Reforming Pig Welfare in the European Union

The Case for a Cage-Free Future

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Executive Summary

This paper provides an overview of the legislative landscape for the protection of pigs in the European Union (EU), with a particular focus on the use of caged systems. It advances a key policy recommendation: the prohibition of farrowing crates under EU law.

To this end, the paper assesses the animal welfare and economic implications of introducing an EU-wide ban on the use of farrowing crates. The policy scenario assumes a **ban announced in 2028 with a 10-year transition period ending in 2038**. During this period, EU pig farmers would transition from crates to larger farrowing pens, guided by farm-level economic decisions and individual circumstances, such as the age of existing infrastructure and the comparative costs of new investments.

As five EU Member States (Sweden, Germany, Austria, Denmark, and Finland) already have national legislation phasing out the routine use of farrowing crates, the impacts of an EU-wide ban are modeled for the remaining **22 Member States**. These impacts are evaluated against a counterfactual scenario where existing national bans, voluntary market-driven adoption, and potential future national laws dictate the pace of transition. The modeling horizon extends to 2060 with monetary values discounted to 2025 EUR.

In terms of economic impact, our central cost estimate for transitioning to free-farrowing is **just under 1 cent per kg** of pig meat (EUR 0.008), resulting in an **aggregate net policy cost of EUR 1.11 billion**. This increase is driven primarily by higher building costs per sow and increased labor requirements, which are partially offset by faster piglet weight gain.

The ban avoids **7.63 billion sow-crate-days**, yielding an aggregate cost-effectiveness of **EUR 0.15 per sow-crate-day avoided**. By the end of the assessment period (2060), the counterfactual central estimate still projects roughly 206 million ongoing sow-crate-days per year. Consequently, over a longer horizon, the cumulative benefits of the ban will grow beyond the figures reported here, while the transition costs will not.

The animal welfare impact is determined by measuring changes in sow welfare using **Animal Quality-Adjusted Life Years (AQALY)**. This metric spans four major domains of the Five Domains model: nutrition, environment, health, and behavior. Based on average domain scores, moving a single sow from a crate to a free-farrowing system yields about **0.003 AQALY per sow-crate-day avoided**, an annualised improvement of **1.07 AQALY**.

Costs and Benefits of an EU Ban on Farrowing Crates

To benchmark these findings against human QALYs, which carry established monetary values, the AQALY can be monetized using a moral weight parameter. Applying a neuron-proportional sentience weight—based on the ratio of cortical neurons between pigs and humans (1/44)—the AQALY converts to a monetized **welfare benefit of EUR 44 billion** and **EUR 5.82 per sow-crate-day avoided**. The **resulting benefit-cost ratio of 40** indicates that for every EUR 1 of cost incurred by farmers, the ban delivers EUR 40 in sow welfare benefits. Two alternative valuation approaches, grounding moral weights in consumer willingness-to-pay and hedonic capacity, produce even higher benefit-cost ratios of 376 and 908, respectively. Across all three monetization frameworks, the net social balance remains positive by one to three orders of magnitude.

1. Introduction

The European Union (EU) is the world's second biggest producer of pork, after China, and the largest exporter of pork and pork products.[1] The pig population in the bloc reached 131 million in 2025, with half kept in Spain, Germany, and Denmark.[2] In Denmark, pigs outnumber the country's six million residents by roughly two to one, making it the most intensive pig-producing country on a per-capita basis.[3]

More broadly, the pig sector in the EU is characterized by a high degree of specialization, with seven Member States farming approximately 80% of all pigs in the Union.[4] Consolidation is also common at specific stages of production, such as slaughtering, which is increasingly concentrated in large slaughterhouses. For example, in 2022, just ten companies operating 60 slaughterhouses slaughtered 90 million pigs, representing 38% of all pigs slaughtered in the EU that year.[5] This development in turn incentivizes the transport of live animals across the bloc, with around 35 million pigs transported across the EU each year.[6]

Most pigs in the EU are kept under intensive production systems, often referred to as "factory farms," while the percentage of pigs kept in backyard farms remains consistently low at around 3 percent.[7] While there is no universal definition of intensive (or "factory") farming under EU law, existing legislation provides an indication of scale. More than 11,600 farms across the EU and the UK keep more than 2,000 pigs, or 750 or more breeding sows, at any given time, i.e. above the threshold listed in Directive 2010/75/EU (Industrial Emissions Directive).[8]

Intensive farming systems pose significant risks to animal welfare, as animals' needs are often subordinated to the pursuit of lower production costs and higher profits. Practices such as the routine mutilation of piglets and the lack of environmental enrichment have become characteristic features of modern pig farming. Perhaps one of the most controversial practices is the use of cages for gilts (female pigs after puberty and before their first litter) and sows: so-called "sow stalls" (or gestation crates) for the breeding and pregnancy stage and "farrowing crates" for the birthing and nursing stage. These metal-bar enclosures run closely alongside the body of a gilt or sow and are so narrow that the animal is unable to turn around. In the EU, gilts and sows typically spend about five weeks in sow stalls and another four to five weeks in farrowing crates during each reproductive cycle (from the weaning of one litter to the weaning of the next). With an average of 2.3 litters per year,[9] this amounts to approximately 160 days (or 44% of the year) spent confined in highly restrictive cages.

Although the EU established minimum standards for pig husbandry decades ago, the legislation is largely tailored to the requirements of

1 European Commission, *Pork* (n.d.), https://agriculture.ec.europa.eu/farming/animal-products/pork_en (accessed 21 April 2026).

2 Eurostat, Pig Population: *Annual Data (apro_mt_lspig)*, dataset, 2025, https://ec.europa.eu/eurostat/databrowser/view/apro_mt_lspig/default/table (accessed 21 April 2026).

3 *Ibid*.

4 European Court of Auditors, *Transport of Live Animals in the EU: Challenges and Opportunities*, Review No 03/2023 (Luxembourg: Publications Office of the European Union, 2023).

5 N. Rouault, "TOP 10 des Abatteurs de Porcs de l'UE en 2022, l'Activité des Leaders en Panne," IFIP – Institut du Porc, 7 December, 2023, https://ifip.asso.fr/place-des-marches/actualites-des-marches/analyse-top-10-des-abatteurs-de-porcs-de-lue-en-2022-lactivite-des-leaders-en-panne/.

6 2017-2021 data. European Court of Auditors, *Transport of Live Animals in the EU: Challenges and Opportunities*, Review No 03/2023 (Luxembourg: Publications Office of the European Union, 2023).

7 M.-L. Augère-Granier, *The EU Pig Meat Sector*, EPRS Briefing PE 652.044 (Brussels: European Parliamentary Research Service, 2020), https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/652044/EPRS_BRI(2020)652044_EN.pdf.

8 Note that this threshold is applicable to Directive 2010/75/EU prior to the revision through Directive (EU) 2024/1785. AGtivist Agency, *The Face of European Farming*, https://stories.agtivistagency.com/the-face-of-european-farming/ (accessed 21 April 2026).

9 Agriculture and Horticulture Development Board (AHDB), 2022 *Pig Cost of Production in Selected Countries* (2023).

intensive farming systems. This regulatory approach is particularly problematic given the behavioral and cognitive complexity of pigs and their corresponding welfare needs. Pigs are considered highly intelligent animals, displaying impressive self-recognition, learning abilities and problem-solving skills,[10] as well as tool use.[11] Hence, these animals inevitably experience considerable suffering when confined in barren systems that deprive them of the ability to meet even their most basic physiological and behavioral needs.

In the context of the European Commission's ongoing efforts to modernize animal welfare legislation and respond to the "End the Cage Age" European Citizens' Initiative signed by 1.4 million EU citizens, this white paper focuses on the issue of caged farming of gilts and sows, and the potential reform to prohibit the use of farrowing crates in pig farming. To provide an evidence-based contribution to the current policy discourse, this paper examines progress in the transition to cage-free systems across Europe and assesses animal welfare and economic impacts of a ban on farrowing crates, before setting out policy recommendations for future action.

10 D. M. Broom, *Broom and Fraser's Domestic Animal Behaviour and Welfare*, 6th ed. (Wallingford: CABI, 2022), 47–53.

11 M. Root-Bernstein, T. Narayan, L. Cornier, and A. Bourgeois, "Context-Specific Tool Use by *Sus cebifrons*," *Mammalian Biology* 98 (2019): 102–110, https://doi.org/10.1016/j.mambio.2019.08.003.

Pigs stand, lay or sit in sow stalls at an industrial farm in Poland. © Andrew Skowron, We Animals; Poland, 2020

A sow and her piglets in a farrowing crate at a farm in Italy. © Stefano Belacchi, We Animals; 2011, Italy

2. Legislative Protection of Pigs Under EU and National Law with Particular Focus on Cage Housing Systems

2.1 Pig Welfare Under EU Law

The EU adopts animal welfare legislation primarily within its shared competence in agriculture, as enshrined in the Treaty on the Functioning of the European Union (TFEU).[12] The TFEU recognizes animals as sentient beings in Article 13 and requires both the EU and its Member States to "pay full regard to animal welfare requirements" when formulating and implementing policies in agriculture.

2.1.1 BRIEF HISTORY OF PIG PROTECTION UNDER EU LAW

The EU adopted its first species-specific directive on the protection of pigs in 1991 through Council Directive 91/630/EEC. This Directive marked important progress in pig welfare by prohibiting routine tail docking and teeth clipping from 1994 onwards, while also requiring that pigs be provided with straw or other suitable materials to satisfy their behavioral needs. However, the enforcement of these provisions remains problematic to this day. More than 30 years after the ban on routine tail docking came into effect, only two EU Member States, Sweden and Finland, properly enforce it.[13] The majority of pigs in the remaining Member States are continually subject to tail docking, including in the three largest producing countries, with tail-docking rates of 98.5% in Spain, 95% in Germany, and 98.5% in Denmark.[14]

In 2001, Directive 91/630/EEC was amended, bringing a restriction on the use of sow stalls, i.e., cages, where gilts and sows are kept during breeding (natural or, in most cases, artificial breeding through insemination) and pregnancy. The amended Directive required that gilts and sows be kept in groups during a period starting from four weeks after natural mating or insemination ("the service") to one week before the expected time of farrowing, meaning that they would be kept outside cages for approximately 11 weeks of pregnancy. The EU legislature has acknowledged that "the welfare of pigs appear[s] to be compromised by severe restrictions of space" and that "sows prefer to have social interactions with other pigs when provided with freedom of movement and environmental complexity."[15]

12 Consolidated version of the Treaty on the Functioning of the European Union, OJ C 326, 26.10.2012, Art. 4(2)(d).

13 European Commission, Overview report: The use of indicators for animal welfare at farm level, 2022, https://ec.europa.eu/food/audits-analysis/overview_reports/details.cfm?rep_id=147. Also in that sense, see A. Poinsot, "L'interdiction de la caudectomie routinière en élevage porcin : état des lieux et perspectives," *Revue de droit rural*, 2025/12 (in French).

14 European Commission, Final report of an audit carried out in Spain from 18 September 2017 to 22 September 2017 in order to evaluate member state activities to prevent tail-biting and avoid routine tail-docking of pigs, DG(SANTE) 2017-6126; Final report of an audit carried out in Germany from 12 February 2018 to 21 February 2018 in order to evaluate member state activities to prevent tail-biting and avoid routine tail-docking of pigs, DG(SANTE) 2018-6445; Final report of an audit carried out in Denmark from 09 October 2017 to 13 October 2017 in order to evaluate member state activities to prevent tail-biting and avoid routine tail-docking of pigs, DG(SANTE) 2017-6123.

15 Council Directive 2001/88/EC of 23 October 2001 amending Directive 91/630/EEC laying down minimum standards for the protection of pigs, OJ L 316, 1.12.2001, Recitals 4) and 5).

The transition period for this measure expired on January 1st, 2013. Despite the ample 12-year implementation period, 11 Member States have failed to comply with the ban. In February 2013, the European Commission initiated infringement proceedings under Article 258 TFEU by sending letters of formal notice to nine non-compliant countries: Belgium, Cyprus, Denmark, France, Germany, Greece, Ireland, Poland, and Portugal.[16] A year later, formal notices were sent to Finland and Slovenia as well.[17] In 2014, the Commission proceeded to the next stage of the infringement procedure by issuing reasoned opinions to Belgium, Cyprus, Greece, and France. However, none of the cases advanced beyond this stage, and all infringement proceedings were eventually closed in the following years.

2.1.2 PIG WELFARE STANDARDS UNDER COUNCIL DIRECTIVE 2008/120/EC

In 2009, the 1991 Directive was repealed and replaced by Council Directive 2008/120/EC (Pig Directive),[18] which is currently in force. The Pig Directive establishes several key obligations for pig farms, primarily concerning the minimum floor area to be provided to pigs or the prohibition of tethering of gilts and sows.[19] However, no space requirements exist for gilts and sows outside of group-housing, thereby permitting the continued use of these highly restrictive confinement systems of sow stalls and farrowing crates. It should be noted, however, that restricting the freedom of movement of farmed animals in a manner that causes unnecessary suffering or injury constitutes a breach of Council Directive 98/58/EC (General Farming Directive), thereby calling into question the legality of sow stalls and farrowing crates given the existence of viable alternatives.[20]

The Directive also sets out additional standards for pig housing in Annex I, including requirements relating to environmental conditions, such as lighting, noise levels, and floor design, as well as rules on feeding practices and mutilations, i.e., procedures involving the removal or alteration of body parts, which are usually performed on young piglets. Mutilations such as tail docking, teeth grinding or clipping, and castration are permitted with very limited conditions.[21] Minimum weaning age is established at four weeks, with the possibility of reducing it to three under certain conditions.[22]

With respect to cages used for gilts and sows during pregnancy, the Pig Directive carries on the requirement of moving pregnant gilts and sows to group housing four weeks after the service, before they can be transferred to farrowing crates one week before the expected time of farrowing.[23] During this group-housing period, each gilt is required to be provided with 1.64m² of space and each sow with 2.25m², with a certain portion of this area required to be solid flooring (as opposed to slatted floors).[24] An exception to the group-housing requirement for gilts and sows exists for “particularly aggressive” animals, as well as those that have been attacked or injured. In that case, the Pig Directive specifies that those individuals can be “temporarily” kept in individual pens, with such pens required to allow them to turn around “if it is not in contradiction with specific veterinary advice.”[25]

16 See procedures INFR(2013)2013 (Belgium), INFR(2013)2014 (Cyprus), INFR(2013)2015 (Denmark), INFR(2013)2018 (Greece), INFR(2013)2016 (Germany), INFR(2013)2021 (France), INFR(2013)2019 (Ireland), INFR(2013)2020 (Poland), and INFR(2013)2017 (Portugal).

17 INFR(2013)2019 (Finland), INFR(2013)2298 (Slovenia).

18 Council Directive 2008/120/EC of 18 December 2008 laying down minimum standards for the protection of pigs, OJ L 47.

19 *Ibid*, Art. 3(1-3).

20 Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes, OJ L 221, 8.8.1998, Point 7 of the Annex.

21 *Ibid*, Point 8 of Chapter I of Annex I.

22 *Ibid*, Point C.3 of Chapter II of Annex I.

23 *Ibid*, Art. 3(4).

24 *Ibid*, Art. 3(1)(b).

25 *Ibid*, Art. 3(8).

With regard to farrowing crates, the Directive is very brief and fails to consider sow welfare. It specifies that in the week between the expected time of farrowing and during farrowing, gilts and sows do not have to be able to see other pigs.[26] The Pig Directive also requires that gilts and sows placed in farrowing crates be "thoroughly cleaned," and provided with "suitable nesting material," unless it interferes with the slurry system in use.[27] If farrowing pens, which are a principal alternative to crates offering more space to a sow, are used instead of crates, there must be means of protecting the piglets, such as farrowing rails designed to protect the piglet from being crushed by the sow.[28]

In light of contemporary animal welfare science (see Section 3), these standards are inadequate to meet pigs' behavioral and welfare needs. This inadequacy is compounded by the Directive's vague and conditional drafting, which leaves significant room for weak enforcement, to the detriment of pigs. For example, the requirement to provide pigs with enrichment material is undermined by imprecise wording that specifies neither the quantity nor the quality of such material.[29] Moreover, the obligation to provide nest-building material for sows is qualified by the technical feasibility of the slurry systems in use, rather than mandating designs that allow for the provision of adequate enrichment without obstruction.[30] Another example is the regulation of tail docking and teeth reduction procedures. Although these practices are formally permitted only as a last resort, the wording leaves considerable room for lax enforcement, thereby undermining the effective protection of pig welfare.[31] These findings underscore the urgent need to revise the Pig

26 *Ibid*, Point 3 of Chapter I of Annex I.

27 *Ibid*, Points B.2 and 3 of Chapter II of Annex I.

28 *Ibid*, Point B.5 of Chapter II of Annex I.

29 *Ibid*, Point 4 of Chapter I of Annex I.

30 *Ibid*, Point B.3 of Chapter II of Annex I.

31 *Ibid*, Point 8 of Chapter I of Annex I.

32 In this sense, see European Commission, Commission Staff Working Document: Fitness Check of the EU Animal Welfare Legislation, SWD(2022) 328 final, October 4, 2022.

33 Eurostat, *Organic Livestock (org_lstspec)*, dataset, 2024, https://ec.europa.eu/eurostat/databrowser/view/org_lstspec/default/table?lang=en&category=agr.org (accessed 15 June 2026).

A pregnant sow in a farrowing crate at an industrial farm. © Andrew Skowron, We Animals; 2020, Poland

Directive and establish clear, precise, harmonized, and science-based requirements for all categories of pigs, thereby enhancing legal certainty and ensuring consistent implementation across Member States.[32]

2.1.3 ORGANIC PIG FARMING

Certified organic farms must comply with requirements that go beyond those applicable to conventional farming, including higher animal welfare standards. As a general rule, female pigs, like other farmed animals, must not be kept in cages under EU organic farming rules. Organic pig production remains a small, niche sector within European agriculture. In 2020, fewer than 100,000 sows among more than 10 million were kept under organic management.[33]

Since the 1990s, the EU Organic Regulation requires organic pig producers to keep sows in groups, except during the final stages of pregnancy and the nursing period.[34] The currently applicable Regulation (EU) 2018/848 (Organic Farming Regulation) maintains this requirement, prohibiting the use of sow stalls.[35] Organic farming rules also prescribe a minimum space allowance of 2.5m² indoors, and 1.9m² outdoors, per gilt or sow.[36]

Similarly, the use of farrowing crates is prohibited in organic pig farming. Since 2000, farrowing sows with piglets must be provided with 7.5m² of indoor space and 2.5m² of outdoor space, effectively prohibiting the close confinement of farrowing crates.[37] The Organic Regulation explicitly requires that a sow must be able to move freely within her pen and that any restriction of her movement may occur only for "short periods," although the legislation does not define or quantify what constitutes a "short period."[38] Farmers are also required to provide straw or other suitable natural material in quantities sufficient to enable nest-building behavior.[39] In addition, piglets' minimum weaning age is established at 40 days.[40]

2.1.4 PERSPECTIVES FOR THE FUTURE OF PIG PROTECTION

The European Commission initiated the process of revising the animal welfare legislation, including the Pig Directive, following the adoption of its flagship 2020 food strategy, Farm to Fork, which envisaged a comprehensive overhaul of the existing framework to better align outdated standards with contemporary animal welfare science.[41] Although the legislative proposals were expected to be published by the end of 2023, none of the measures addressing on-farm welfare or welfare at the time of slaughter materialized. This outcome was met with considerable disappointment, particularly as the revision process also included the assessment of a transition toward cage-free farming for all farmed animals, including gilts and sows. This consideration stemmed from the "End the Cage Age" European Citizens' Initiative, which was supported by 1.4 million EU citizens.[42]

The ECI was positively received by the three main EU Institutions. On June 10th, 2021, the European Parliament's Plenary adopted a Resolution calling on the Commission to phase out the use of cages in animal farming in the EU, with an overwhelming majority of MEPs (558) voting

34 Council Regulation (EC) No 1804/1999 of 19 July 1999 supplementing Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs to include livestock production, OJ L 222, 24.8.1999, Point 8.3.8 of Part B of the Annex.

35 Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007, OJ L 150, 14.6.2018, Point 1.9.3.2 d) of Part II of Annex II.

36 Commission Implementing Regulation (EU) 2020/464 of 26 March 2020 laying down certain rules for the application of Regulation (EU) 2018/848 of the European Parliament and of the Council as regards the documents needed for the retroactive recognition of periods for the purpose of conversion, the production of organic products and information to be provided by Member States, OJ L 98, 31.3.2020, Art. 10 in conjunction with Part III of Annex I.

37 The requirement was first introduced by Council Regulation (EC) No 1804/1999 of 19 July 1999 supplementing Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs to include livestock production, OJ L 222, 24.8.1999, by adding Annex VIII.

38 Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007, OJ L 150, 14.6.2018, Point 1.9.3.2 d) of Part II of Annex II.

39 *Ibid*, Point 1.9.3.2 e) of Part II of Annex II.

40 Commission Implementing Regulation (EU) 2020/464 of 26 March 2020 laying down certain rules for the application of Regulation (EU) 2018/848 of the European Parliament and of the Council as regards the documents needed for the retroactive recognition of periods for the purpose of conversion, the production of organic products and information to be provided by Member States, OJ L 98, 31.3.2020, Art. 9.

41 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions, A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system, COM/2020/381 final.

in favor and only 37 against.[43] Later that month, on June 30th, 2021, the European Commission published a Communication committing to propose a ban on caged farming for all species named in the Initiative by the end of 2023.[44] The Commission highlighted the fact that the Initiative "reflects social concerns, supported by scientific evidence." Finally, the AGRIFISH Council endorsed the plans in July 2021, with Ministers overwhelmingly welcoming the proposed phase-out of cage systems and stressing the need for scientific evidence and financial assistance to ensure a smooth transition. However, the original deadline for the proposal was not met by the Commission, and the organizers of the ECI filed an action for failure to act before the Court of Justice of the European Union.[45]

As the 2019-2024 legislative term ended without delivering the anticipated reforms in animal welfare policy, the current European Commission has revived the process through a more narrowly scoped "modernization" of the animal welfare acquis, accompanied by a public consultation launched in 2025. Among the four principal areas of reform under consideration is, once again, the potential introduction of a ban on the use of cages in animal farming.

