The base model, using only conventional crates, showed a production cost of 145.0 p/kg cwt, and using the PigSAFE system this rose to 147.3 p/kg cwt, a difference of 2.3 p, or 1.6% (Table 7). The costs calculated for the other two alternative farrowing systems, namely the 360 Farrower and the Danish free farrowing system, showed lower cost increases as a result of their lower capital (building) costs. The 360 Farrower had the lowest additional cost above the farrowing crate at 1.1 p/kg cwt, with the Danish system 1.5 p/kg cwt above the crate system.

When considering changes in performance, if numbers of piglets weaned from the PigSAFE system were reduced by 5% (to 9.5 pigs per litter) the cost difference compared to farrowing crates rose markedly to 4.7 p/kg cwt, and when reduced by 10% (9.0 pigs per litter) the cost difference rose to 7.7 p/kg cwt or 5.3%.

When the new-build construction costs for the PigSAFE system were reduced by 10%, as could happen if this novel system became more popular and producers might benefit from economies of scale in fabrication of the system, the difference in production cost narrowed to 1.5 p/kg cwt. Similarly, if it were possible to alter existing buildings to allow PigSAFE to be installed by renovation rather than new-build, the difference in cost of production was also less at 1.8 p/kg cwt. When improved weaning weights were assumed for the PigSAFE system, the additional 0.3 kg of liveweight at weaning which was experienced in the trials resulted in a narrowing of the production cost difference by 1.0 p/kg cwt compared to the conventional system or 1.3 p/kg cwt compared to the basic PigSAFE system (see Table 7).

The effect of scale of the pig enterprise on the structure and level of production costs was examined. There is evidence to suggest that larger scale units can achieve lower labour costs, of the order of 15 to 20% per animal, and lower building costs through construction of larger units. The evidence for differences in physical performance is mixed, with some survey data showing better performance in smaller units. As far as the current study is concerned, the calculations do not suggest that scale would differentially affect the cost of production under the various farrowing systems and is therefore unlikely to effect the decision about whether adopt a particular farrowing system beyond those factors analysed in the base model.

8. Conditions for adoption of the PigSAFE system by the UK pig industry

The results presented above showed differences in the cost of pigmeat production between conventional farrowing crates and the PigSAFE system under various financial and physical conditions. The base models were re-run to test the conditions under which the adoption of PigSAFE would be cost neutral to the pig industry. The first of these conditions would simply be the receipt of a premium of 2.3 p/kg cwt to cover the higher cost of production. In the UK, pigmeat from certain production systems such as outdoor-reared or under the RSPCA Freedom Food scheme commands a premium, suggesting that there may be a proportion of the market which might be prepared to pay more for pigmeat from sows which are not confined at farrowing. Similarly, if the building costs of the PigSAFE system matched those of the conventional crate (a considerable reduction of 28%) whilst performance remained constant, adoption of this alternative farrowing system would clearly be cost neutral. In terms of pig performance, the re-runs of the models also showed that the adoption of the PigSAFE system would be cost neutral if it could deliver higher performance (0.5 more pigs weaned per litter for example). Similarly, a higher weaning weight, of about 0.75 kg/pig, would also eliminate the gap in production cost. Clearly, not all of these factors are achievable individually, but combinations of more realistic changes (e.g. a modest premium coupled with slightly higher weaning weight or an effect on the efficiency of sows rebreeding) might be more feasible and lead to voluntary adoption of non-crate systems such as PigSAFE by the UK pig industry.

9. Conclusions

This analysis of the economic impact of using alternative non-crate farrowing systems suggests that there are two principal factors which affect cost of production: capital costs of construction and animal performance.

Capital costs of construction ranged from £3,170/sow place for conventional crates, up to £4,388/sow place for the PigSAFE system. This difference resulted in a production cost differential of 2.3 p/kg cwt over the lifetime of the system. Such a cost penalty would be further compounded if it were linked with lower physical performance of the animals. For example, the loss of an additional 0.5 piglets weaned per litter lead to a rise in production costs of 4.7 p/kg cwt. Conversely, improved performance in the PigSAFE system could narrow the gap in cost of production, with an average higher weaning weight of 0.3 kg weaning saving 1.0 p/kg cwt. This illustrates the different scenarios under which commercial pig producers might be encouraged to adopt non-crate systems such as PigSAFE.

This study has focused on production costs and not profitability. The other factor in the profit calculation is price received for pigmeat produced under the various systems. Although not explicitly considered in this study, clearly carcass value would depend on the details of any contract and the grading of pigs produced, as well as any premium accorded to the different systems under which the animals are produced. Changes to housing legislation would be another important factor which could affect the level of uptake of alternative farrowing systems. Whilst there is nothing currently in the pipeline, it could be that future changes in EU animal welfare rules force the adoption of alternative systems, a possibility that has prompted the recent interest by producers in developments in free farrowing systems.

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