2.2 National Regulation of Pig Caged Farming in Europe and Beyond

Under EU law, EU Member States are permitted to adopt stricter standards for pig protection beyond those in the Pig Directive.[46] In practice, several Member States have done so over the years, limiting or prohibiting the use of sow stalls and farrowing crates in their territories, largely in response to sustained advocacy efforts for stronger animal welfare rules and growing public concern over the conditions in which animals are kept.

Among these, some countries prohibit the use of sow stalls altogether and instead require gilts and sows to be group-housed throughout breeding and pregnancy, subject to limited exceptions for specific management procedures. Others continue to permit the use of sow stalls but restrict the period during which they may be legally used.

As for the housing of sows during the farrowing and nursing stage, this paper distinguishes, from a regulatory perspective, three principal systems at the national level:

1. **Permanent crating:** As the Pig Directive does not explicitly regulate the restriction of a gilt's or sow's movement throughout the farrowing and nursing period, permanent crating remains the prevailing practice in Member States that have not adopted standards exceeding the requirements of the Pig Directive. In practice, a sow is typically confined in a crate measuring approximately 2 metres in length and 0.45-0.65 meters in width,[47] for four to five weeks.
2. **Temporary crating:** Positioned between permanent crating and free-farrowing systems, this system permits the restriction of a gilt's or a sow's movement for a limited, explicitly established period around farrowing. In practice, a farrowing pen that contains a crate that can be

42 European Commission, "End the Cage Age", European Citizens' Initiative, https://citizens-initiative.europa.eu/initiatives/details/2018/000004_en (accessed 21 April 2026).

43 European Parliament resolution of 10 June 2021 on the European Citizens' Initiative "End the Cage Age" (2021/2633(RSP)).

44 European Commission, Communication from the Commission on the European Citizens' Initiative (ECI) "End the Cage Age," C(2021) 4747 final.

45 T-151/24, Action brought on 16 March 2024 – "End the Cage Age" v Commission.

46 Council Directive 2008/120/EC of 18 December 2008 laying down minimum standards for the protection of pigs, OJ L 47, Art. 12.

47 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," EFSA Journal, 20(8), 2022, https://doi.org/10.2903/j.efsa.2022.7421.

opened from one or both sides or removed can be used. Temporary crating may present an enforcement risk that the maximum permissible confinement period may be exceeded unless compliance is subject to effective monitoring. Germany, Austria, and Denmark are currently transitioning toward this system.

3. **Free farrowing:** Under this system, the use of farrowing crates is prohibited. Instead, sows are usually housed in farrowing pens, which provide more space. Typically, exceptions permitting restraint of a sow's freedom of movement exist, including short-term restraint for management purposes, such as feeding (usually lasting minutes or hours), or even longer restraint in individual cases (which can last days). The specifications of such restraint vary across countries and pen designs used; the key distinction from temporary crating is that any longer-term restraint is not permitted by default, but only on a case-by-case basis. Sweden is currently the only EU Member State that mandates free farrowing as the standard system.

This section examines national legislation that goes beyond the requirements of the Pig Directive with regard to the housing of gilts and sows. It also considers selected non-EU jurisdictions where notable developments in this area have taken place.

2.2.1 AUSTRIA

Austria has limited the use of sow stalls and banned the permanent crating of sows, moving instead toward temporary crating, with a transition period for both measures running until 2033.[48] From that year, group housing of gilts and sows will be required from a period beginning after service and ending five days before the expected date of farrowing, with the exception of farms with fewer than ten sows. These smaller farms may continue to house gilts and sows individually, provided that the animals are kept in pens that allow them to turn around freely.[49] The same requirement applies where a gilt or sow cannot be kept in group housing, for example due to illness or injury. However, sow stalls will not be entirely phased out. The Austrian Animal Husbandry Ordinance permits the use of individual stalls during the service period for up to ten days. The minimum dimensions of such stalls are 65cm in width and 190cm in length, which is broadly comparable to conventional sow stalls and does not provide sufficient space for the animal to turn around.[50]

Farrowing pens, where a gilt or a sow may be moved five days before the expected farrowing date, must be designed to allow them to move freely while enabling piglets to nurse without hindrance. Including the piglets' lying area, each farrowing pen must provide a minimum floor area of 5.5m² and have a minimum width of 160cm. Sows may be temporarily confined from one day before the expected farrowing date until five days after farrowing, corresponding to the critical period around birth. During this period, any farrowing crate used is required to be adjustable to the body size of the sow or gilt in both width and length.[51]

48 Verordnung der Bundesministerin für Gesundheit und Frauen über die Mindestanforderungen für die Haltung von Pferden und Pferdeartigen, Schweinen, Rindern, Schafen, Ziegen, Schalenwild, Lamas, Kaninchen, Hausgeflügel, Straußen und Nutzfischen (BGBl. II Nr. 485/2004), Fassung vom 07.06.2026 (Tierhaltungsverordnung), Point 9 of Annex 5.

49 *Ibid*, Point 3.1.1. of Annex 5.

50 *Ibid*, Point 3.2 of Annex 5.

51 *Ibid*, Point 3.3.2 of Annex 5.

2.2.2 DENMARK

In 2024, the Danish government signed an agreement with six political parties called "Together for Animals" (*Sammen om Dyrene*). This agreement acknowledged that constant confinement of sows in farrowing crates compromises animal welfare and should no longer be permissible. For that reason, the agreement stressed that the use of farrowing crates should be phased out.[52]

This objective has recently materialized with the new executive order that came into force on January 1st, 2026, which prohibits permanent crating and instead moves toward temporary crating.[53] During farrowing and nursing, female pigs will have to be kept in farrowing pens instead of farrowing crates starting from April 2041, but their freedom of movement can still be restricted through the use of farrowing bars during the period immediately before expected farrowing, to a maximum of four days after farrowing.[54] The legislation further requires that farrowing pens allow a sow or gilt to turn around without hindrance, and the piglets must have sufficient space to nurse without difficulty. The required minimum area of a farrowing pen will be 6.5m², including a screened area for the piglets, and at least 3m² of the pen's floor area must have a continuous solid or drained floor.[55] Female pigs in the farrowing pens will also have to be provided with suitable nest-building material of sufficient quality beginning in 2041, replacing the currently applicable "limitation by the feasibility of the slurry system" akin to the EU legislation.[56]

The use of sow stalls will also be limited from 2035 onwards.[57] From weaning until four weeks after service, sows must be kept in loose group housing systems in larger or smaller groups. Individual pigs that are aggressive, have been attacked by other pigs, or are sick or injured may be temporarily housed in individual pens. The same applies to the period between four weeks after service until seven days before the expected farrowing date, where individual exceptions to group housing may be permitted under EU law.[58]

Following the 2026 parliamentary elections, the Danish government published its manifesto in June, in which it reiterated its objective of improving pig welfare, including by completely phasing out the confinement of sows during farrowing and nursing.[59]

2.2.3 FINLAND

In 2023, Finland adopted a new Animal Welfare Act. The Act provides that animals' movement must not be continuously restricted by structures that prevent them from turning around.[60] However, two exceptions apply to pigs. First, the new law establishes a moratorium on farrowing crates, meaning crates that were already in use when the Act entered into force may continue to be used, and only the construction and introduction of new farrowing crates is prohibited. Second, sow stalls may continue to be used, but their use will be limited to a maximum of eight days in connection with service from January 1st, 2035. For pig holdings constructed or substantially renovated after the Act entered into force, this restriction applies immediately upon completion of the construction or renovation.[61]

52 Ministry of Food, Agriculture and Fisheries of Denmark, *Sammen om dyrene – dyrevelfærdsaftalen af 9. februar 2024* ("Together for Animals – Animal Welfare Agreement of 9 February 2024"), https://fvm.dk/nyheder-og-pressemeddelelser/2026/jan/minister-udfaser-fiksering-af-soeer (accessed 4 June 2026).

53 Bekendtgørelse om dyrevelfærdsmæssige mindstekrav til hold af grise (BEK nr 1603 af 04/12/2025). The Executive Order has since been repealed and Bekendtgørelse om dyrevelfærdsmæssige mindstekrav til hold af grise (BEK nr 400 af 26/03/2026) is applicable at the time of writing.

54 Bekendtgørelse om dyrevelfærdsmæssige mindstekrav til hold af grise (BEK nr 400 af 26/03/2026), § 72, Subsections 1, 3 and 5 in conjunction with § 90.

55 *Ibid*, § 72, Subsection 2.

56 *Ibid*, § 71 in conjunction with § 91.

57 *Ibid*, § 65, Subsection 1 in conjunction with § 88.

58 *Ibid*, § 65, Subsection 2.

59 Danish Government, *Det politiske grundlag for firkløverregeringen* (Statsministeriet, 2 June 2026), https://regeringen.dk/aktuelt/publikationer-og-aftaletekster/det-politiske-grundlag-for-firkloeverregeringen/ (accessed 3 June 2026).

60 Laki eläinten hyvinvoinnista (693/2023), 37(2) §.

61 *Ibid*, 122 §.

2.2.4 GERMANY

With approximately 1.4 million sows, Germany has the second largest sow population in the EU after Spain.[62] The country is currently transitioning to full group housing of sows, with a transition period until 2029,[63] and to temporary crating during farrowing, with a transition period until 2036,[64] following an amendment to its Animal Welfare Farmed Animal Husbandry Ordinance (*Tierschutz-Nutztierhaltungsverordnung*) in 2021.[65]

Gilts and sows will have to be group-housed.[66] Sick and injured gilts and sows can be kept individually, but in a way that enables them to turn around.[67] If gilts or sows are not kept in groups during the period from one week before the expected farrowing date until weaning, they may only be kept in pens that provide 6.5m² of floor area and allow the gilt or a sow to turn around without hindrance.[68] Gilts and sows may only be kept in crates for a maximum period of five days, including the period during which farrowing takes place.[69] On that note, the law further specifies that gilts and sows may be crated only if it is not clearly apparent that this form of housing causes persistent agitation which, in particular, cannot be remedied by the provision of enrichment material.[70]

2.2.5 NETHERLANDS

While Dutch law does not limit the use of farrowing crates, it provides stricter standards than EU legislation by limiting the use of sow stalls. Since 2013, gilts and sows must be kept in groups, although they may be kept individually from weaning up to and including four days after mating or insemination.[71]

In the absence of any specific regulation, farrowing crates have been the subject of legal proceedings involving the Netherlands Food and Consumer Product Safety Authority (*Nederlandse Voedsel- en Warenautoriteit*, NVWA). In 2021, the Dutch organization *Varkens in Nood* ("Pigs in Need") filed an enforcement request (*handhavingsverzoek*) with the NVWA, asking it to recognize farrowing crates as a violation of the law, as animals' freedom may only be restricted in a manner that does not cause unnecessary suffering.[72] While farrowing crates have traditionally been justified as a way of protecting piglets, the organization argued that, when provided with a proper environment, a sow does not need to be confined in a crate to protect her piglets. Moreover, crating becomes virtually unnecessary only a few days after birth, once piglets have grown enough to move away from the sow independently, which does not justify the several weeks during which she is typically confined.[73] However, the NVWA continued to consider farrowing crates reasonable for the purpose of protecting piglets. As a result, *Varkens in Nood* brought the matter before the court. In 2024, the Trade and Industry Appeals Tribunal ruled that the NVWA had failed to demonstrate that the long-term use of farrowing crates complies with the law and held that the Minister of Agriculture must re-examine the necessity of their use.[74]

62 Eurostat. (2025). *Pig population: Annual data* (apro_mt_lspig) [Dataset]. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/apro_mt_lspig/default/table (accessed 13 May 2026).

63 Tierschutz-Nutztierhaltungsverordnung in der Fassung der Bekanntmachung vom 22. August 2006 (BGBl. I S. 2043), die zuletzt durch Artikel 1a der Verordnung vom 29. Januar 2021 (BGBl. I S. 146) geändert worden ist (TierSchNutztV), § 30 in conjunction with § 45(11a).

64 *Ibid*, § 30 in conjunction with § 45(11b).

65 Siebte Verordnung zur Änderung der Tierschutz-Nutztierhaltungsverordnung vom 29. Januar 2021, Bundesgesetzblatt Jahrgang 2021 Teil I Nr. 5, ausgegeben zu Bonn am 8. Februar 2021.

66 TierSchNutztV, § 30(2) and (2a).

67 *Ibid*, § 30(3).

68 *Ibid*, § 30(2b) and § 24(4).

69 *Ibid*, § 30(2b).

70 *Ibid*, § 30(4).

71 Varkensbesluit, Art. 19(1), later repealed by Besluit houders van dieren, Art. 2.15(1)(b), sub 2.

72 Besluit houders van dieren, Art. 1.6(1), Sub 1.

73 Varkens in Nood, "Juridische Strijd Moet Einde Maken aan Kraamkooi," April 7, 2022, https://www.varkensinnood.nl/nieuwsartikelen/juridische-strijd-moet-einde-maken-aan-kraamkooi (accessed 21 May 2026).

74 College van Beroep voor het bedrijfsleven, *Stichting Varkens in Nood te Amsterdam v. minister van Landbouw, Visserij, Voedselzekerheid en Natuur*, 27 August 2024, ECLI:NL:CBB:2024:578.

A sow lies in a farrowing pen with a small amount of straw bedding, which is legally required. Although Sweden has the most advanced legislation in the EU on sow housing during farrowing and nursing, most sows are still kept indoors. © Noah Marsten, We Animals; Sweden, 2025

2.2.6 SWEDEN

Sweden was the first country to prohibit the routine use of sow stalls and farrowing crates. In 1988, the Animal Welfare Act and Animal Welfare Ordinance were adopted, which required that pigs be kept in loose housing systems.[75] This law was replaced in 2019 by a new Animal Welfare Act and Ordinance, which retained this requirement.[76] Currently, Sweden is the only EU country where farrowing crates are fully phased out.

The Animal Welfare Ordinance empowers the Swedish Board of Agriculture (*Jordbruksverket*) to specify conditions under which the freedom of movement of animals can be restricted. Gilts and sows must be kept in pairs or groups, except for the week before farrowing and during nursing.[77] Temporary confinement to stalls after weaning and during pregnancy is, however, possible for feeding or for handling during care and treatment.[78] The freedom of movement of a nursing sow can be restricted using a safety gate or an equivalent device on two grounds; in exceptional cases during the piglets' first days of life (the number of days is not specified) if a sow exhibits aggressive or abnormal behavior that poses a clear risk of harm to the piglets, as well as for routine management purposes, such as feeding and veterinary treatment.[79] Guidance documents for animal welfare inspectors state that the confinement of sows via safety gates should be kept as short as possible, with 2-3 days justified only in exceptional cases.[80]

A farrowing pen must provide at least 6m² of total floor area, including 4m² of lying area, or 7m² in deep-bedded systems.[81] Sannö *et al*. reports that from measuring 37 different pens across Sweden, average pen size was 6.5m².[82] However, an amendment to the current minimum pen dimension requirements has been proposed, as the Swedish Board of Agriculture has acknowledged that the existing standards are outdated. The proposed amendment would introduce a requirement to provide space to the sow to allow her to move freely of a 1.8-meter diameter. Such a requirement is absent from the current legislation as only a total pen size is established, resulting in pen designs that can restrict the sow's movement area. Under the proposed rules, the minimum total size of a farrowing pen would be removed and the pen size would depend on both the chosen pen design and the litter size for which it is intended. According to the Swedish Board of Agriculture, a farrowing pen designed for a sow with, for example, 14 piglets would need to be approximately 1m² larger than the current minimum requirement of 6m².[83]

The Swedish Board of Agriculture's regulations also specify that gilts and sows must have access to bedding material in the week before farrowing, in ways that enable them to perform nest-building behavior. As a general recommendation to this provision, the regulations add that manure removal systems in housing units with conventional farrowing pens should be designed to handle large amounts of bedding material.[84] However, the proposed amendment to the Swedish Board of Agriculture's regulations concerning pigs prohibits the use of vacuum manure removal systems for lactating sows and with that, this general recommendation would be removed. Although the vacuum manure removal system is not widely used in Sweden, it nevertheless interferes with the provision of nest-building material.[85]

75 Djurskyddslag (1988:534); (1988:539), 14 §. Also called Lex Lindgren in honour of writer Astrid Lindgren.

76 Djurskyddslag (2018:1192); Djurskyddsförordning (2019:66), 12 §.

77 Statens jordbruksverks föreskrifter och allmänna råd om grishållning inom lantbruket m.m., SJVFS 2019:20, 8 § of Chapter 2.

78 *Ibid*, 10 § of Chapter 2.

79 *Ibid*, 6 § of Chapter 5.

80 Animal Equality UK, *Captive in Cages: The Silent Struggle of Mother Pigs* (May 2025), https://animalequality.org.uk/app/uploads/2025/06/2025-may-cages-report-uk.pdf (accessed 19 June 2026).

81 *Ibid*, 10 § of Chapter 2.

82 A. Sannö, R. Westin, K. Nilsson, K & A. Wallenbeck, Förbättrad utformning av svenska grisningsboxar för att anpassa till stora kullar, Sveriges lantbruksuniversitet, 2024.

83 Jordbruksverket, Konsekvensutredning, *Förslag till Ändrade Föreskrifter för Grishållning* (31 March 2026), https://www.sva.se/media/f15mio2k/konsekvensutredning-foerslag-till-aendrade-foereskrifter-foer-grishaallning.pdf (accessed 13 May 2026).

84 SJVFS 2019:20, 5 § of Chapter 4.

85 Jordbruksverket, Konsekvensutredning, *Förslag till Ändrade Föreskrifter för Grishållning* (31 March 2026), https://www.sva.se/media/f15mio2k/konsekvensutredning-foerslag-till-aendrade-foereskrifter-foer-grishaallning.pdf (accessed 13 May 2026).

2.2.7 NON-EU COUNTRIES

2.2.7.1 New Zealand

Notable developments have also been occurring outside Europe. In 2020, the High Court of New Zealand conducted a judicial review of the use of farrowing crates and sow stalls for female pigs under the Animal Welfare Act 1999.[86] The High Court ruled that minimum animal welfare standards allowing the use of sow stalls and farrowing crates are unlawful and invalid, directing the Minister to "consider recommending new regulations phasing out the use of farrowing crates and mating [sow] stalls." Regulations 26 and 27 of the Animal Welfare (Care and Procedures) Regulations 2018, which were the subject of the judicial review, were scheduled to expire on 18 December 2025. In late 2025, however, the government proposed a new bill that would extend the transition period by ten years, until December 18th, 2035, much to the disappointment of animal welfare advocates.[87] The bill was signed into law on December 15th, 2025.[88] Under the amended regulations, the confinement of female pigs is not completely phased out, but the use of sow stalls is limited only to mating and reduced from the current limit of seven days to a maximum of three hours (after which the stall cannot be used for another three hours), while the use of farrowing crates is permitted temporarily for up to seven days, comprising three days before and four days after farrowing.[89]

2.2.7.2 Norway

Progress toward the phase-out of restrictive gilt and sow confinement systems has been made in other countries in the European Economic Area (EEA). Norway prohibited the permanent crating of sows during farrowing and nursing in the 1990s, permitting only the temporary crating of sows for 10 days during farrowing from 2000.[90] Since 2003, when the currently applicable Regulation on the keeping of pigs was adopted, only free farrowing in farrowing pens that are at least 6m² in size and 1.8m wide has been permitted,[91] with limited exceptions comparable to those under Swedish law.

Conventional sow stalls have also been effectively phased out in Norway. If gilts and sows are housed individually, they must be kept in pens that allow them to turn around, providing at least 3m² for an individual pen with 1.5m as the shortest side, which is approximately twice the size of a conventional sow stall. As in the EU, gilts and sows must be group-housed from four weeks after service until one week before the expected farrowing date.[92]

As a general rule, the restraint of sows is allowed in connection with feeding, veterinary treatment/insemination, for particularly restless individual animals during heat, and for particularly restless sows from the time of farrowing and up to 7 days after farrowing.[93] In 2025, following consideration of a report on animal welfare, the Norwegian Parliament (*Storting*) called for further improvements to pig welfare standards. In particular, it requested the phasing out of the exception for particularly restless sows from January 1st, 2028 and an increase in the minimum area for farrowing pens in newly constructed buildings to at least 7.5m². The Norwegian Food Safety Authority subsequently prepared

86 *The New Zealand Animal Law Association v The Attorney-General*, 13 November 2020, NZHC 3009.

87 New Zealand Parliament, *Animal Welfare (Regulations for Management of Pigs) Amendment Bill* (call for public submissions, Primary Production Committee, 9 October 2025), https://www3.parliament.nz/en/pb/sc/make-a-submission/document/54SCPRIP_SCF_648FDD9D-9331-43B1-C811-08DE009746D1/animal-welfare-regulations-for-management-of-pigs-amendment (accessed 2 June 2026).

88 New Zealand Parliament, *Animal Welfare (Regulations for Management of Pigs) Amendment Bill* (Bill No 207–1, introduced 1 October 2025), https://bills.parliament.nz/v/Bill/648fdd9d-9331-43b1-c811-08de009746d1?lang=en (accessed 2 June 2026).

89 Animal Welfare (Care and Procedures) Regulations 2018 (LI 2018/50), Version as of 9 May 2026, Regulation 26 (to be inserted on 19 December 2026) and 27 (to be inserted on 19 December 2035), Schedule 3.

90 Forskrift om hold av storfe og svin (FOR-1996-01-15-91), § 16(1) and §23(3).

91 Forskrift om hold av svin (FOR-2003-02-18-175), § 25(4).

92 *Ibid*, § 25(1) and (2).

93 *Ibid*, § 11(1).

amendments to the Regulation on the Keeping of Pigs (*Forskrift om hold av svin*) to implement these changes. On behalf of the Norwegian Ministry of Agriculture and Food, these proposed amendments were submitted for public consultation until mid-June 2026.[94] The legislative process is expected to be completed by the end of 2026.

2.2.7.3 Switzerland

Switzerland has imposed limitations on the use of sow stalls and has prohibited the use of farrowing crates since 2007.[95] As a general rule, pigs must be kept in groups, although exceptions apply, including sows during the service and suckling period. Individual sow stalls may only be used during the service period and for a maximum of ten days.[96] Farrowing pens must be designed so that the sow can turn around freely.

During the farrowing period, a sow may be temporarily restrained in individual cases if she behaves aggressively toward her piglets or suffers from limb disorders.[97] Swiss priority programme on animal welfare controls in pig husbandry states that “the option of confinement is only available on farms with foldable crates in the farrowing pen” and that confinement can last from the beginning of nest-building behavior until, at the latest, the end of the third day after farrowing.[98] Inspection manual published by the Federal Food Safety and Veterinary Office states that there must be a document recording which sow was confined during this period and what was the reason for her confinement.[99]

Enrichment material to enable nest building must be provided in the farrowing pen before farrowing and during nursing.[100] Farrowing pens installed after September 1st, 2008 must provide at least 5.5m² of floor space and have a minimum width of 150cm. The area accessible to the sow must include a continuous lying area of at least 1.2m², with a minimum width of 65cm and a minimum length of 125cm.[101]

2.2.7.4 United Kingdom

Outside of the EEA, the UK Government published its Animal Welfare Strategy for England in 2025. The Strategy states that 92% of indoor production systems still rely on farrowing crates, highlighting cage-free transition as a “key priority for this government” and an “essential component of the government’s plan to ensure all farmed animals have a life worth living, and that as many animals as possible have a good life.” As an action point, the Strategy proposes working with the industry to explore how the transition to alternative systems can be facilitated, whether through temporary crating or free-farrowing systems.[102]

94 Mattilsynet, *Endring av reglene om fødebinger for griser*, https://hoering.mattilsynet.no/Hoering/3822 (accessed 1 June 2026).

95 This was first adopted in 1997 by amending the 1981 Animal Welfare Ordinance (Tierschutzverordnung vom 27. Mai 1981 (TSchV), with the transition period until the end of June 2007 (Art. 23 in conjunction with Art. 77(8). This ordinance was replaced in 2008 by the currently applicable ordinance, Tierschutzverordnung (TSchV) vom 23. April 2008 (Stand am 1. Februar 2026).

96 Tierschutzverordnung (TSchV) vom 23. April 2008 (Stand am 1. Februar 2026), Art. 48(1) and (4).

97 *Ibid*, Art. 50(1).

98 Bundesamt für Lebensmittelsicherheit und Veterinärwesen (BLV). *Schwerpunktprogramm Tierschutzkontrollen in der Schweinehaltung 2017–2019*. 2016. https://www.blv.admin.ch/blv/de/home/tiere/tierschutz/nutztierhaltung/schweine.html (accessed 19 Juni 2026).

99 Bundesamt für Lebensmittelsicherheit und Veterinärwesen (BLV), *Tierschutz-Kontrollhandbuch über den Tierschutz bei Schweinen*, https://www.blv.admin.ch/blv/de/home/tiere/tierschutz/nutztierhaltung/schweine.html (accessed 19 June 2026).

100 Tierschutzverordnung (TSchV) vom 23. April 2008 (Stand am 1. Februar 2026), Art. 50(2).

101 *Ibid*, Table 3 of Annex I.

102 Department for Environment, Food & Rural Affairs, *Animal Welfare Strategy for England*, 22 December 2025, https://www.gov.uk/government/publications/animal-welfare-strategy-for-england (accessed 1 June 2026).

Map: National regulation of housing systems for female pigs

Countries with legislation on sow stalls

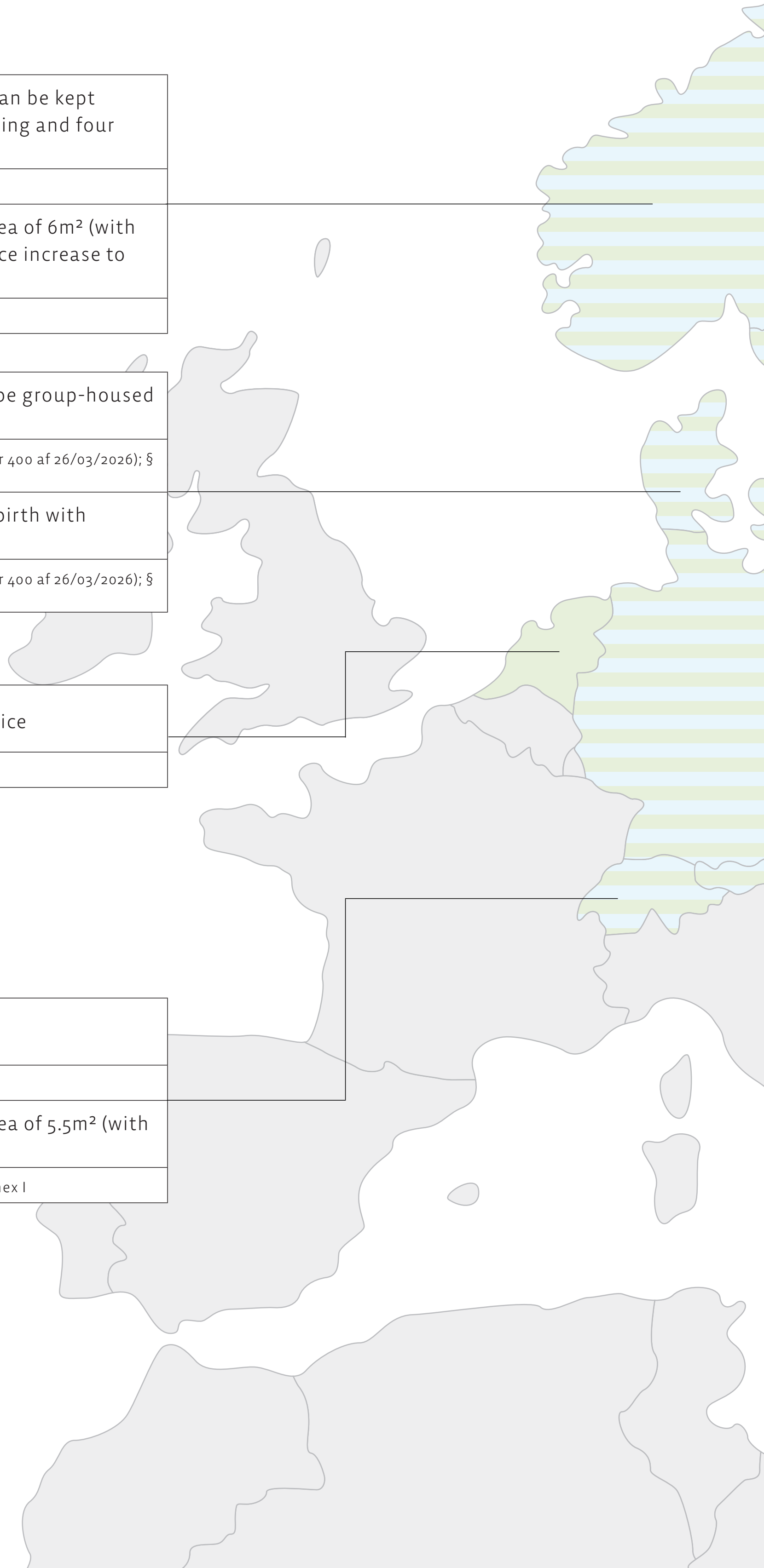
Countries with legislation on farrowing crates

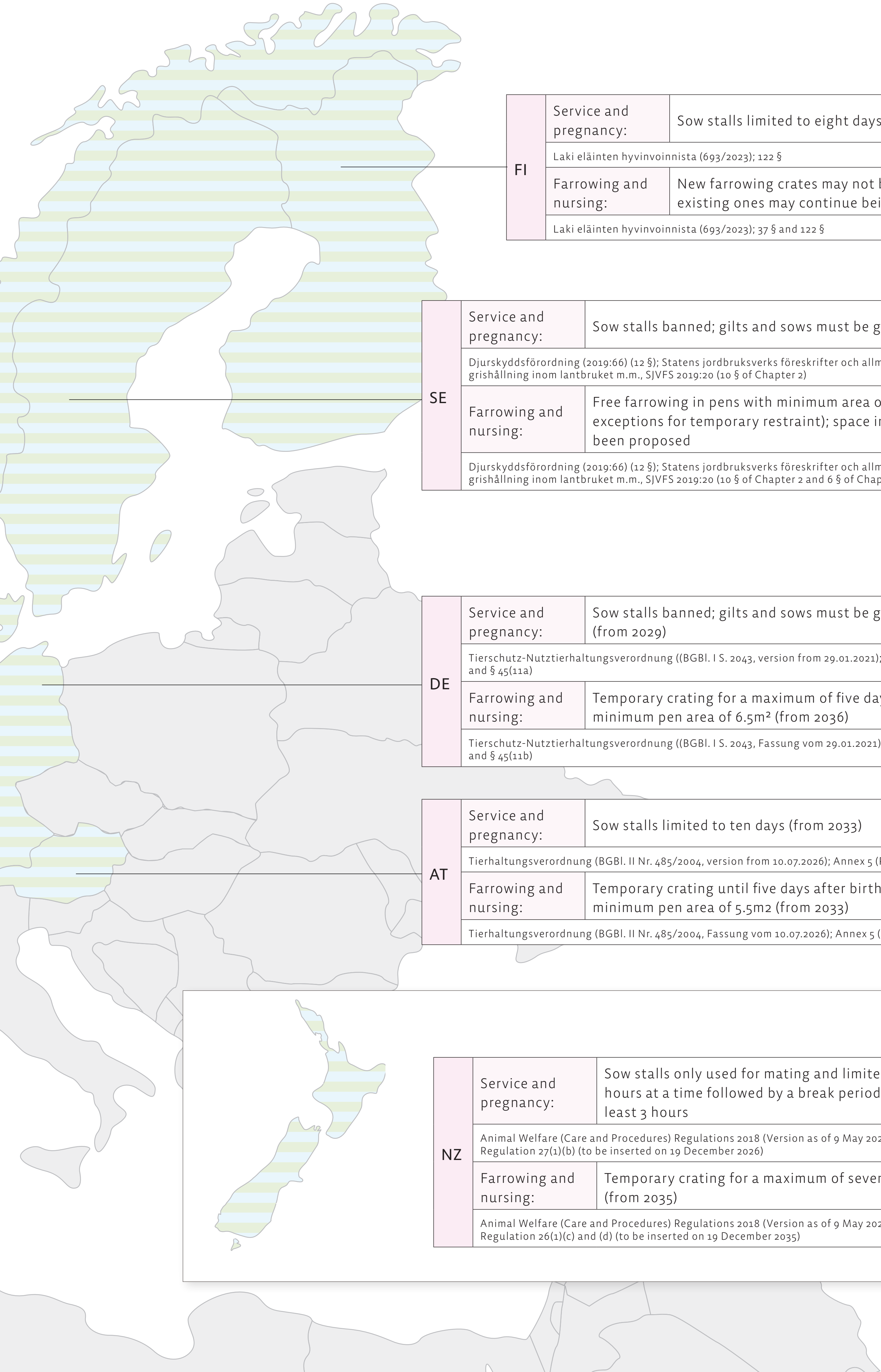
NO	Service and pregnancy:	Sow stalls effectively prohibited; sows can be kept individually in the period between weaning and four weeks after service, but in 3m² pens
	Forskrift om hold av svin (FOR-2003-02-18-175); § 11 and § 25	
	Farrowing and nursing:	Free farrowing in pens with minimum area of 6m² (with exceptions for temporary restraint); space increase to 7.5m² has been proposed
	Forskrift om hold av svin (FOR-2003-02-18-175); § 11 and § 25	

DK	Service and pregnancy:	Sow stalls banned; gilts and sows must be group-housed (from 2035)
	Bekendtgørelse om dyrevelfærdsmæssige mindstekrav til hold af grise (BEK nr 400 af 26/03/2026); § 65 and § 88	
	Farrowing and nursing:	Temporary crating until four days after birth with minimum pen area of 6.5m² (from 2041)
	Bekendtgørelse om dyrevelfærdsmæssige mindstekrav til hold af grise (BEK nr 400 af 26/03/2026); § 72 and § 90	

NL	Service and pregnancy:	Sow stalls limited to four days after service
	Besluit houders van dieren (version from 07/07/2026); Article 2.15(1)(b), sub 2)	

CH	Service and pregnancy:	Sow stalls limited to ten days
	Tierschutzverordnung (version from 01/02/2026); Art. 48(1) and (2)	
	Farrowing and nursing:	Free farrowing in pens with minimum area of 5.5m² (with exceptions for temporary restraint)
	Tierschutzverordnung (version from 01/02/2026); Art. 50(1) and Table 3 of Annex I	





FI	Service and pregnancy:	Sow stalls limited to eight days (from 2035)
	Laki eläinten hyvinvoinnista (693/2023); 122 §	
	Farrowing and nursing:	New farrowing crates may not be built, existing ones may continue being used
	Laki eläinten hyvinvoinnista (693/2023); 37 § and 122 §	

SE	Service and pregnancy:	Sow stalls banned; gilts and sows must be group-housed
	Djurskyddsförordning (2019:66) (12 §); Statens jordbruksverks föreskrifter och allmänna råd om grishållning inom lantbruket m.m., SJVFS 2019:20 (10 § of Chapter 2)	
	Farrowing and nursing:	Free farrowing in pens with minimum area of 6m² (with exceptions for temporary restraint); space increase has been proposed
	Djurskyddsförordning (2019:66) (12 §); Statens jordbruksverks föreskrifter och allmänna råd om grishållning inom lantbruket m.m., SJVFS 2019:20 (10 § of Chapter 2 and 6 § of Chapter 5)	

DE	Service and pregnancy:	Sow stalls banned; gilts and sows must be group-housed (from 2029)
	Tierschutz-Nutztierhaltungsverordnung ((BGBl. I S. 2043, version from 29.01.2021); § 30(2) and (2a) and § 45(11a)	
	Farrowing and nursing:	Temporary crating for a maximum of five days with a minimum pen area of 6.5m² (from 2036)
	Tierschutz-Nutztierhaltungsverordnung ((BGBl. I S. 2043, Fassung vom 29.01.2021); § 30(2b), § 24(4) and § 45(11b)	

AT	Service and pregnancy:	Sow stalls limited to ten days (from 2033)
	Tierhaltungsverordnung (BGBl. II Nr. 485/2004, version from 10.07.2026); Annex 5 (Points 3.2 and 9)	
	Farrowing and nursing:	Temporary crating until five days after birth with minimum pen area of 5.5m2 (from 2033)
	Tierhaltungsverordnung (BGBl. II Nr. 485/2004, Fassung vom 10.07.2026); Annex 5 (Point 3.3.2)	

NZ	Service and pregnancy:	Sow stalls only used for mating and limited to 3 hours at a time followed by a break period of at least 3 hours
	Animal Welfare (Care and Procedures) Regulations 2018 (Version as of 9 May 2026); Regulation 27(1)(b) (to be inserted on 19 December 2026)	
	Farrowing and nursing:	Temporary crating for a maximum of seven days (from 2035)
	Animal Welfare (Care and Procedures) Regulations 2018 (Version as of 9 May 2026); Regulation 26(1)(c) and (d) (to be inserted on 19 December 2035)	

3. Assessment of Pig Welfare in Farrowing Crates and Farrowing Pens

This chapter presents an animal welfare impact assessment of an EU ban on farrowing crates. To evaluate the welfare consequences for sows, selected indicators are examined in detail. The selection of key welfare indicators is based on a targeted review of the scientific literature. Particular emphasis is placed on identifying aspects that are most likely to be affected by the transition from conventional farrowing crates to free-farrowing systems. On this basis, six issues are selected from the Environment, Health, and Behavioral Interactions domains of the Five Domains Model[103] that are sensitive to changes in housing design and management associated with the system shift:[104]

Environment	Space and freedom to move
	Comfortable climatic conditions
	Separate pen into functional areas
Health	Injuries
Behavior	Nest-building and explorative behavior
	Interaction between sow and piglets

The Nutrition domain was not examined in this impact assessment, as the nutritional management of sows is not expected to be affected in any significant way by the changes in the farrowing system.

The Five Domains framework links physical domains to mental states, which together shape the welfare of an animal.[105] The effects of crates and free farrowing on mental states are described for each indicator in terms of welfare consequences. Although an increasing amount of research is available on positive subjective experiences of pigs, the animal welfare literature mainly remains focused on negative affective states. This emphasis is reflected in the present section and is acknowledged as a limitation.

The following sections outline the main design characteristics of conventional farrowing crates and free-farrowing systems, which fundamentally shape sow welfare outcomes. In addition, implications for farm workers, work safety, and human-animal interactions are described.

103 D. J. Mellor, "Operational Details of the Five Domains Model and Its Key Applications to the Assessment and Management of Animal Welfare," *Animals* 7, no. 8 (2017): 60; D. J. Mellor and N. J. Beausoleil, "Extending the 'Five Domains' Model for Animal Welfare Assessment to Incorporate Positive Welfare States," *Animal Welfare* 24, no. 3 (2015): 241–253.

104 V. A. Moustsen *et al*., "Animal Board Invited Review: The Need to Consider Emissions, Economics and Pig Welfare in the Transition from Farrowing Crates to Pens with Loose Lactating Sows," *Animal* 17, no. 9 (2023): 100913; E. M. Baxter *et al*., "Alternative Farrowing Systems: Design Criteria for Farrowing Systems Based on the Biological Needs of Sows and Piglets," *Animal* 5, no. 4 (2011): 580–600; A. Malak-Rawlikowska *et al*., "Unlocking Sows' Welfare: The Farm-Level Economic Impact of Phasing Out Farrowing Crates for Sows in the European Union's Pig Breeding Industry," *Agriculture* 14, no. 2 (2024): 187; E. M. Baxter *et al*., *Rapid Evidence Assessment (REA) of Alternative Indoor Farrowing and Lactation Systems* (Stoneleigh: AHDB, 2021), https://projectblue.blob.core.windows.net/media/Default/Pork/REA%20for%20AHDB%20on%20alternative%20indoor%20farrowing%20systems%20Baxter%20%20Moustsen%20Bell%20310821%20(002).pdf (accessed 29 June 2026).

105 D. J. Mellor, N. J. Beausoleil, K. E. Littlewood, A. N. McLean, P. D. McGreevy, B. Jones, and C. Wilkins, "The 2020 Five Domains Model: Including Human–Animal Interactions in Assessments of Animal Welfare," *Animals* 10, no. 10 (2020): 1870.

106 A. Grahofer, "Sow Behaviour, Parturition Process and Management in Free Farrowing Systems," *Porcine Health Management* 12 (2026).

3.1 Key Design Characteristics of Conventional Farrowing Crate Systems

Conventional farrowing crate systems are considered advantageous primarily from a production and management perspective, particularly in the context of larger litters, which are now standard in intensive pig production.[106] These systems facilitate closer monitoring and management of both sows and piglets by controlling sow movement to reduce piglet crushing, providing heating in creep areas, and implementing management procedures such as tail docking and injections. In addition, interventions aimed at improving piglet survival, including cross-fostering, can be performed more safely and efficiently by farm staff in these systems.[107] Further reasons for using farrowing crates include space efficiency and ease of manure management.[108]

A key aspect in the scientific assessment of farrowing crates is their effect on piglet mortality. While some studies have shown that confinement before and after farrowing can reduce piglet mortality during the first days post-partum, the evidence overall is mixed, with other studies finding no significant differences in piglet survival between farrowing crates and loose-farrowing pens. [109]

Beyond piglet mortality, farrowing crates have substantial direct implications for sow welfare. The housing conditions are characterised by severe spatial restriction of sows. The sows are only able to stand, lie down, and roll onto their sides, but are unable to turn around. Any walking or other forward locomotory behavior is prevented.[110] The space provided in a conventional farrowing crate is between 0.9 - 1.3m². The crate is installed in a pen measuring between 3.7 - 5.2m².[111]

3.2 Key Design Characteristics of Free-Farrowing Systems

Free farrowing is a loose housing, pen-based system without any crate. This system can also be referred to as "zero confinement" or "full free farrowing." Separation of the sow may be achieved using protective barriers such as gates or feeding-area partitions. These structures may allow temporary separation of the sow for management purposes, but they are not intended to crate the sow during farrowing.[112]

Goumon *et al*. (2022) define free farrowing as:

> *[a] system or practice where there is no possibility to confine the sow in a crate when in farrowing and lactation accommodation. Sows are able to freely turn around at all times. Pens may have feeding stalls or areas to separate the sow from the piglets temporarily for management purposes, but the fixtures would not permit crating for farrowing.*[113]

Besides the area for the sow, the pen also includes a heated creep area for the piglets. Depending on the pen design, there may be lying-down supports installed for the sow – e.g. rails, sloped walls or panels[114] – to prevent piglet crushing.

Free farrowing pens are usually between 6.5 to 8.0m² in size.[115] Pen dimensions vary considerably depending on the manufacturer, and, in some countries, legal requirements.

107 S. Goumon, G. Illmann, V. A. Moustsen, E. M. Baxter, and S. A. Edwards, "Review of Temporary Crating of Farrowing and Lactating Sows," *Frontiers in Veterinary Science* 9 (2022): 811810.

108 L. J. Pedersen, A. Patt, M. A. Ruis, A. Hoofs, H. M. Vermeer, and A. Kongsted, *Review on Farrowing Housing and Management* (2020), 1–19.

109 J. Hales, V. A. Moustsen, A. M. Devreese, M. B. F. Nielsen, and C. F. Hansen, "Comparable Farrowing Progress in Confined and Loose Housed Hyper-Prolific Sows," *Livestock Science* 171 (2015): 64–72; G. M. Cronin *et al*., "A Comparison of Piglet Production and Survival in the Werribee Farrowing Pen and Conventional Farrowing Crates at a Commercial Farm," Australian Journal of Experimental Agriculture 40, no. 1 (2000): 17–23; L. J. Pedersen *et al*., "Early Piglet Mortality in Loose-Housed Sows Related to Sow and Piglet Behaviour and to the Progress of Parturition," Applied Animal Behaviour Science 96, nos. 3–4 (2006): 215–232; R. Weber *et al*., "Piglet Mortality on Farms Using Farrowing Systems with or Without Crates," Animal Welfare 16, no. 2 (2007): 277–279; J. K. Blackshaw *et al*., "Comparison of Behaviour Patterns of Sows and Litters in a Farrowing Crate and a Farrowing Pen," Applied Animal Behaviour Science 39, nos. 3–4 (1994): 281–295; J. Hales *et al*., "Higher Preweaning Mortality in Free Farrowing Pens Compared with Farrowing Crates in Three Commercial Pig Farms," Animal 8, no. 1 (2014): 113–120; J. N. Marchant *et al*., "The Influence of Sow Behaviour on Piglet Mortality Due to Crushing in an Open Farrowing System," Animal Science 72, no. 1 (2001): 19–28.

110 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," EFSA Journal, 20(8), 2022; K. L. Chidgey, P. C. Morel, K. J. Stafford, and I. W. Barugh, "Observations of Sows and Piglets Housed in Farrowing Pens with Temporary Crating or Farrowing Crates on a Commercial Farm," Applied Animal Behaviour Science 176 (2016): 12–18.

111 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20(8), 2022.

112 S. Goumon, G. Illmann, V. A. Moustsen, E. M. Baxter, and S. A. Edwards, "Review of Temporary Crating of Farrowing and Lactating Sows," *Frontiers in Veterinary Science* 9 (2022): 811810; EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

113 S. Goumon, G. Illmann, V. A. Moustsen, E. M. Baxter, and S. A. Edwards, "Review of Temporary Crating of Farrowing and

When considering space allocation in free-farrowing systems, it is important to distinguish between the total pen area and the area accessible to the sow. While the total pen area includes all functional areas within the pen, the area accessible to the sow refers specifically to the space that can be freely used by the sow for movement, turning, exploration, nest-building behavior, and resting. The pen size should also be sufficient enough to allow older, and therefore larger, sows to manoeuvre comfortably within the pen.

Flooring design can also vary between free-farrowing systems. Most provide solid flooring in the lying area and slatted flooring in other areas.[116] Deep-bedded systems are comparatively uncommon in most free-farrowing systems.

3.3 Implications of Farrowing System Design for Farm Workers and Human–Animal Interaction

Farrowing pen design also has implications for farm workers, especially regarding management of animals, work time, work safety concerns, and workload.[117] Farrowing crates generally reduce the level of contact between sows and farm workers. Working with unconfined sows poses the risk of negative interactions including injuries caused by reactivity toward humans, sudden standing, vocalising, lunging, and biting, which mainly stem from maternal aggression in sows.[118] From an occupational safety perspective, when handling sows during management and care procedures, it is important that the sow can be confined in some way, for example in the feeding stall.[119] Since there is currently only a small body of scientific literature on work safety in free-farrowing systems, more research is needed to successfully transition to free farrowing.[120]

The quality of human–animal interactions is shaped by the farm worker's behavior toward the animals. A good understanding of sow behavior is essential for farmworkers caring for sows in either system, whether crate or free farrowing. A lack of understanding in sow behavior can result in reduced confidence in free-farrowing systems, while better understanding is associated with greater confidence and more positive attitudes toward sow welfare, and safer working conditions in free farrowing. The implementation of safety assessments and training programmes can improve not only workplace safety standards but also farm workers' attitudes toward free-farrowing systems. Changes in farm worker attitudes and behaviors are an important driver in the transition to free farrowing.[121]

3.4 Welfare Assessment Based on Key Indicators

In the next section, each of the key sow welfare indicators relevant to farrowing systems is described. First, the underlying behavioral and physical needs associated with each respective indicator are outlined. Second, the welfare consequences are described in relation to farrowing crates and free-farrowing pens. A final section presents the overall conclusions.

Lactating Sows," *Frontiers in Veterinary Science* 9 (2022): 811810.

114 E. M. Baxter, A. B. Lawrence, and S. A. Edwards, "Alternative Farrowing Systems: Design Criteria for Farrowing Systems Based on the Biological Needs of Sows and Piglets," *Animal* 5, no. 4 (2011): 580–600; EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

115 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

116 K. E. Boe, I. Kvaal, E. J. S. Hall, and G. M. Cronin, "Individual Differences in Dunging Patterns in Loose-Housed Lactating Sows," *Acta Agriculturae Scandinavica, Section A—Animal Science* 66, no. 4 (2016): 221–230.

117 E. M. Baxter, V. A. Moustsen, S. Goumon, G. Illmann, and S. A. Edwards, "Transitioning from Crates to Free Farrowing: A Roadmap to Navigate Key Decisions," *Frontiers in Veterinary Science* 9 (2022): 998192; A. Malak-Rawlikowska, E. Majewski, N. Potori, M. Hamulczuk, V. Szili, and E. Egri, "Unlocking Sows' Welfare: The Farm-Level Economic Impact of Phasing Out Farrowing Crates for Sows in the European Union's Pig Breeding Industry," *Agriculture* 14, no. 2 (2024): 187.

118 L. M. Staveley, K. J. Plush, D. S. Lines, L. M. Hemsworth, D. N. D'Souza, and R. J. van Barneveld, "Stockperson Attitudes Towards Maternity Rings and Farrowing Crates," *Frontiers in Veterinary Science* 12 (2025): 1579263.

119 J. H. Guy, P. J. Cain, Y. M. Seddon, E. M. Baxter, and S. A. Edwards, "Economic Evaluation of High Welfare Indoor Farrowing Systems for Pigs," *Animal Welfare* 21, suppl. S1 (2012): 19–24.

120 L. M. Staveley, K. J. Plush, D. S. Lines, L. M. Hemsworth, D. N. D'Souza, and R. J. van Barneveld, "Stockperson Attitudes Towards Maternity Rings and Farrowing Crates," *Frontiers in Veterinary Science* 12 (2025): 1579263.

121 A. Malak-Rawlikowska, E. Majewski, N. Potori, M. Hamulczuk, V. Szili, and E. Egri, "Unlocking Sows' Welfare: The Farm-Level Economic Impact of Phasing Out Farrowing Crates for Sows in the European Union's Pig Breeding Industry," *Agriculture* 14, no. 2 (2024): 187; L. M.

Staveley, K. J. Plush, D. S. Lines, L. M. Hemsworth, D. N. D'Souza, and R. J. van Barneveld, "Stockperson Attitudes Towards Maternity Rings and Farrowing Crates," *Frontiers in Veterinary Science* 12 (2025): 1579263.

122 E. M. Baxter, A. B. Lawrence, and S. A. Edwards, "Alternative Farrowing Systems: Design Criteria for Farrowing Systems Based on the Biological Needs of Sows and Piglets," *Animal* 5, no. 4 (2011): 580–600.

123 I. Ekesbo and S. Gunnarsson, *Farm Animal Behaviour: Characteristics for Assessment of Health and Welfare* (Wallingford: CABI, 2018).

124 Hukkinen, V. M., Munsterhjelm, C., Kurtti, M., Immonen, N., and Valros, A., "Impact of Farrowing System and Prepartum Nest-Building Material on Nest-Building Behaviour and Farrowing in Sows," *Animal* 18, no. 6 (2024): 101183, 1 (citing Andersen *et al.*).

Table 1: Overview of key indicators affected by the transition from crates to free-farrowing systems.

Domain	Indicator
Environment	Space and freedom to move
	Comfortable climatic conditions
	Separate pen into functional areas
Health	Injuries
Behavior	Nest-building and explorative behavior
	Interaction between sow and piglets

3.4.1 SPACE AND FREEDOM TO MOVE

Besides the minimum space required due to the animal's size,[122] additional space is needed for movement, for example to change position. Pigs also require sufficient space for the expression of locomotory behavior. Their locomotion is closely linked with exploratory and foraging behavior, involving walking, rooting, and grazing. Locomotion is also part of social behavior.[123]

3.4.1.1 Farrowing Crates

Farrowing crates impose severe spatial restrictions on sows. The body-sized crate inhibits the sow's movement, so she can only stay within the

A mother pig chews on the metal bars of her farrowing crate. This repetitive bar-biting behavior is a sign of stress and boredom caused by the restrictive environment she is forced to live in. © Nevinné oběti, Czech Republic

crate, either standing or lying down. The crate prohibits forward movement like walking and running, as well as turning around.[124]

Restriction of movement in crates also negatively impacts resting behavior of sows. When lying on their side, they come in contact with the metal bars. Additionally, they face difficulty in postural changes due to limited space available. The inadequate space allowance prevents them from resting comfortably.[125]

Furthermore, the crate impairs the sow's standing-up and lying-down behavior, which results in atypical lying-down movements.[126] Additionally, sows in crates spend more time sitting, make fewer posture changes after farrowing, and show lower frequencies of lying down and standing up compared to sows kept loose in pens.[127] Sows in farrowing crates need multiple attempts to rise before successfully standing, as well as multiple attempts to lie down.[128] The crate also prevents adequate movement during birth.[129]

Confined sows cannot express locomotory behaviors such as leaving the nest-site/farrowing area and engaging in nest-maintaining behavior that relies on moving around.[130] Further details on related housing and behavioral constraints are provided in the sections 3.4.3, 3.4.5 and 3.4.6.

Generally, the fixed dimensions of farrowing crates result in a progressively worsening spatial mismatch over time between sow body size and crate dimensions, in two respects:

- modern sows are larger than in the past, due to genetic selection;
- within individual animals, body size increases further until they reach their full maturity at around parity 4 - 5.[131]

Since sows in crates are unable to move freely and cannot walk, they experience stress and/or negative affective states such as pain, fear, discomfort, and/or frustration.[132],[133] Additionally, confinement leads to restlessness as well as development of stereotypies, such as chewing on pen fittings.[134] The locomotion problems are also associated with shoulder lesions and injuries to the limbs.[135] For more information on such related health issues, see section on 3.4.4.

3.4.1.2 Free-Farrowing Pens

Loose-farrowing systems allow for greater freedom of movement than crate systems, as loose-housed sows can access different areas in the farrowing pen. Minimum pen dimensions accessible to the sow should be 6.6m² to allow behavioral freedom and achieve similar preweaning mortality of piglets as in crated systems. If the area is smaller than 6.6m², the sow's freedom of movement is reduced and the mortality of piglets increases. When considering both sow and piglet welfare, the total pen area should be at least 7.8m² (including the creep area not accessible for the mother sow). It should further be noted that, when it comes to the full expression of locomotory behavior, sows would need access to at least 47m².[136]

Besides locomotion, space and freedom to move are also important to sows when it comes to postural changes, i.e. moving from one position to another. However, the data on welfare consequences due to space

125 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

126 *Ibid*.

127 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

128 J. A. C. Díaz, I. M. Stienezen, F. C. Leonard, and L. A. Boyle, "The Effect of Overgrown Claws on Behaviour and Claw Abnormalities of Sows in Farrowing Crates," *Applied Animal Behaviour Science* 166 (2015): 44–51.

129 K. Plush, D. Lines, L. Staveley, D. D'Souza, and R. Van Barneveld, "A Five Domains Assessment of Sow Welfare in a Novel Free Farrowing System," *Frontiers in Veterinary Science* 11 (2024): 1339947.

130 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

131 V. A. Moustsen, H. P. Lahrmann, and R. B. d'Eath, "Relationship between Size and Age of Modern Hyper-Prolific Crossbred Sows," *Livestock Science* 141, nos. 2–3 (2011): 272–275.

132 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

133 European Food Safety Authority (EFSA), "Animal Health and Welfare Aspects of Different Housing and Husbandry Systems for Adult Breeding Boars, Pregnant, Farrowing Sows and Unweaned Piglets," *EFSA Journal* 5, no. 10 (2007), 572.

134 Hukkinen, V. M., Munsterhjelm, C., Kurtti, M., Immonen, N., and Valros, A., "Impact of Farrowing System and Prepartum Nest-Building Material on Nest-Building Behaviour and Farrowing in Sows," *Animal* 18, no. 6 (2024): 101183, 1 (citing Andersen *et al.*).

135 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

136 *Ibid*.

137 *Ibid*.

allowance in different pen sizes for postures (e.g. sternal and recumbent lying, sitting, and standing) are ambiguous.[137]

Housing sows in loose-farrowing systems allows them to move and manipulate enrichment/foraging material.[138]

3.4.2 THERMAL COMFORT CONDITIONS

Pigs can regulate their body temperature only to a limited extent. High ambient temperatures pose a particular challenge for adult pigs and will be discussed further in this section. To cope with heat, pigs seek ways to cool themselves. In natural and semi-natural environments, they rely on wallowing, as water and mud baths facilitate heat loss and help regulate body temperature through evaporative cooling from the skin. While domestic pigs show the same behavior to regulate their body temperature compared to wild boars, modern pigs face multiple risk factors for heat susceptibility. Namely, they are considerably heavier than their wild counterparts and have differences in organ size and morphology, such as relatively smaller hearts and shorter snouts.[139]

Sows prefer temperatures around 14°C, while their thermal comfort zone lies between 12 and 22°C.[140] Lactating sows increasingly prefer to lie on cool flooring during the course of lactation, since milk production and a higher feed intake increase their heat production considerably and their high metabolic heat load leads to reduced heat tolerance.[141]

3.4.2.1 Farrowing Crates

Given the high ambient temperatures in barns, particularly in summer, the risk of thermal extremes and discomfort due to overheating and heat stress is increased, especially in individual crates. Due to insufficient space, crates do not allow sows to perform compensatory thermoregulatory behaviors, such as selecting pen areas with cooler flooring for thermoregulation. Thermoregulation through evaporation from the lungs and by increased blood flow to the skin is not enough to maintain a constant internal body temperature. Heat stress around farrowing can result in prolonged farrowing and reduced feed intake during lactation, which also has a negative impact on piglet welfare.[142] Heat stress is considered a major threat to sow welfare and can, in severe cases, even result in death due to heart failure.[143]

3.4.2.2 Free-Farrowing Pens

In free-farrowing pens, sows have greater opportunities for behavioral adaptations to high ambient temperatures compared to farrowing crates. They can adjust their position more easily and, to some extent, make use of different areas within the pen. These conditions increase their thermal comfort.[144] However, thermal comfort is also strongly influenced by other aspects, particularly flooring design, climatic conditions within the barn, and the location of the pen within the farrowing room.[145]

3.4.3 SEPARATE PEN INTO FUNCTIONAL AREAS

Pigs perform different activities during the day, like lying, feeding, drinking, elimination, and exploration, in distinct functional areas.[146]

138 *Ibid*.

139 I. Ekesbo and S. Gunnarsson, *Farm Animal Behaviour: Characteristics for Assessment of Health and Welfare* (Wallingford: CABI, 2018).

140 V. Madeira Pacheco, T. M. Brown-Brandl, G. A. Rohrer, R. Vieira de Sousa, and L. Silva Martello, "Impacts of Farrowing Pen Design, Season, and Sow Parity on Litter Performance and Piglet Mortality," *Animals* 14, no. 2 (2024): 325.

141 European Food Safety Authority (EFSA), "Animal Health and Welfare Aspects of Different Housing and Husbandry Systems for Adult Breeding Boars, Pregnant, Farrowing Sows and Unweaned Piglets," *EFSA Journal* 5, no. 10 (2007), 572; A. M. Williams, T. J. Safranski, D. E. Spiers, P. A. Eichen, E. A. Coate, and M. C. Lucy, "Effects of a Controlled Heat Stress During Late Gestation, Lactation, and After Weaning on Thermoregulation, Metabolism, and Reproduction of Primiparous Sows," *Journal of Animal Science* 91, no. 6 (2013): 2700–2714.

142 R. Muns *et al*., "High Environmental Temperature Around Farrowing Induced Heat Stress in Crated Sows," *Journal of Animal Science* 94, no. 1 (2016): 377–384.

143 I. Ekesbo and S. Gunnarsson, Farm Animal Behaviour: Characteristics for Assessment of Health and Welfare (Wallingford: CABI, 2018); EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022); European Food Safety Authority (EFSA), "Animal Health and Welfare Aspects of Different Housing and Husbandry Systems for Adult Breeding Boars, Pregnant, Farrowing Sows and Unweaned Piglets," *EFSA Journal* 5, no. 10 (2007); A. M. Williams *et al*., "Effects of a Controlled Heat Stress During Late Gestation, Lactation, and After Weaning on Thermoregulation, Metabolism, and Reproduction of Primiparous Sows," *Journal of Animal Science* 91, no. 6 (2013): 2700–2714.

144 K. L. Chidgey *et al*., "Observations of Sows and Piglets Housed in Farrowing Pens with Temporary Crating or Farrowing Crates on a Commercial Farm," *Applied Animal Behaviour Science* 176 (2016): 12–18.

145 V. Madeira Pacheco *et al*., "Impacts of Farrowing Pen Design, Season, and Sow Parity on Litter Performance and Piglet Mortality," *Animals* 14, no. 2 (2024): 325.


A sow in a farrowing crate nurses her piglets. As the sow cannot leave the crate, she is forced to lie on a soiled floor covered in her own excreta. © Nevinné oběti, Czech Republic

Specifically, they separate a dung area from the nest, feeding, and lying areas, which represents their biological need.[147] A proposed explanation for how pigs establish separation of functional areas is that pigs do not primarily choose where to eliminate. Rather, they first establish a preferred resting area and then avoid soiling it.[148] Sows leave the nest site for eliminative behavior to avoid soiling the nest floor.[149] Piglets begin to eliminate outside the nest at around five days of life, indicating that separating different areas may be largely innate behavior.[150]

3.4.3.1 Farrowing Crates

The separation of the pen into functional areas is not possible due to severe spatial restrictions within crates. Regarding separating an elimination area from their lying area, crates do not allow sows to leave the nest site for eliminative behavior, which forces them to excrete at the nest site.[151]

146 H. M. Vermeer *et al*., "Rooting Area and Drinker Affect Dunging Behaviour of Organic Pigs," *Applied Animal Behaviour Science* 165 (2015): 66–71.

147 E. M. Baxter, A. B. Lawrence, and S. A. Edwards, "Alternative Farrowing Systems: Design Criteria for Farrowing Systems Based on the Biological Needs of Sows and Piglets," *Animal* 5, no. 4 (2011): 580–600.

148 E. Nannoni, A. J. Aarnink, H. M. Vermeer, I. Reimert, M. Fels, and M. B. Bracke, "Soiling of Pig Pens: A Review of Eliminative Behaviour," *Animals* 10, no. 11 (2020): 2025..

149 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

150 T. S. Whatson, "Development of Eliminative Behaviour in Piglets," Applied Animal Behaviour Science 14, no. 4 (1985): 365–377; D. Buchenauer *et al*., "Investigations on the Eliminative Behaviour of Piglets," *Applied Animal Ethology* 9, no. 2 (1982): 153–164, both cited in E. Nannoni *et al*., "Soiling of Pig Pens: A Review of Eliminative Behaviour," *Animals* 10, no. 11 (2020): 2025.

151 European Food Safety Authority (EFSA), "Animal Health and Welfare Aspects of Different Housing and Husbandry Systems for Adult Breeding Boars, Pregnant, Farrowing Sows and Unweaned Piglets," *EFSA Journal* 5, no. 10 (2007), 572.

3.4.3.2 Free-Farrowing Pens

Separation of different areas in free-farrowing pens is mainly discussed in relation to sows' defecating behavior. Soiling problems may arise in loose pens,[152] such as soiling of the feeding trough or the nesting/lying area. This may occur when only the front part of the body is positioned over the slatted floor. Around 40% of excreta can be deposited on the solid flooring area. Besides soiling the nesting/lying area with faeces, this also adds additional workload on farm workers for manual manure removal.[153]

One factor contributing to soiling problems is limited space in free-farrowing pens. Another is the individual experience and age of the pigs, with younger sows defecating more on their lying area than older sows. Design of the pen layout, room ventilation, and the location and arrangement of the pen in the farrowing room also play a role in soiling problems.[154] Additionally, loosely kept sows may use the dunging area for their thermoregulation. This puts them into a conflict between their motivation to avoid excrement and their need to increase heat loss by getting wet.[155]

3.4.4 INJURIES

Sows in intensive piglet production face a range of health problems, particularly reproductive disorders, which represent one of the leading reasons for sow culling.[156], Specifically, housing systems can cause specific injuries, often referred to as "technopathies." The following section focuses on injuries in the form of soft tissue lesions and integument (skin) damage.

3.4.4.1 Farrowing Crates

Confinement in crates gives rise to a distinct set of health issues. The design of farrowing crate systems, especially flooring and crate structures, contributes to abrasions, lesions, and pressure sores. Pigs kept in these housing systems suffer from physical damage to their integument and underlying tissues, which can cause open or scabbed wounds, ulcers, and abscesses in general. Typical injuries include teat and udder lesions, capped hocks and wounds on the hocks, shoulder ulcers, as well joint conditions such as bursitis. This leads to negative affective states such as pain, discomfort, and distress.[157] Impaired locomotory behavior induced by, for example, bone, joint, skin, or muscle damage leads to negative affective states such as pain or discomfort.[158]

Crates are often too small for the sows' bodies, and many are permanently compressed against their sides.[159] The narrow bars surrounding the sow can cause injuries and bruising, particularly when they change position to lie down.[160]

Crates impair postural changes and increase time spent lying down, which in turn can increase the risk of shoulder sores.[161]

3.4.4.2 Free-Farrowing Pens

According to a 2022 scientific opinion by the European Food Safety Authority (EFSA), soft-tissue lesions and integument damage are not considered highly relevant welfare consequences in free-farrowing

152 E. Nannoni, A. J. Aarnink, H. M. Vermeer, I. Reimert, M. Fels, and M. B. Bracke, "Soiling of Pig Pens: A Review of Eliminative Behaviour," *Animals* 10, no. 11 (2020): 2025.

153 K. E. Bøe, I. Kvaal, E. J. S. Hall, and G. M. Cronin, "Individual Differences in Dunging Patterns in Loose-Housed Lactating Sows," *Acta Agriculturae Scandinavica, Section A—Animal Science* 66, no. 4 (2016): 221–230.

154 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

155 E. Nannoni, A. J. Aarnink, H. M. Vermeer, I. Reimert, M. Fels, and M. B. Bracke, "Soiling of Pig Pens: A Review of Eliminative Behaviour," *Animals* 10, no. 11 (2020): 2025.

156 S. Björkman, J. Kauffold, and M. Ø. Kaiser, "Reproductive Health of the Sow During Puerperium," *Molecular Reproduction and Development* 90, no. 7 (2023): 561–579; "Sow Behaviour, Parturition Process and Management in Free Farrowing Systems," *Porcine Health Management* 12 (2026).

157 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

158 *Ibid*.

159 J. J. McGlone, B. Vines, A. C. Rudine, and P. DuBois, "The Physical Size of Gestating Sows," *Journal of Animal Science* 82, no. 8 (2004): 2421–2427.

160 L. Anil, S. S. Anil, and J. Deen, "Evaluation of the Relationship Between Injuries and Size of Gestation Stalls Relative to Size of Sows," *Journal of the American Veterinary Medical Association* 221, no. 6 (2002): 834–836.

161 L. Anil, S. S. Anil, and J. Deen, "Relationship Between Postural Behaviour and Gestation Stall Dimensions in Relation to Sow Size," *Applied Animal Behaviour Science* 77, no. 3 (2002): 173–181; E. Rolandsdotter, R. Westin, and B. Algers, "Maximum Lying Bout Duration Affects the Occurrence of Shoulder Lesions in Sows," *Acta Veterinaria Scandinavica* 51, no. 1 (2009): 44.

A sow with a pressure ulcer on her side sits confined in a farrowing crate. Pressure ulcers are common from lying on hard, often wet flooring. © Kristo Muurimaa, We Animals; 2022, Finland

systems. Loose farrowing allows sows to avoid frequent contact between the body and metal bars. Farrowing pens can still have poor floor quality, such as worn surfaces, sharp edges, lack of proper drainage, and abrasive floors, which can lead to soft tissue lesions and integument damage.[162]

When it comes to shoulder ulcers, reduced body condition during lactation is a risk factor for their occurrence. Other factors are lactation length and number of parities. One study showed that, if the body condition is in a normal range, the different farrowing systems have no effect on the incidence of shoulder ulcers.[163]

3.4.5 NEST-BUILDING AND EXPLORATIVE BEHAVIOR

Sows are highly motivated to express nest-building behavior.[164] Their motivation is driven by hormonal changes before birth, and it persists even in environments where nest-building behavior cannot be fully expressed.[165]

Nest-building is comprised of four functional behavioral elements:

1. rooting and pawing material on the ground to make a depression;
2. finding and carrying material back to the nest site;
3. biting and tearing material to give it the correct structure;
4. arranging the material by carrying (picking material up and depositing it with the mouth), rooting, and pawing it to accumulate the material into a heap at the nest-site.[166]

162 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

163 R. Y. Lohmeier, C. G. E. Gimberg-Henrici, O. Burfeind, and J. Krieter, "Suckling Behaviour and Health Parameters of Sows and Piglets in Free-Farrowing Pens," *Applied Animal Behaviour Science* 211 (2019): 25–32.

164 D. Wischner, N. Kemper, and J. Krieter, "Nest-Building Behaviour in Sows and Consequences for Pig Husbandry," *Livestock Science* 124, nos. 1–3 (2009): 1–8.

165 L. J. Pedersen, A. Patt, M. A. Ruis, A. Hoofs, H. M. Vermeer, and A. Kongsted, "Review on Farrowing Housing and Management," *EURCAW-Pigs* (2020): 1–19; A. Grahofer, "Sow Behaviour, Parturition Process and Management in Free Farrowing Systems," *Porcine Health Management* 12 (2026).

166 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

A lack of sufficient or appropriate nesting material around birth can induce stress in sows, which can prolong the duration of farrowing and consequently increase piglet mortality, as well as farrowing-related stress in the sow.[167]

3.4.5.1 Farrowing Crates

Farrowing crates severely restrict the expression of nest-building and exploratory behavior. Due to the fully or partially slatted flooring in crates, no loose substrate is provided, preventing nest-building behavior.[168] Additionally, the spatial restriction of the farrowing crate inhibits explorative behavior. Crated sows attempt to build nests (rubbing nose against and pawing the floor), but they perform quantitatively less nest-building behavior, which is less varied and more fragmented as measured by postural changes.[169]

In crate systems, confined sows may lose access to loose nesting material over time as it moves out of their reach. As a result, materials are often fixed to the crate structure, but this does not adequately meet the sows' nesting needs.[170]

Crated sows are not able to freely collect nest-building material. They express restlessness and have to endure enforced inactivity. Sows in crates experience stress and/or other negative affective states, such as frustration, resulting from the thwarting of their motivation to build nests and care for their offspring.[171] Frustration of the behavior disrupts parturition, resulting in prolonged farrowing times.[172] The inability to build nests is stressful for sows. In this state, the stress level stays high after farrowing.[173] During the last hour preceding farrowing, crated sows have higher heart rates and perform more oral/nasal stereotypies than sows housed loose in pens.[174]

3.4.5.2 Free-Farrowing Pens

Overall, free-farrowing systems allow greater freedom of movement, especially turning around, and more opportunities to express nest-building behaviors before and after birth. Sows in free-farrowing pens show higher nest-building activity than sows in crates.[175] However, functional nest-building is dependent on the provision of nesting material. The effects of nest-building material most likely depend on the amount of material and the timing of when the sows get access to it. Commercial farms may only provide a relatively small amount of material.[176] However, loose housing, in combination with access to nest-building material, allows sows to gather nesting material, deposit it at the nest-site, turn around, and show pawing and rooting behavior over several hours.[177] Research on the effects of different types and quantities of nesting material in free-farrowing systems remains limited.[178]

To allow for active nest-building behavior, the area accessible for the sow should be at least $4.9 m^2$.[179] Free farrowing reduces the problem of lack of space, which leads to restriction or prevention of nest-building behavior. Although according to EFSA, it is impossible to quantify nest-building behavior in relation to available space, based on existing data.[180]

167 A. Grahofer, "Sow Behaviour, Parturition Process and Management in Free Farrowing Systems," *Porcine Health Management* 12 (2026).

168 E. M. Baxter, A. B. Lawrence, and S. A. Edwards, "Alternative Farrowing Systems: Design Criteria for Farrowing Systems Based on the Biological Needs of Sows and Piglets," *Animal* 5, no. 4 (2011): 580–600.

169 European Food Safety Authority (EFSA), "Scientific Opinion Concerning a Multifactorial Approach on the Use of Animal and Non-Animal-Based Measures to Assess the Welfare of Pigs," *EFSA Journal* 12(5), 2014.

170 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," EFSA Journal, 20 no. 8 (2022); A. Grahofer, "Sow Behaviour, Parturition Process and Management in Free Farrowing Systems," *Porcine Health Management* 12 (2026).

171 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

172 *Ibid*.

173 Lawrence *et al*. (1994) and Oliviero *et al*. (2008), cited in European Food Safety Authority (EFSA), "Scientific Opinion Concerning a Multifactorial Approach on the Use of Animal and Non-Animal-Based Measures to Assess the Welfare of Pigs," *EFSA Journal* 12, no. 5 (2014): 3702, 17.

174 B. I. Damm, L. Lisborg, K. S. Vestergaard, and J. Vanicek, "Nest-Building, Behavioural Disturbances and Heart Rate in Farrowing Sows Kept in Crates and Schmid Pens," *Livestock Production Science* 80, no. 3 (2003): 175–187; A. Grahofer, "Sow Behaviour, Parturition Process and Management in Free Farrowing Systems," Porcine Health Management 12 (2026).

175 Andersen *et al*. (2014); Oliviero *et al*. (2010), both cited in V. M. Hukkinen, C. Munsterhjelm, M. Kurtti, N. Immonen, and A. Valros, "Impact of Farrowing System and Prepartum Nest-Building Material on Nest-Building Behaviour and Farrowing in Sows," *Animal* 18, no. 6 (2024): 101183.

176 V. M. Hukkinen, C. Munsterhjelm, M. Kurtti, N. Immonen, and A. Valros, "Impact of Farrowing System and Prepartum Nest-Building Material on Nest-Building Behaviour and Farrowing in Sows," *Animal* 18, no. 6 (2024): 101183, 11.

177 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

178 A. Grahofer, "Sow Behaviour, Parturition Process and Management in Free

3.4.6 INTERACTION BETWEEN SOW AND PIGLETS

Only a limited body of research currently exists on the mother–offspring relationship of pigs, such as the expression of maternal care.[181] The following section addresses behavior between sows and piglets with a particular focus on two aspects: (positive) interaction between sows and their piglets, and the possibility for sows to separate from their piglets. Both aspects are strongly influenced by farrowing system design.

After giving birth, the mother sow actively initiates social contact with her offspring in the form of sniffing, nosing, touching, vocalization, and investigation.[182] Nursing is an important behavior between the sow and her piglets, and in the first days after birth, the mother sow initiates nursing with a deep pitched grunt followed by rhythmic grunting.[183]

Under semi-natural conditions, sows stay in or near the nest for the first 10 days following farrowing, after which, they return to their herd.[184] During this initial post-farrowing phase, however, sows may already begin to show motivation to move away from the nest. In the first 8 days following farrowing under semi-natural conditions, sows spend increasing amounts of time more than 10 meters away from the nest site, though they typically regularly return to the nest site.[185] Over the course of the lactation period, the sows generally become more active again.[186] With lactation progressing further, the sow will gradually and continuously wean her piglets. Under semi-natural conditions piglets will be weaned on average 17.2 weeks after farrowing.[187]

3.4.6.1 Farrowing Crates

The housing system influences sow–piglet interactions.[188] In crates, social interactions between sows and piglets are substantially constrained. Crated sows show reduced investigation and generally fewer interactions with piglets than sows in pen systems.[189] Crated sows also show less vocalization (e.g. low frequency rhythmic grunts or suckling grunts) to their piglets.[190] Sow-to-piglet nosing, sniffing, touching, and investigating of piglets is only possible if piglets approach the front part of the crate, as the sow is confined and cannot turn around or access different areas of the pen.[191]

Crating can influence nursing behavior, but the evidence on the effects of crating on nursing behavior is mixed. Some studies find no differences in nursing frequency or duration between crates and pens (including temporary crating), while others report differences mainly in the very early lactation period.[192] A 2022 study compared nursing behavior in crated and loosely housed sows and found that nursing frequency was similar, but nursing duration was shorter in loose housing and more nursing events were terminated by loosely housed sows, mirroring the natural nursing behavior of pigs.[193]

Additionally, the crate prohibits the sow from separating from her piglets at any time. As lactation advances, and piglets develop and become more demanding, the sow increasingly wants to move away from them but is prevented from showing escape behavior.[194] To prevent access to her udder, the sow will instead lie more often in a sternal position instead of lying on her side.[195]

Farrowing Systems," *Porcine Health Management* 12 (2026).

179 E. M. Baxter, A. B. Lawrence, and S. A. Edwards, "Alternative Farrowing Systems: Design Criteria for Farrowing Systems Based on the Biological Needs of Sows and Piglets," *Animal* 5, no. 4 (2011): 580–600.

180 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20(8), 2022.

181 K. Portele *et al.*, "Sow-Piglet Nose Contacts in Free-Farrowing Pens," *Animals* 9, no. 8 (2019): 513.

182 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

183 I. Ekesbo and S. Gunnarsson, *Farm Animal Behaviour: Characteristics for Assessment of Health and Welfare* (Wallingford: CABI, 2018).

184 *Ibid*.

185 D. Csermely, "Maternal Behaviour of Free-Ranging Sows during the First 8 Days," *Journal of Ethology* 12 (1994): 53–62.

186 A. Valros *et al.*, "Sow Activity Level, Frequency of Standing-to-Lying Posture Changes and Anti-Crushing Behaviour—Within Sow-Repeatability and Interactions with Nursing Behaviour and Piglet Performance," *Applied Animal Behaviour Science* 83, no. 1 (2003): 29–40.

187 P. Jensen and B. Recén, "When to Wean—Observations from Free-Ranging Domestic Pigs," *Applied Animal Behaviour Science* 23, nos. 1–2 (1989): 49–60.

188 D. H. Wiechers *et al.*, "Does Nursing Behaviour of Sows in Loose-Housing Pens Differ from That of Sows in Farrowing Pens with Crates?," *Animals* 12, no. 2 (2022): 137.

189 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

190 G. M. Cronin, G. J. Simpson, and P. H. Hemsworth, "The Effects of the Gestation and Farrowing Environments on Sow and Piglet Behaviour and Piglet Survival and Growth in Early Lactation," *Applied Animal Behaviour Science* 46, nos. 3–4 (1996): 175–192.

191 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

3.4.6.2 Free-Farrowing Pens

Farrowing pens generally allow sows greater control over their interactions with their piglets.[196] Loosely housed sows in pens have, by design, more opportunity to positively interact and touch their piglets than sows housed in crates during birth and the period of lactation. Sows in pens are more active and investigate their piglets more than sows kept in crates.[197]

In general, sows can change their position to lie on their sternum to terminate nursing.[198] Additionally, if provided enough space, they will retreat from their piglets as lactation progresses. This has been studied in loose housing with a get-away area.[199] Although free-farrowing pens are not large enough to provide a dedicated get-away area, they still allow sows some degree of control over social interactions by enabling the sow to move away from their piglets. Data from one study on nursing behavior in loose pens show that sows terminate more nursings compared to crated sows, which mirrors the nursing behavior of sows in semi-natural conditions. However, other studies show that crated sows terminate more nursing events than sows housed in pens, that crated sows spend less time nursing their piglets compared to sows in temporary confinement systems (confinement for 5 days postpartum), and show less nursing bouts and a longer interval between nursings. Other studies found no effect of housing on nursing behavior.[200]

A mother sow sleeps with her piglets inside a farrowing pen on an industrial pig farm.
© Jo-Anne McArthur, We Animals; Sweden, 2009

192 L. J. Pedersen *et al*., "Neonatal Piglet Traits of Importance for Survival in Crates and Indoor Pens," *Journal of Animal Science* 89, no. 4 (2011): 1207–1218; L. Loftus *et al*., "The Effect of Two Different Farrowing Systems on Sow Behaviour, and Piglet Behaviour, Mortality and Growth," *Applied Animal Behaviour Science* 232 (2020): 105102; C. Singh *et al*., "The Behaviour and Welfare of Sows and Piglets in Farrowing Crates or Lactation Pens," *Animal* 11, no. 7 (2017): 1210–1221; G. Illmann *et al*., "Effect of Crate Opening from Day 3 Postpartum to Weaning on Nursing and Suckling Behaviour in Domestic Pigs," *Animal* 13, no. 9 (2019): 2018–2024; K. Thodberg *et al*., "Nursing Behaviour, Postpartum Activity and Reactivity in Sows: Effects of Farrowing Environment, Previous Experience and Temperament," *Applied Animal Behaviour Science* 77, no. 1 (2002): 53–76; J. Hales *et al*., "The Effect of Temporary Confinement of Hyperprolific Sows in Sow Welfare and Piglet Protection Pens on Sow Behaviour and Salivary Cortisol Concentrations," *Applied Animal Behaviour Science* 183 (2016): 19–27.

193 D. H. Wiechers *et al*., "Does Nursing Behaviour of Sows in Loose-Housing Pens Differ from That of Sows in Farrowing Pens with Crates?," *Animals* 12, no. 2 (2022): 137.

194 D. Csermely, "Maternal Behaviour of Free-Ranging Sows during the First 8 Days," *Journal of Ethology* 12 (1994): 53–62.

195 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal*, 20 no. 8 (2022).

196 *Ibid*.

197 K. L. Chidgey *et al*., "Observations of Sows and Piglets Housed in Farrowing Pens with Temporary Crating or Farrowing Crates on a Commercial Farm," *Applied Animal Behaviour Science* 176 (2016): 12–18.

198 J. M. Osotsi *et al*., "Sow and Piglet Behaviour During Lactation: A Review Focusing on Selected Behaviour Manifested by Foster Sows and Their Fostered Piglets," in *BIO Web of Conferences* 167 (2025)..

199 A. D. Pitts *et al*., "Alternative Housing for Sows and Litters: Part 5. Individual Differences in the Maternal Behaviour of Sows," *Applied Animal Behaviour Science* 76, no. 4 (2002): 291–306.

200 EFSA (European Food Safety Authority), "Scientific opinion on the welfare of pigs on farm," *EFSA Journal,* 20(8), 2022.

3.5 Overall Welfare Impact of a Ban of Farrowing Crates

Farrowing crates severely restrict sow movement, allowing only standing, lying, or sitting, while preventing walking, turning, and behavioral thermoregulation. Due to such confinement, no functional area separation is possible. Farrowing crates prevent or drastically restrict the expression of virtually all basic ethological needs of sows. In particular, the expression of functional nest-building behavior and maternal care behavior is negatively affected. Crates are associated with multiple negative health and welfare consequences: physical injuries, heat stress, distress, stereotypies, and different negative affective states such as pain, fear, discomfort, and frustration. Farrowing crates cannot be considered as an adequate farrowing environment for either the sow or her piglets. Additionally, such systems present serious welfare concerns.

Free-farrowing pens provide sows with greater freedom of movement and more opportunities to express their natural behavior. They can adjust their position more easily and make use, at least to some extent, of different areas within the pen. Soiling of the lying area may occur and should be prevented by pen design and environmental management. Free-farrowing systems better support sows in their nest-building behavior, and in their interactions with their piglets, than crates do, but the expression of nest-building behavior strongly depends on the

Table 2: Overview of welfare key indicators affected by transitioning from crates to free farrowing.

Domain	Indicator	Farrowing Crate	Free Farrowing
Environment	*Space and freedom to move*	Severe restriction due to confinement	Sows are able to turn around and move freely
	Comfortable climatic conditions	Less opportunities for thermoregulation via posture change due to confinement	More opportunities for thermoregulation via posture change and changing location to a certain degree
	Separate pen into functional areas	No separation into functional areas due to confinement	More opportunities for zonation, but risk for soiling (Note: influenced by pen shape and design)
Health	*Injuries*	Higher risk for abrasion, lesion and pressure sores due to flooring, fixtures, and fittings	Lower risk for soft tissue lesions and integument damage due to loose housing
Behavior	*Nest-building and explorative behavior*	No performance of all behavioral elements of nest-building at a functional level possible	More opportunity for showing active nest-building behavior
	Interaction between sow and piglets	Restricted sow-piglet interaction due to confinement of sow; no opportunity to escape piglets due to confinement of sow; nursing bouts can only be terminated via sternal lying rather than retreating	More opportunities for interaction between sow and piglets due to loose housing; more opportunities for regulation of contact, including separation to a certain degree

provision of nesting material. Skin lesions are generally of lower relevance in free-farrowing systems, and risks mainly depend on flooring quality and sow body condition. Within free-farrowing pens, minimum space requirements must be met to ensure adequate welfare outcomes. Based on the impact assessment, the transition to crateless farrowing systems will significantly improve animal welfare outcomes.

3.6 Model Assumptions of the Impact Assessment

This impact assessment is based on a set of defined assumptions regarding the design and management of farrowing systems under commercial conditions. For the farrowing crate scenario, the assessment assumes that sows are kept under good commercial conditions in permanently closed individual metal crates. The total pen area ranges between 3.7 and 5.2m², with a fixed sow space and lying area of 1.23m² within the crate. No functional zonation is possible, and the floor is fully or partially slatted. Nesting material is assumed to be available but attached or fixed to the crate, without the provision of bedding. Outdoor access is not included, and weaning is assumed to take place between 21 and 28 days.

For the free farrowing scenario, this assessment assumes that sows are kept under good commercial conditions without a crate. Movement restrictions may be applied through protective gates or similar devices, but no temporary crating is used. The total pen area is assumed to be 7.8m², with approximately 6.6m² available to the sow. The lying area is assumed to be rectangular and as wide as the pen. Furnishings are provided to guide both sow and piglets, which can lead to up to 0.5m² of the designated area being inaccessible to piglets near the pen walls. At least three-quarters of the lying area is assumed to consist of solid flooring. Nesting material is provided in loose form together with straw bedding. As in the crate scenario, no outdoor access is assumed, and weaning occurs between 21 and 28 days.

A sow lies in a farrowing pen with her piglets. © Noah Marsten, We Animals; Sweden, 2025

4. Economic and Welfare Assessment of an EU Ban on Farrowing Crates

4.1 Introduction

4.1.1 BACKGROUND

There are approximately 10.27 million sows in EU pig farming,[201] of which approximately 96% are housed in farrowing crates.[202] Five Member States have enacted legislation that restricts or bans farrowing crates. These five Front-runner Member States account for around 29% of EU sows, although the legislation is being phased in. The national bans fall into three categories:

- Temporary crating (maximum 4-5 days of crating around farrowing): Austria (from 2033), Germany (from 2036), Denmark (from 2041).
- Free farrowing with temporary restraint permitted (sow loose throughout lactation; temporary restraint for exceptional cases only): Sweden (in force since 1994).
- New farrowing crate construction prohibited (existing crates remain in service until end of useful life): Finland (since 2024).

For the remaining 22 Non-legislator Member States, approximately 98% of sows are kept in farrowing crates.[203]

4.1.2 POLICY SCENARIO

This assessment models an EU ban on farrowing crates announced in 2028 with a 10-year transition period ending in 2038. From the announcement year, no new farrowing crate or temporary crating installations are permitted; from the enforcement year, no crate use is permitted.

The scope covers the 22 Non-legislator Member States, approximately 7.28 million sows or 71% of the EU total.[204] The five Front-runner Member States that have enacted national legislation restricting or banning farrowing crates are excluded from active calculation. If the EU-level pen area standard is set at or above 7.8m², some Front-runners whose existing pen specifications fall below this threshold may face incremental costs not captured here.

The counterfactual assumes no EU-level legislation, with Non-legislators (the 22 Member States without national farrowing crate legislation) transitioning at a baseline rate that would prevail in the absence of EU policy.

201 Eurostat, *Pig Population: Annual Data (apro_mt_lspig)*, dataset, 2025, https://ec.europa.eu/eurostat/databrowser/view/apro_mt_lspig/default/table (accessed 15 June 2026).

202 Industry survey data; see section 4.2.1.

203 Institute of Agricultural Economics (AKI), *An Assessment of the Impacts of the Phasing Out of Cages in EU Livestock Farming: The Pig and Layer Sectors* (2023), Table 33; Author's calculations.

204 Eurostat, *Pig Population: Annual Data (apro_mt_lspig)*, dataset, 2025, https://ec.europa.eu/eurostat/databrowser/view/apro_mt_lspig/default/table (accessed 15 June 2026).

4.1.3 APPROACH

This assessment proceeds by first analyzing the economic impact of an EU ban, then analyzing the animal welfare impact, and finally combining both analyses to calculate the benefit-cost ratio.

4.2 Economic Methodology

4.2.1 COST FRAMEWORK

The cost framework accounts for farm-level cost differences between three systems: free farrowing, temporary crating, and permanent crating (referred to as "crates"). The central estimate sums eight components in three groups. Fixed costs relate to investments in capital expenses: pen construction, building depreciation, and maintenance. The variable costs are labor, veterinary, feed, and other variable items (bedding, maintenance). The piglet effects are based on pre-weaning and post-weaning mortality and grow-finish rates.

Country-specific cost data for individual Member States are not available at sufficient granularity to support country-level modeling. Published sources report EU-average cost structures.[205] We therefore apply the EU-average cost difference to all Non-legislators.

In the calculations, all monetary values are expressed in 2025 EUR. There are an estimated 80.5 crate-days per sow per year.[206] This implies that a sow spends 22% of its time in a farrowing crate.

4.2.1.1 Discount Rate

We use a 3% social discount rate in line with the EC Better Regulation Toolbox with sensitivity analysis results at 2% and 5% (section 4.4.3).[207] A higher rate produces lower Net Present Value (NPV) estimates because it discounts distant-future costs more heavily.

4.2.1.2 Sow Population

The base-year EU sow population is 10.27 million.[208] The central projection assumes a 1% per year exponential decline from this base, reflecting moderation of the observed 1.7% per year structural consolidation trend over 2000–2024, with sensitivity testing at 0% and 2% per year decline. The decline reflects secular structural consolidation and biological productivity gains, not a policy-induced production contraction. Historical evidence from the 2013 sow stall ban and the 2012 cage-free egg transition do not show production contraction as a result of welfare reforms (Annex A, section A10.2)

4.2.2 TRANSITION PATHWAY

This assessment models the transition from crates to free farrowing under two scenarios: an EU ban and a counterfactual with no EU ban.

The counterfactual crate share for the 22 Non-legislator Member States follows the logistic S-curve – the standard reduced-form for diffusion processes in agriculture[209] – with a long-run floor of 50% that captures both the possibility of further national bans within the Non-legislators over the assessment horizon and the possibility that voluntary adoption

205 Institute of Agricultural Economics (AKI), *An Assessment of the Impacts of the Phasing Out of Cages in EU Livestock Farming: The Pig and Layer Sectors* (2023); InterPIG / Wageningen Economic Research, International Comparison of Pig Production Costs 2022: Results of InterPIG (2022).

206 Sow-crate-days are calculated as 35 days per litter x 2.3 litters per year = 80.5.

207 European Commission, *Better Regulation Toolbox*, Publications Office of the European Union (2025), tool #64.

208 Total sow population over 2022-2024 remained in the 10.21-10.52 million range. Eurostat, *Pig Population: Annual Data (apro_mt_lspig)*, dataset, 2025, https://ec.europa.eu/eurostat/databrowser/view/apro_mt_lspig/default/table (accessed 15 June 2026).

209 Z. Griliches, "Hybrid Corn: An Exploration in the Economics of Technological Change," Econometrica 25, no. 4 (1957): 501–22; P. Geroski, "Models of Technology Diffusion," Research Policy 29, nos. 4–5 (2000): 603–25; C. A. K. Dissanayake, W. Jayathilake, H. V. A. Wickramasuriya, U. Dissanayake, K. P. P. Kopiyawattage, W. M. C. B. Wasala, "Theories and Models of Technology Adoption in Agricultural Sector," Human Behavior and Emerging Technologies (2022): Article 9258317.

alone plateaus short of full transition. Sensitivity scenarios at 12% (fast voluntary) and 98% (status quo) bracket this uncertainty; full detail on calibration is in Annex 2.

For the EU ban scenario we use the Carpenter and Kanepajs vintage-based investment model, which forecasts farm-level investment timing as a function of equipment vintage and the legislation announcement and ban-enforcement dates.[210] This is based on standard production economics: a farmer maximising profit over a multi-year horizon makes investment decisions in durable assets such as buildings and equipment whose payoffs accrue years later, and accounts for each at its annual cost.[211] Under the model, a large proportion of farms invest directly in free farrowing rather than replace soon-to-be-stranded crate assets after the legislation is passed. This is because of aging infrastructure (average building age 17.3 years against a 25-year lifecycle; equipment 9.7 against 12.5) and investment being postponed until legislative uncertainty (e.g. on post-ban minimum requirements) is resolved. After an initial spike, the transitions proceed at natural replacement rates until forced conversion at the ban year.

The assessment period runs from 2025 to 2060. This horizon is chosen to allow for a 25-year building depreciation cycle from the final year of the EU ban scenario in 2038. Beyond 2060, the ban has virtually eliminated crate use, while the counterfactual retains a persistent, virtually constant crate proportion. Scenario-specific parameter calibration (logistic floor, ban announcement and enforcement dates, transition-speed sensitivities) is detailed in section 4.4.

4.2.3 SOURCING CONVENTION

4.2.3.1 Within-Study Primary Inputs in Similar Settings

All primary cost and outcome coefficients in this assessment are drawn from within-study comparisons of farrowing systems in similar settings. Comparisons that span different geographies (InterPIG costs in Sweden against the EU average, for instance) are excluded from the primary evidence base. Such comparisons are systematically undermined by exchange-rate movements, construction-cost inflation, interest-rate dispersion, and herd-health / genetics / production-intensity confounders; detailed rationale in Annex A, section A3.1.

4.2.3.2 Conventional Commercial Practice, Not Best-Practice Demonstration Designs

Central cost values reflect conventional commercial practice, not engineering-optimum or demonstration designs. When a source reports several designs in one category, the central averages them by arithmetic mean or commercial-prevalence weight rather than selecting the most favorable design.

4.2.3.3 Scope: Individual-Pen Free Farrowing Only

Group, multi-suckling, outdoor, and kennel systems are structurally distinct from individual-pen free farrowing, with different capital, labor, and piglet-effect profiles, and are not included in the assessment.

210 G. Carpenter and A. Kanepajs, When to Ban Farrowing Crates? Analysing EU Policy Options for Ban Dates and Transition Periods (2026).

211 D. L. Debertin, Agricultural Production Economics (2012).

Table 1: Costs for free farrowing and temporary crating compared to conventional crates, measured in EUR per sow per year

Line	Free farrowing pen of 7.8m²	Temporary crating of 5.5m²	Key source
Capital + building depreciation + maintenance	+€59.2	+€21.4	Regression β = 14.68 pp/m² (section 4.3.2)
Labor	+€22.0	+€10.0	Three-study commercial pool (section 4.3.3)
Veterinary	€0.0	€0.0	AHDB DST + Quendler null (section 4.3.4)
Feed (sow lactation)	€0.0	€0.0	AHDB DST + Cheon + Dumniem null (section 4.3.5)
Other variable (bedding, maintenance)	+€5.5	+€2.5	AHDB 2019 DST composite, energy excluded (section 4.3.6)
Pre-weaning mortality	+€0.0	+€5.8	EFSA (2022) (section 4.3.7)
Faster grow-finish (revenue)	−€60.0	€0.0	Pool B (3-study) x Pool C x AHDB chain (section 4.3.7)
Post-weaning mortality reduction	−€7.0	€0.0	Collins (2017) (section 4.3.7)
Net cost increase vs crate	**+€19.7 (+0.3%)**	**+€39.7 (+0.7%)**	**Calculated**
Per piglet marketed	**+€0.70**	**+€1.41**	**Calculated**
Per kg carcass weight	**+€0.0075**	**+€0.0151**	**Calculated**

Notes: Net cost increases represent approximately 0.3% (free farrowing) and 0.7% (temporary crating) of total production cost relative to a central estimate of EUR 5,976 per sow per year or EUR 2.27 per kg carcass weight.[212] Cost per piglet marketed is calculated at 28.2 pigs sold per sow per year.[213] Per kg carcass weight calculated at 93.2kg carcass weight (cold) per pig.[214] See Annex A, section A3.6 for details.

4.3. Cost Accounting

4.3.1 COST STACK: BUILD-UP APPROACH

The main results for the cost stack is in Table 1 above.

4.3.2 CAPITAL COSTS

Free farrowing requires more space per sow, which leads to higher capital costs in the form of pen construction and building depreciation. We estimate how the capital cost increase of free farrowing over crates varies with pen area. The method is an OLS regression of within-study cost increases, with study fixed effects. The pooled slope is β_m^2 = +14.68 percentage points per m² of pen area. At EUR 112 per sow per year for the crate central estimate, the capital cost increases are EUR 21 per sow per year for the 5.5m² temporary-crating system and EUR 59 per sow per year for the 7.8m² free-farrowing system.[215] Full panel inclusion/exclusion list and detailed reasoning are in Annex A, section A3.3; derivation, scatter plot, per-study premium bar chart, and the crate central estimate decomposition are in Annex A, sections A4.2 and A4.3.

4.3.3 LABOR COSTS

Free farrowing may require more labor than crate systems, for example because piglet processing and routine handling take longer around an

212 In 2025 EUR. Eurostat, Slaughtering: All Data (apro_mt_pann), dataset, 2025, https://ec.europa.eu/eurostat/databrowser/view/apro_mt_pann/default/table (accessed 15 June 2026).

213 Agriculture and Horticulture Development Board (AHDB), 2024 Pig Cost of Production in Selected Countries: Overview (2024), https://ahdb.org.uk/news/2024-pig-cost-of-production-in-selected-countries-overview (accessed 15 June 2026), Table 4, EU average.

214 Eurostat, Slaughtering: All Data (apro_mt_pann), dataset, 2025, https://ec.europa.eu/eurostat/databrowser/view/apro_mt_pann/default/table (accessed 15 June 2026).

215 A pen area of 7.8m² total (6.6m² sow space plus 1.2m² piglet creep) is the EFSA expert-elicited estimate of the pen area at which pre-weaning mortality in free-farrowing systems equals crate mortality. European Food Safety Authority, "Scientific opinion on the welfare of pigs on farm," EFSA Journal, 20(8), 2022, https://doi.org/10.2903/j.efsa.2022.7421.

unrestrained sow. Crushing-risk management also demands more frequent inspections, while straw-based pens add bedding and cleaning work, among other tasks. Pooling three within-study primary sources,[216] the cross-study mean is +1.479 hours per sow per year for free farrowing compared to crate systems. At a EUR 15/hour wage reference,[217] this gives +EUR 22 per sow per year for free farrowing and +EUR 10 per sow per year for temporary crating.[218] Note that this calculation does not consider the difference between systems that may arise through novel technological advances. Labor-reducing robotics and AI-based systems for autonomous inspection, feeding, and cleaning are advancing in pig production.[219] Some are especially relevant for target free farrowing. For example, automated computer-vision systems can detect sow-induced piglet crushing, which is the primary reason for the additional inspection labor required in loose pens.[220] Over a transition of a decade or more, such tools are likely to narrow the labor gap between free farrowing and crate systems.

4.3.4 VETERINARY COSTS

Free farrowing may have higher veterinary costs[221] or lower veterinary costs from stronger piglets and reduced physical and behavioral problems and the need for medical intervention.[222] However, on average the reported veterinary costs are similar,[223] with no more than 1.5% differences between vet costs across all considered systems.[224] The +7.5% vet-medicine coefficient in AKI *et al*. is an exception,[225] labeled as an expert estimate with no cited source. The opposite tendency has also been observed: InterPIG production-cost data show that despite the universal free farrowing requirement in Sweden since 1994, total Swedish veterinary costs are below the EU average.[226] However, this could be explained by routine prophylactic use and fewer endemic diseases. With no clear evidence to the contrary, we assume that veterinary costs are similar across all considered systems. A likely benefit not quantified in this study is a reduction in the need for antibiotics, and therefore in antimicrobial resistance risk, from the lower stress of free farrowing, consistent with evidence that higher animal welfare lowers antimicrobial use.[227]

4.3.5 FEED COSTS

Free farrowing may have higher or lower feed costs than crate systems. AHDB decision support tool (DST) reports sow + creep feed as identical at £127.69 per sow for both crate systems and PigSAFE free-farrowing pens.[228] Dumniem *et al*. report no significant difference in sow feed intake between free-farrowing and crate systems,[229] and Cheon *et al*. report similar overall feed intake between free-farrowing pens with temporary crating and conventional farrowing crates.[230] As a result, we assume similar feed costs for all three systems.

4.3.6 OTHER VARIABLE COSTS

Other variable costs include bedding and maintenance. AHDB DST breaks out the non-capital farrowing-stage line items: bedding +EUR 0.38 per sow per year (straw for PigSAFE part-slatted) and maintenance +EUR

216 E. M. Baxter *et al*., “Alternative Farrowing Accommodation: Welfare and Economic Aspects of Existing Farrowing and Lactation Systems for Pigs,” Animal 6, no. 1 (2012): 96–117; B. Heidinger *et al*., “Pro-SAU: Ausgewählte Ergebnisse zu den neuartigen Bewegungsbuchten in der Abferkelung,” in Nutztierschutztagung Raumberg-Gumpenstein 2018 (2018): 17–23; E. Quendler *et al*., “Performance, Labour and Economic Aspects of Different Farrowing Systems,” Agricultural Engineering International: the CIGR Ejournal, Manuscript MES 1135, vol. XI (2009).

217 Eurostat, Economic Accounts for Agriculture: Agricultural Income Indicators (aact_eaa06), dataset, 2025, https://ec.europa.eu/eurostat/databrowser/view/aact_eaa06/default/table (accessed 15 June 2026).

218 The latter estimate of +EUR 10 is from B. Heidinger *et al*., “Pro-SAU: Ausgewählte Ergebnisse zu den neuartigen Bewegungsbuchten in der Abferkelung,” in Nutztierschutztagung Raumberg-Gumpenstein 2018 (2018): 17–23. This study finds increased labor cost for both free farrowing and temporary crating but no significant difference between the two. The plausible sensitivity range spans EUR 0-35 for free farrowing and EUR 0-20 for temporary crating. Full per-study pool construction is in Annex A, section A3.5.

219 L. Zhou, L. Hao, Y. Xiong, H. Qin, A. Bao, and Z. Chen. 2026. “Research Progress of Robotic Technologies and Applications in Smart Pig Farms” Agriculture 16, no. 3: 334.

220 H. Gan, X. Wu, F. Menegon, A. Scollo, A. Sun, T. Norton, and Y. Xue, “Occlusion-Robust Detection of Sow-Induced Piglet Crushing Incidents Using Spatial and Motion Reasoning,” Computers and Electronics in Agriculture 231 (2025).

221 Institute of Agricultural Economics (AKI), An Assessment of the Impacts of the Phasing Out of Cages in EU Livestock Farming: The Pig and Layer Sectors (2023), p. 29.

222 ACO Funki A/S, Marketing Material: Sow Farrowing Pen Designs (n.d.).

223 Agriculture and Horticulture Development Board (AHDB), Alternative Farrowing Systems Economic Model (Decision Support Tool) (2019); Agriculture and Horticulture Development Board (AHDB), 2019 Pig Cost of Production in Selected Countries (2020).

5.12 per sow per year (larger pen to maintain).[231] The DST also reports an energy saving of EUR 3.51 per sow per year for PigSAFE, but this reflects lower creep-lamp demand specific to the covered-creep design monitored at Cockle Park; it is not transferable to generic free farrowing pens and is excluded. Net composite is roughly +EUR 5.5 per sow per year for free farrowing vs crate; pro-rata for temporary crating at 5.5m² gives approximately +EUR 2.5 per sow per year.

4.3.7 PIGLET ECONOMIC EFFECTS

The effects of the farrowing system on piglets can extend beyond farrowing. In particular, increased weaning weight has been linked to faster growth, shorter time to finish, and cost savings in addition to any possible reduction in veterinary and medicinal costs. Also, post-weaning mortality can differ based on the farrowing system.

We estimate the heavier-weaning effect as EUR 60 per sow per year. This is the result of a central weaning-weight gain estimate in free farrowing vs temporary crating at +0.349kg (literature review in Annex A, section A5.1), a saving of 4.91 days per kg weight gain (literature review in Annex A, section A5.1), a cost saving of EUR 1.29 per piglet per day at the finishing stage,[232] all multiplied through 27.17 piglets weaned per sow per year.[233]

The post-weaning mortality reduction of 0.47 percentage points (EUR 7 per sow per year) is derived from the Collins *et al*. mortality-vs-weaning-weight slope applied to the central weaning-weight gain.[234] InterPIG data on Sweden corroborate the direction: grower-pig mortality in Sweden was 2.3% in 2023 against an InterPIG average of 3.6%, the difference partly attributed to higher weaning weights from longer lactation,[235] although other factors such as fewer endemic diseases and lower antimicrobial use in Sweden also contribute.[236]

Another cost-affecting factor is pre-weaning mortality, which in free-farrowing systems is strongly influenced by the size of the farrowing pen. At smaller pen sizes, including the minimum size used in existing national bans, there is generally higher mortality in free farrowing than crating. The EFSA expert knowledge elicitation finds no discernible difference in pre-weaning mortality at or above 6.6m² of sow-accessible space (7.8m² total pen area, including 1.2m² piglet creep area) – the pen specification used for this study.[237]

Overall, raising piglets in a free-farrowing system results in an economic benefit of approximately EUR 67 per sow per year compared to crate systems. This is the result of two effects: a faster grow-finish period due to heavier weanings (EUR 60 per sow per year) and a small reduction in post-weaning mortality (EUR 7 per sow per year). There is no difference in pre-weaning mortality between farrowing crates and free-farrowing pens of 7.8m².

4.3.8 PER-SOW COST ESTIMATE

Based on these cost differences, the central estimate is a +EUR 20 per sow per year cost increase for free farrowing over conventional crate and a +EUR 40 per sow per year cost increase for temporary crating over permanent crating (Figure 1).

224 E. Quendler, C. Podiwinsky, J. Baumgartner, C. Winckler, and J. Boxberger, "Performance, Labour and Economic Aspects of Different Farrowing Systems," Agricultural Engineering International: the CIGR Ejournal, Manuscript MES 1135, vol. XI (2009).

225 Institute of Agricultural Economics (AKI), An Assessment of the Impacts of the Phasing Out of Cages in EU Livestock Farming: The Pig and Layer Sectors (2023).

226 *Ibid*.

227 M. Rodrigues da Costa, and A. Diana. 2022. "A Systematic Review on the Link between Animal Welfare and Antimicrobial Use in Captive Animals" Animals 12, no. 8: 1025.

228 Agriculture and Horticulture Development Board (AHDB), 2019 Pig Cost of Production in Selected Countries (2019).

229 N. Dumniem, R. Boonprakob, T. D. Parsons, and P. Tummaruk, "Pen versus Crate: A Comparative Study on the Effects of Different Farrowing Systems on Farrowing Performance, Colostrum Yield and Piglet Preweaning Mortality in Sows under Tropical Conditions," Animals 13, no. 2 (2023): 233.

230 S. N. Cheon, S. H. Jeong, G. Z. Yoo, S. J. Lim, C. H. Kim, G. W. Jang, and J. H. Jeon, "Effect of Alternative Farrowing Pens with Temporary Crating on the Performance of Lactating Sows and Their Litters," Journal of Animal Science and Technology 64, no. 3 (2022): 574.

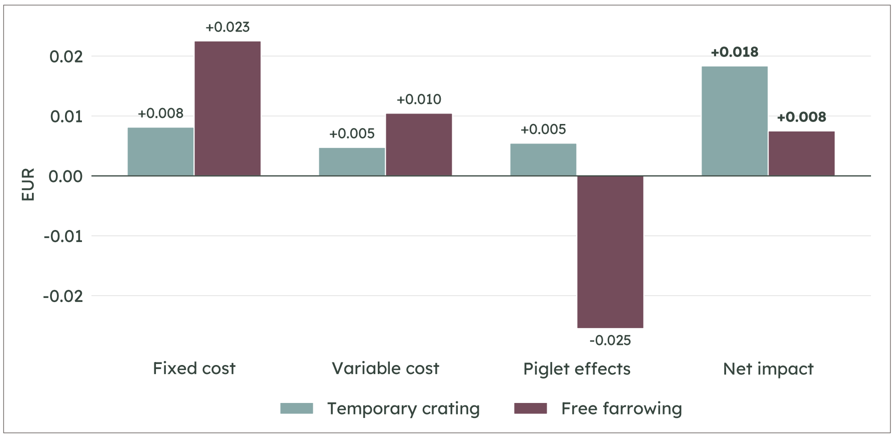
231 Agriculture and Horticulture Development Board (AHDB), 2019 Pig Cost of Production in Selected Countries (2019).

232 Eurostat, Slaughtering: All Data (apro_mt_pann), dataset, 2025, https://ec.europa.eu/eurostat/databrowser/view/apro_mt_pann/default/table (accessed 15 June 2026); Agriculture and Horticulture Development Board (AHDB), 2022 Pig Cost of Production in Selected Countries (2023).

233 2022 EU average, Agriculture and Horticulture Development Board (AHDB), 2022 Pig Cost of Production in Selected Countries (2023).

234 C. L. Collins, J. R. Pluske, R. S. Morrison, T. N. McDonald, R. J. Smits, D. J. Henman, I. Stensland, and F. R. Dunshea, "Post-Weaning and Whole-of-Life Performance of Pigs Is Determined by Live Weight at Weaning and the Complexity of the

Figure 1: Cost difference for free farrowing and temporary crating compared to crates, measured in EUR per kg of carcass weight



Notes: Own calculations in 2025 EUR from the cost build-up divided by approximately 2,628kg of cold carcass weight per sow per year.[238] Fixed and variable costs add to production cost (positive bars); piglet effects are a further cost for temporary crating (pre-weaning mortality only) but a net saving for free farrowing (growth and post-weaning mortality reduction outweigh pre-weaning mortality, increasing output per sow and thus reducing cost per kg). Central estimates: crate EUR 0, temporary crating +EUR 0.015 per kg, free farrowing +EUR 0.008 per kg. Full per-line decomposition for the six-state stack is in Annex A, section A3.6.

The higher direct costs of free farrowing are mostly offset (compared to crates) by the revenue gain from heavier weanings, which is only realized when the sow is free farrowing throughout lactation. The six farrowing systems considered (crate, retrofitted crate, temporary crating, retrofitted temporary crating, free farrowing, retrofitted free farrowing), with per-line breakdown and source basis, are presented in Annex A, section A3.6. Comparison with the engineering-stack estimate of AKI *et al*. is presented in section 4.5.1.

Because temporary crating and free farrowing eliminate or limit the time that sows spend in farrowing crates, the cost differences between the production systems can also be measured in terms of cost per sow-crate-day avoided. The accounting shows that temporary crating reduces profit by about EUR 0.57 per sow-crate-day avoided and free farrowing reduces profit by only EUR 0.25 (about EUR 0.32 less), despite a much larger fixed cost impact because the piglet effects more than offset the difference (Figure 2).

Diet Fed after Weaning," Animal Nutrition 3, no. 4 (2017): 372–379.

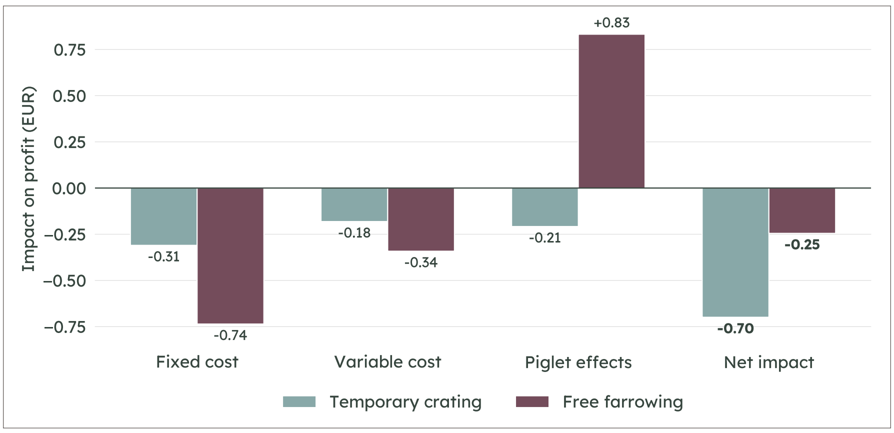
235 Gård & Djurhälsan, Internationella Rapporten 2024 (Gård & Djurhälsan / LRF Kött, 2024).

236 Swedres-Svarm, Sales of Antibiotics and Occurrence of Resistance in Sweden (Public Health Agency of Sweden and Swedish Veterinary Agency, 2024), https://www.sva.se/media/amupibfr/swedres-svarm-2024-we-bb.pdf (accessed 15 June 2026).

237 EFSA (European Food Safety Authority), "Scientific Opinion on the Welfare of Pigs on Farm," EFSA Journal 20, no. 8 (2022), https://doi.org/10.2903/j.efsa.2022.7421.

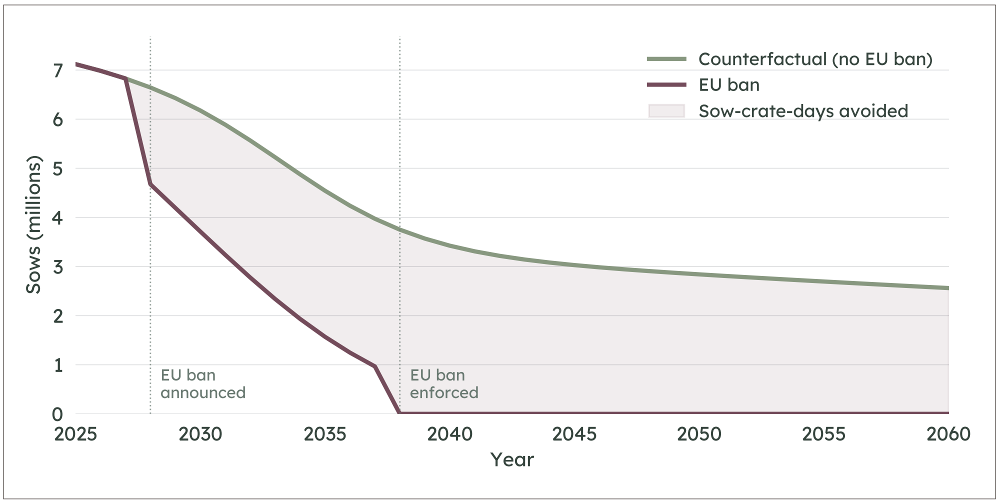
238 28.2 pigs sold per sow at 93.2kg average carcass weight; Agriculture

Figure 2: Profit difference for free farrowing and temporary crating compared to crates, measured in EUR per sow-crate-day avoided



Notes: Own calculations in 2025 EUR from the cost build-up divided by 80.5 sow-crate-days per sow per year. Fixed and variable costs reduce profit (negative bars); piglet effects are a net cost for temporary crating (pre-weaning mortality only) but a net revenue for free farrowing (growth + post-weaning mortality reduction outweigh pre-weaning mortality). Central estimates: crate EUR 0, temporary crating −EUR 0.57 per sow-crate-day avoided, free farrowing −EUR 0.25 per sow-crate-day avoided. Full per-line decomposition for the six-state stack is in Annex A, section A3.6.

Figure 3: Sows in farrowing crates – counterfactual and EU ban



Notes: Own calculations under the multiplicative coupling of the logistic counterfactual with 50% floor and the vintage-based ban schedule, with an EU ban announced in 2028 and enforced in 2038 (section 4.2.2), with the EU sow herd declining at 1% per year from the 2025 base. The counterfactual line shows the declining absolute number of sows in crates – the 50% floor in crate share translates to roughly 2.6 million sows by 2060, down from 7.1 million in 2025, even without an EU ban. The shaded area represents sow-crate-days avoided by the ban. Non-legislators only; Front-runners excluded per section 4.1.2.

and Horticulture Development Board (AHDB), 2024 Pig Cost of Production in Selected Countries: Overview (2024), https://ahdb.org.uk/news/2024-pig-cost-of-production-in-selected-countries-overview (accessed 15 June 2026); Eurostat, Slaughtering: All Data (apro_mt_pann), dataset, 2025, https://ec.europa.eu/eurostat/databrowser/view/apro_mt_pann/default/table (accessed 15 June 2026).

4.4 Economic Results

4.4.1 TRANSITION PATHWAY

Under the EU ban, legislation is announced in 2028 with a 10-year transition to the 2038 end date. The transition path follows the vintage-based investment model (section 4.2.2): a spike in transitions in the legislation year, as farms with aging infrastructure invest directly in free farrowing rather than replace soon-to-be-stranded crate assets; replacement-paced transitions over the 10-year window; and forced conversion of any remaining crate systems at the ban year.

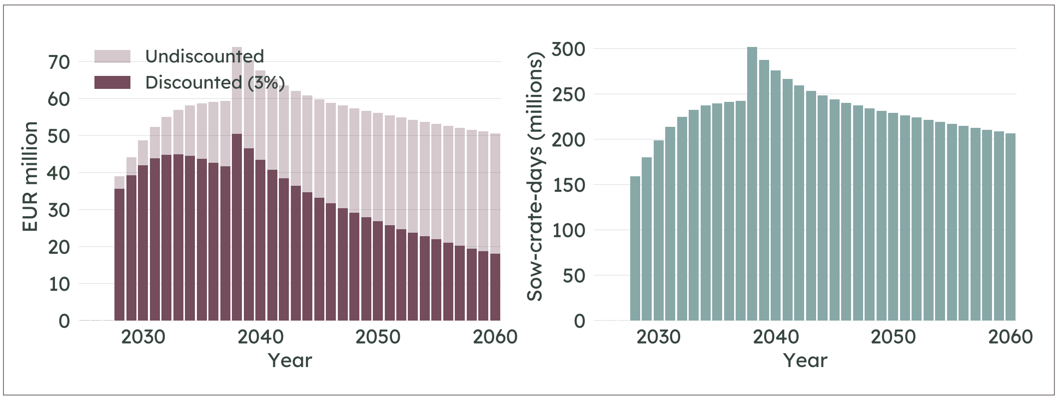
In 2060, the counterfactual still projects roughly 206 million sow-crate-days per year, an ongoing animal welfare cost that the EU ban eliminates but that falls outside the 2025–2060 horizon

4.4.2 ECONOMIC COSTS

Under the main scenario, the EU farrowing-crate ban produces a combined net cost of approximately EUR 1.11 billion in net present value (2025 EUR, discounted at 3% over 2025–2060). The cost is borne by the 22 Non-legislator Member States. The ban avoids 7.63 billion sow-crate-days over the same time period, giving an aggregate cost-effectiveness of EUR 0.15 per sow-crate-day avoided.

The annual cost profile is shown in Figure 4. Transition costs rise from 2028 and peak at the 2038 enforcement deadline as all remaining crate systems must be converted, then decrease toward a steady-state level reflecting the constant rate at which crates would otherwise be replaced under the counterfactual. The contrast between the undiscounted and discounted cost panels makes the time-value of money visible: 3% NPV discounting substantially compresses post-2038 costs, while the corresponding sow-crate-days avoided panel (physical units, undiscounted) keeps full weight on every year of the horizon.

Figure 4: Impact of an EU ban on farrowing crates, showing annual net production cost (left) and annual sow-crate-days avoided (right)



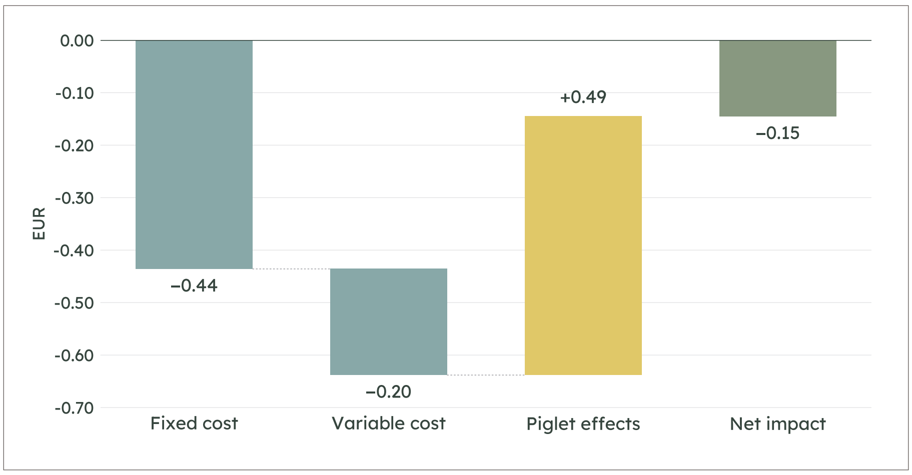
Notes: Own calculations of the EU ban main scenario. Left panel: undiscounted (light blue) and discounted (dark blue, 3%) annual transition cost. Right panel: sow-crate-days avoided per year (physical units, undiscounted). Both panels span 2025–2060.

As a consequence of cost discounting, the aggregate cost-effectiveness (EUR 0.15 per sow-crate-day avoided) is roughly 60% of the per-farm steady-state unit cost.

Figure 5 decomposes the aggregate cost-effectiveness of EUR 0.15 per sow-crate-day avoided into its three component groups. At the EU-ban aggregate (NPV-discounted) level, fixed costs reduce profit by EUR 0.44 per sow-crate-day avoided, variable costs by a further EUR 0.20, and piglet-effect revenue gains add back EUR 0.49, offsetting roughly three-quarters of the gross cost. The proportional decomposition is the same at the per-farm steady-state level (EUR 0.25 per sow-crate-day), because the discount rate scales all three component groups uniformly.

The 2060 horizon understates the cumulative effect of an EU ban. At the end of the assessment period, the central counterfactual still projects 50% of sows in the Non-legislators in crates, corresponding to roughly 206 million sow-crate-days per year that the ban continues to eliminate beyond the horizon. The figures reported here therefore represent a lower bound on the lifetime impact of the policy.

Figure 5: Impact of an EU ban on farrowing crates measured in profit per sow-crate-day avoided



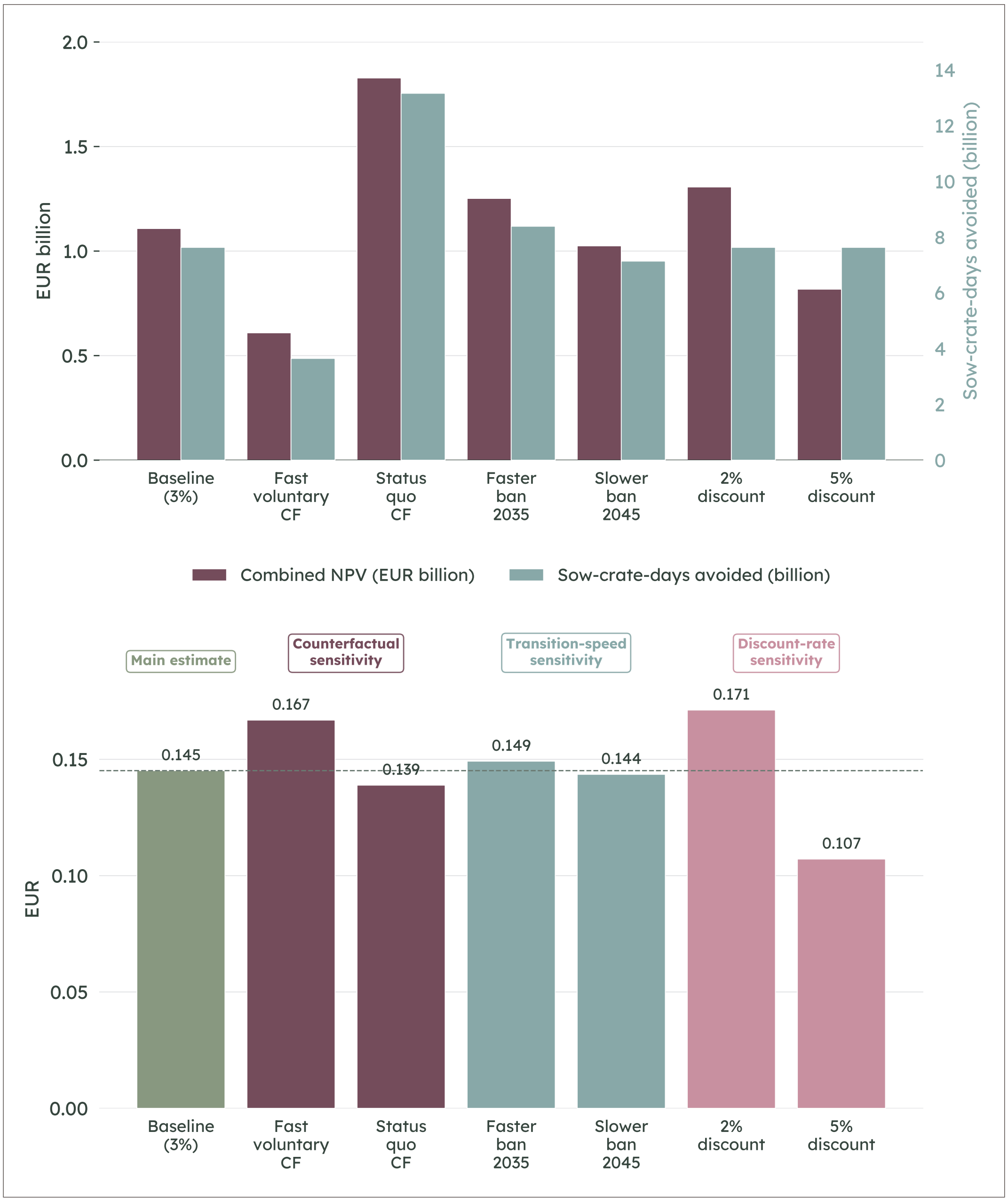
Notes: Free farrowing vs crate, expressed at the EU-ban aggregate (NPV-discounted) level. Fixed costs (capital + building depreciation + maintenance) reduce profit by EUR 0.44 per sow-crate-day avoided; variable costs (labor + veterinary + feed + other) reduce profit by a further EUR 0.20; piglet mortality and weight-gain effects (post-weaning mortality, faster grow-finish) add EUR 0.49 of revenue gain (section 4.3). Net impact is a cost of EUR 0.15 per sow-crate-day avoided. The per-farm steady-state decomposition (single-sow-year, undiscounted) reads EUR 0.74 fixed, EUR 0.34 variable, EUR 0.83 piglet revenue, EUR 0.25 net cost; both views share the same component proportions because the outer discount rate scales all three components uniformly (Annex A, section A6). All values are in 2025 EUR.

4.4.3 SENSITIVITY TESTING

Figure 6 compiles results across the seven sensitivity tests: three counterfactual scenarios (status quo at 98%, main scenario at 50% floor, fast voluntary at 12% floor), two transition-speed scenarios (faster ban 2035, slower ban 2045), and two discount-rate sensitivities (2% and 5%). An EU ban carries an economic cost throughout, spanning +EUR 0.6 billion to +EUR 1.8 billion.

The corresponding per-sow-crate-day unit cost stays in a band of +EUR 0.11 to +EUR 0.17, because both numerator and denominator scale with the size of the counterfactual crate stock that the ban acts on.

Figure 6: Impact of an EU ban on farrowing crates, with sensitivity analysis, measured as total cost, total sow-crate-days avoided (top) and cost per sow-crate day avoided (bottom)



Notes: Own calculations. Top pane: NPV of transition cost (EUR billion, left axis) and sow-crate-days avoided (billion, right axis) for each scenario. Bottom pane: cost-effectiveness (EUR per sow-crate-day avoided) grouped by sensitivity dimension; the dashed line marks the central estimate of EUR 0.15. All values in 2025 EUR, assessment period 2025–2060.

4.5 Discussion of Economic Results

4.5.1 COMPARISON WITH PREVIOUS RESEARCH

The most comprehensive comparable cost estimate for EU free farrowing is AKI *et al*.,[239] whose component-level cost build-up of EUR 184.8 per sow per year (2025 EUR) is approximately nine times the central estimate in this assessment. The gap reflects higher capital cost assumptions in AKI *et al*. and a framework that does not account for revenue from higher weaning weights, with a smaller contribution from veterinary and feed cost differentials, which are not consistently supported in the wider literature (Annex A, sections A3 and A5). Using the AKI *et al*. cost parameters, Carpenter and Kanepajs report cost-effectiveness of EUR 0.47–0.66 per sow-crate-day in a vintage-based investment model, roughly 3–5 times the central estimate in this assessment; the same two structural drivers explain most of the difference.[240] IEEP concludes independently that well-managed free-farrowing systems can achieve operational performance comparable to crates, consistent with the modest net operating cost increase found here.[241]

4.5.2 REMAINING UNCERTAINTIES

Three uncertainties matter most for the central estimates: the weaning-weight benefit of free farrowing; the counterfactual crate-share trajectory for the 22 Non-legislator Member States; and the gap between the revealed-preference logic that free farrowing should be the preferred system over temporary crating (but not conventional crating) and the observed slow voluntary adoption.

A major source of uncertainty is the magnitude of the weaning-weight benefit of free farrowing over crates, as few studies have quantified this effect. Our estimate for this benefit (EUR 60 per sow) is derived from a pool of three studies with a sample-size-weighted central estimate of +349 grams per piglet (Annex A, section 5.1). The largest contributor, Radtke *et al*., is a UK-based randomised trial that demonstrated weaning-weight gains depend on conditions during the first four days post-farrowing, showing +340 grams per piglet in the free farrowing arm.[242]

A second major source of uncertainty is the counterfactual crate share of Non-legislators, which is unknown and depends on potential future legislation and market changes in EU Member States. Varying the central scenario from a floor of 50% to a fast voluntary transition of 12% or a flat status quo transition held at 98% shifts the combined NPV materially between +EUR 0.61 bn and +EUR 1.83 bn. Importantly, however, the per-sow-crate-day unit cost remains within a narrow range (between +EUR 0.11 and +EUR 0.17), because the sow-crate-day denominator scales with the cost numerator.

A third source of uncertainty relates to the implications of the finding that free farrowing is more profitable (EUR 20 per sow per year) than temporary crating (section 4.3), which by revealed-preference logic predicts no voluntary uptake of temporary crating systems in our modeling. The gap between this expected-NPV ranking and observed farmer behavior does not necessarily invalidate the finding. Farmer

239 Institute of Agricultural Economics (AKI), An Assessment of the Impacts of the Phasing Out of Cages in EU Livestock Farming: The Pig and Layer Sectors (2023).

240 G. Carpenter and A. Kanepajs, When to Ban Farrowing Crates? Analysing EU Policy Options for Ban Dates and Transition Periods (2026).

241 IEEP, Financing the Transition to Cage-Free Farming in the EU (Institute for European Environmental Policy, 2026), p. 23.

242 L. Radtke, M. Magnan, R. Clarkson, H. Rong, and K. McDermott, "Adaptive Farrowing: Piglet Mortality and the Lactation Performance and Welfare of Sows," Livestock Science 303 (2026): 105874, https://doi.org/10.1016/j.livsci.2025.105874.

investment decisions are documented to deviate systematically from profit-maximization benchmarks: Hermann, Mußhoff, and Agethen, in an incentivised experiment with conventional and organic hog farmers, show that investment timing is shaped by the current production method of the farmer, independently of expected returns (status quo bias);[243] Dessart, Barreiro-Hurlé and van Bavel, reviewing two decades of evidence, group such frictions into dispositional, social and cognitive clusters, with resistance to change and risk aversion identified as major barriers;[244] and Huber *et al.*, in two Swiss case studies, find that cognitive and dispositional factors together reduce adoption of sustainable practices by 20–70% relative to the profit-maximising benchmark.[245] Free farrowing outcomes additionally depend on the experience of farmers,[246] so early adopters bear a learning-curve variance that a risk-averse farmer will rationally discount. Slow voluntary adoption can therefore be consistent with the free farrowing cost advantage; realizing the advantages of free farrowing can require regulatory intervention and transitional support.

4.5.3 LIMITATIONS

In addition to the previously described uncertainties, there are also key limitations in this assessment that materially shape the central estimate:

Animal welfare benefits are not quantified beyond estimating the sow-crate-days spared, which the animal welfare analysis will address.

The cost framework captures only direct farm-level transition costs. Compliance and enforcement, transition management, decommissioning, and stranded-asset write-downs are excluded.

EU-average costs are used for all 22 Non-legislators. Country-specific cost data are not available at sufficient granularity. Spain (approximately 26% of EU pork) and Eastern European Member States likely differ materially from the EU-average (Annex A, section A4.3).

4.6 Welfare Methodology

4.6.1 AQALY FRAMEWORK

The Animal Quality-Adjusted Life Year (AQALY) framework was developed by Espinosa *et al.* as an empirically grounded method for measuring animal welfare in economic units.[247] The variant used here, AQALY-4PD-9L, operates on four physical domains (Table 2)[248] with a nine-level severity scale (Table 3).

Table 2: AQALY-4PD-9L domain structure

Domain	Subdomains
Nutrition	3
Environment	5
Health	2
Behavior	8
Total	**18**

243 D. Hermann, O. Mußhoff, and K. Agethen, “Investment Behavior and Status Quo Bias of Conventional and Organic Hog Farmers: An Experimental Approach,” Renewable Agriculture and Food Systems 31, no. 4 (2016): 318–329, https://doi.org/10.1017/S1742170515000265.

244 F. J. Dessart, J. Barreiro-Hurlé, and R. van Bavel, “Behavioural Factors Affecting the Adoption of Sustainable Farming Practices: A Policy-Oriented Review,” European Review of Agricultural Economics 46, no. 3 (2019): 417–471, https://doi.org/10.1093/erae/jbz019.

245 R. Huber, C. Kreft, K. Späti, and R. Finger, “Quantifying the Importance of Farmers’ Behavioral Factors in Ex-Ante Assessments of Policies Supporting Sustainable Farming Practices,” Ecological Economics 224 (2024): 108304, https://doi.org/10.1016/j.ecolecon.2024.108303.

246 E. M. Baxter, V. A. Moustsen, S. Goumon, and S. A. Edwards, “Transitioning from Crates to Free Farrowing: A Roadmap to Navigate Key Decisions,” Frontiers in Veterinary Science (2022).

247 R. Espinosa, H. Browning, and N. Treich, “The Animal Quality-Adjusted Life Year (AQALY),” SSRN Working Paper No. 5255360 (2025).

248 The AQALY-4PD-9L framework shares its domain architecture with the Five Domains model (D. J. Mellor, “Operational Details of the Five Domains Model and Its Key Applications to the Assessment and Management of Animal Welfare,” Animals 7, no. 8 (2017): 60; D. J. Mellor, N. J. Beausoleil, K. E. Littlewood, A. N. McLean, P. D. McGreevy, B. Jones, and C. Wilkins, “The 2020 Five Domains Model: Including Human-Animal Interactions in Assessments of Animal Welfare,” Animals 10, no. 10 (2020): 1870). Both partition welfare assessment into Nutrition, Environment, Health, and Behaviour. The Five Domains model adds a fifth domain, Mental State, as an integrative overlay; AQALY-4PD-9L omits it. The omission is deliberate: the discrete choice experiments that calibrate the AQALY coefficients already capture affective weighting implicitly through respondents’ trade-off judgements. Including a separate Mental State domain would double-count the affective component.

Table 3: AQALY-4PD-9L grade interpretation

Grade	Welfare level	Interpretation
1	High-level positive experiences	Reference state; no welfare decrement in this domain
2	Significant positive experiences	Very good conditions; minor sub-optimality only
3	Mild positive experiences	Good conditions
4	Minor positive experiences	Above-neutral; basic positive provisions present
5	Neutral	Neither positive nor negative welfare in this domain
6	Minor negative experiences	Below-neutral; some compromise of needs
7	Mild negative experiences	Clear welfare compromise; chronic mild suffering
8	Severe negative experiences	Significant suffering; multiple needs unmet
9	Very severe negative experiences	Worst state; extreme and sustained suffering

Note: Scale labels from Espinosa *et al.*;[249] measured coefficients from the same source.

Each subdomain is scored on a 1-9 severity scale, where 1 represents high-level positive experiences and 9 represents very severe negative experiences. Subdomain scores within each domain are averaged arithmetically to produce a domain-level grade.

Domain-level grades are converted to welfare coefficients through non-linear interpolation (Annex B) of coefficients taken from Table A2 of Espinosa *et al.*[250]

4.6.2 SUBDOMAIN SCORING PROTOCOL

Eighteen subdomains (Annex B1) that are most relevant for farrowing conditions are identified and scored for each system.[251] The scoring is calibrated from institutional evidence where available: published assessments by regulatory or professional bodies (BVA and PVS, 2025; EFSA, 2022) that assign explicit welfare judgements to farrowing crate conditions serve as anchor points for several subdomains. Grades are placed on the 1-9 scale, with grade 1 representing a fully met subdomain (best possible), grade 5 a moderate compromise, and grade 9 a severe compromise (condition essentially unmet), with intermediate grades informed by the behavioral and physiological evidence in Annex B1. Each system is scored independently against the species-typical standard; the free farrowing comparator is a well-managed Swedish-model pen, not a zero-compromise benchmark, so where both systems fall short of species-typical standards (for example, fibre content in commercial diets), both receive high severity scores.

Evidence tiers. Each subdomain score is classified by the strength of supporting evidence:

- **Tier 1 (primary literature):** score grounded in a published empirical study with direct species and condition relevance.
- **Tier 2 (institutional assessment):** score grounded in a formal welfare assessment by a regulatory or professional body (EFSA, BVA and PVS, national food authorities).

249 R. Espinosa, H. Browning, and N. Treich, "The Animal Quality-Adjusted Life Year (AQALY)," SSRN Working Paper No. 5255360 (2025), Table A2.

250 *Ibid.*

251 Marie Reinke of Expertise for Animals is a veterinarian with clinical and academic experience in pig welfare.

- **Tier 3 (clinical judgement):** score based on the clinical experience of the scoring veterinarian where published evidence is absent or indirect.

4.6.3 MONETIZATION FRAMEWORK

The welfare difference between systems (delta AQALY per year) is converted to a monetary value per sow-crate-day. The primary monetization follows Espinosa *et al*. in using the cortical-neuron ratio as a species moral-weight parameter.[252] Two alternative approaches provide sensitivity bounds.

- **Primary:** Neuron-proportional. The species moral-weight parameter (the pig moral weight) scales the value of one animal QALY relative to one human QALY. Following the derivation in the AQALY framework,[253] the cortical-neuron ratio gives a pig moral weight of 1/44 (approximately 0.023).[254]
- **Sensitivity 1:** Consumer willingness to pay. Consumer willingness to pay a premium for higher-welfare pork provides a market-derived valuation independent of the AQALY delta. Lagerkvist *et al*. estimate a willingness-to-pay premium of 72% to ban the permanent fixation of sows.[255] Applying this premium to a retail price of EUR 11.71 per kg and divided by 3 to correct for hypothetical bias, leads to an estimate of EUR 2.83 per kg of pork.[256]

The willingness-to-pay approach captures what consumers state they would pay, not a welfare-science-derived estimate; it serves as an independent cross-check on the neuron-proportional approach.

- **Sensitivity 2:** Hedonic-capacity-based. The Rethink Priorities estimate, which weights across multiple theories of moral status, produces a pig moral weight of 0.515.[257] The calculation parallels the neuron-proportional approach. This upper bound reflects a substantially higher interspecies moral weight.

4.7 Welfare Results

4.7.1 DOMAIN-LEVEL RESULTS AND AQALY COMPUTATION

Table 4 summarises the domain-level grades and the resulting AQALY values.

252 R. Espinosa, H. Browning, and N. Treich, "The Animal Quality-Adjusted Life Year (AQALY)," SSRN Working Paper No. 5255360 (2025).

253 *Ibid*.

254 S. Herculano-Houzel, "The Human Brain in Numbers: A Linearly Scaled-Up Primate Brain," Frontiers in Human Neuroscience 3 (2009): 31, https://doi.org/10.3389/neuro.09.031.2009.

255 C. J. Lagerkvist and S. Hess, "A Meta-Analysis of Consumer Willingness to Pay for Farm Animal Welfare," European Review of Agricultural Economics 38, no. 1 (2011): 55–78.

256 INSEE (Institut national de la statistique et des études économiques), Prix moyens mensuels de vente au détail en métropole: Porc, échine avec os (série 000442450), dataset (2025), https://www.insee.fr/fr/statistiques/serie/000442450; J. A. List and C. A. Gallet, "What Experimental Protocols Influence Disparities between Actual and Hypothetical Stated Values?" Environmental and Resource Economics 20, no. 3 (2001): 241–254.

257 Rethink Priorities, Moral Weight Project: Welfare Range Estimates (2023), https://rethinkpriorities.org/research-area/moral-weight/ (accessed 15 June 2026).

Table 4: Domain averages and AQALY values

Domain	Farrowing crate grade	Free farrowing grade
Nutrition	5.667	4.667
Environment	8.200	3.600
Health	7.500	3.500
Behavior	7.875	3.750
AQALY	**-0.6267**	**+0.4465**

Domain-average grades are converted to coefficients through non-linear interpolation of the coefficients in Table B1 (Annex B). The four domain coefficients sum to -1.6267 for the crate and -0.5535 for the free-farrowing pen. Adding the intercept (1.0) yields the AQALY values above.

The crate system produces a negative AQALY (-0.6267), indicating a welfare state below the zero-welfare baseline as assessed by discrete choice experiment respondents. The free-farrowing system produces a positive AQALY (+0.4465): welfare above zero but well below full welfare (1.0).

The welfare gain from replacing a farrowing crate with a free-farrowing pen is 1.07 AQALY per sow-year, or approximately 0.003 AQALY per sow-crate-day (1.07 divided by 365).

The domain-level welfare heatmap (Figure B1) illustrates these gaps visually, with Environment and Behavior showing the largest disparities between systems.

4.7.2 WELFARE VALUE PER SOW-CRATE-DAY

The primary monetization uses the neuron-proportional approach,[258] which anchors pig moral weight on the cortical-neuron ratio (1/44). Applied to the AQALY delta of 1.0733 per sow per year, this yields EUR 9.82 per sow-crate-day undiscounted, and EUR 5.82 per sow-crate-day discounted for the 2025-2060 EU ban scenario.

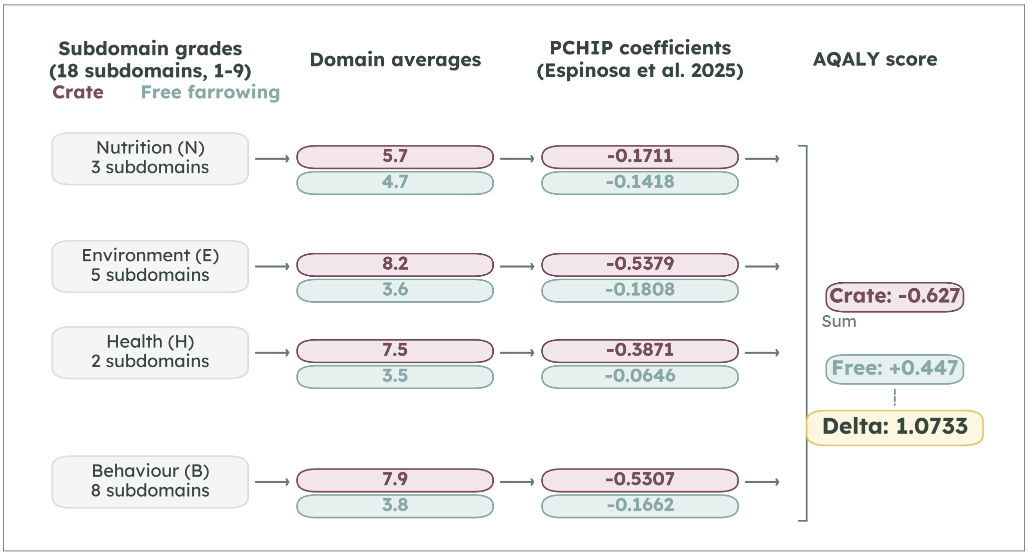
Two alternative approaches serve as sensitivity bounds. Consumer willingness-to-pay estimates from Lagerkvist *et al*.,[259] based on stated-preference surveys of pork consumers, give EUR 92.25 per sow-crate-day: an independent cross-check from the demand side, not from the welfare state of the animal. Hedonic-capacity-based monetization following Rethink Priorities gives EUR 222.61 per sow-crate-day, an upper bound reflecting the full hedonic range attributed to pigs.[260]

258 R. Espinosa, H. Browning, and N. Treich, "The Animal Quality-Adjusted Life Year (AQALY)," SSRN Working Paper No. 5255360 (2025).

259 C. J. Lagerkvist and S. Hess, "A Meta-Analysis of Consumer Willingness to Pay for Farm Animal Welfare," European Review of Agricultural Economics 38, no. 1 (2011): 55–78.

260 Rethink Priorities, Moral Weight Project: Welfare Range Estimates (2023), https://rethinkpriorities.org/research-area/moral-weight/ (accessed 15 June 2026).

Figure 7: AQALY computation chain from subdomain scores to monetized welfare



Notes: Four-stage flow: (1) subdomain grades averaged within each of four domains, (2) domain averages mapped to coefficients through non-linear interpolation, (3) domain coefficients added to the intercept of 1.0 to produce the AQALY index, (4) AQALY delta monetized via pig moral weight (1/44).

4.7.3 SENSITIVITY TESTING

As a sensitivity test for the scoring, each subdomain score is perturbed by plus or minus one grade, one subdomain at a time, while holding all others constant. This is done separately for the crate and free-farrowing systems, isolating the marginal contribution of each scoring judgement to the central AQALY delta (1.073 per sow per year).

Crate score perturbation has the larger effect (Figure B4, Panel A). The Health domain produces the largest shift (+0.12 AQALY per sow per year for a one-grade worsening), followed by Environment, Behavior, and Nutrition. These domains have subdomains at or near the ceiling of the severity scale (grades 7-9) in the crate system, where the PCHIP interpolation curve is steepest: a one-grade improvement at grade 8-9 produces a larger welfare change than the same improvement at grade 3-4.

Free farrowing score perturbation has a much smaller effect (Figure B4, Panel B): approximately one-fifth the magnitude of crate perturbation. This asymmetry arises because free-farrowing scores cluster in the 2-4 range, where the coefficient curve is flatter.

The impact of each subdomain on the delta also depends on how many subdomains are identified per domain: domains with more subdomains (Behavior has eight; Health has two) have more granular sensitivity because each subdomain contributes a smaller share to the domain average.

No single subdomain perturbation reverses the sign of the delta. For the positive welfare finding to reverse entirely (AQALY parity), the cumulative shift would need to reach -1.07; for the benefit-cost ratio to fall below 1 under neuron-proportional monetization, -1.05. The largest observed single-domain perturbation is 0.12, less than 12% of either threshold. The central estimate is robust to individual scoring errors in either system.

4.8. Discussion of Animal Welfare Results

4.8.1 REMAINING UNCERTAINTY

The interspecies moral weight is the single largest source of uncertainty in the monetized estimate. However, under the range of alternative values in the literature (Budolfson *et al.*: 0.05-0.30; Kuruc and McFadden: 0.10-0.40),[261] the benefit-cost ratio remains well above 1.

Other sources of uncertainty are relatively less important:

1. **Subdomain scoring judgement.** Individual scores reflect expert assessment grounded in published evidence, but alternative scorers applying the same evidence could assign different grades. The perturbation analysis (section 4.7.3) shows no single-subdomain shift reverses the sign of the delta.
2. **Interpolation method.** The choice between non-linear and linear interpolation affects the delta by approximately 2.8% (Annex B2). This is small relative to the moral-weight range.

261 M. B. Budolfson, R. Espinosa, B. Fischer, and N. Treich, "Monetizing Animal Welfare Impacts for Benefit-Cost Analysis," Journal of Benefit-Cost Analysis 15, no. S1 (2024): 206–223; K. Kuruc and J. McFadden, "Monetizing the Externalities of Animal Agriculture: Insights from an Inclusive Welfare Function," Social Choice and Welfare, 65(4).

3. **Domain weighting.** The AQALY framework treats subdomains as equal weight within each domain. Reweighting by discrete-choice-experiment-derived coefficient magnitudes increases the delta by approximately 5-8% (Annex B3), because the domains with the largest crate-free gaps also carry the largest maximum-grade coefficients.

The central neuron-proportional estimate (EUR 9.82 per sow-crate-day) incorporates estimation choices at multiple levels, each leaning toward understating the welfare benefit:

1. **Scope**: sow only; piglet welfare excluded.
2. **Moral weight:** the neuron-weight-based value of 1/44 is conservative (low) compared to the rest of the literature.
3. **Time window:** lactation only; gestation stall confinement excluded.
4. **Comparator**: commercial Swedish-model pen (approximately 6.5m²), which has less space than the 7.8m² used in the economic analysis and is not a minimal-confinement or outdoor system.

4.8.2 LIMITATIONS

Sow-only scope. Piglet welfare is excluded from the analysis, which likely understates the benefits: with sufficient space there is no additional crushing risk, but free farrowing may improve piglet socialization, vitality, and thermoregulation through better access to the sow.[262]

- **Static scoring.** Each subdomain receives a single score for the entire 28-day lactation period. In practice, welfare states vary within the period: thermal stress is most acute in the first 48 hours post-farrowing when metabolic heat output of the sow peaks; nest-building frustration is concentrated in the 12-24 hours pre-farrowing. A time-varying profile would add precision but requires intra-period behavioral data that are not available at subdomain resolution.
- **Single discrete choice experiment study.** The interpolated coefficients derive from one merged sample (N = 1,062) in Espinosa *et al.*[263] The authors provide separate country-level samples, but the merged coefficients are the recommended default. Future discrete choice experiment replications may shift coefficient magnitudes.

4.9 Combined Account

The economic and animal welfare modules account for changes relative to each sow-crate-day avoided by the ban. At the individual farm level, the net cost of avoiding one sow-crate-day is EUR 0.25. Over the full assessment period (2025–2060), the ban avoids a cumulative 7.63 billion sow-crate-days across the 22 non-legislating Member States. This yields an aggregate net present value (NPV) transition cost of EUR 1.11 billion, which equates to EUR 0.15 per sow-crate-day on an NPV-discounted basis.

The animal welfare module quantifies the welfare gain from eliminating crate confinement using the AQALY-4PD-9L framework. Transitioning a single sow from a crate to a free-farrowing system generates an

262 European Food Safety Authority, "Scientific opinion on the welfare of pigs on farm," EFSA Journal, 20(8), 2022.

263 R. Espinosa, H. Browning, and N. Treich, "The Animal Quality-Adjusted Life Year (AQALY)," SSRN Working Paper No. 5255360 (2025).

annualised welfare increase of 1.07 AQALY. Three monetization approaches are evaluated to convert this welfare delta into EUR per avoided sow-crate-day, with the neuron-proportional approach serving as the central estimate (Table 5).

Under the EU ban scenario, applying EUR 9.82 per sow-crate-day to the avoided crate-days and discounting the resulting flow amounts to a welfare benefit of EUR 44.4 billion (Table 5). Spread over the 7.63 billion sow-crate-days avoided across 2025–2060, this is EUR 5.82 per sow-crate-day.

The total undiscounted producer cost of avoiding 7.63 billion sow-crate-days is EUR 2.04 billion. When discounted at a 3% social discount rate, the producer cost is EUR 1.11 billion, or EUR 0.15 per sow-crate-day avoided. Against these costs, the monetized and discounted welfare benefit ranges from EUR 44.4 billion under the neuron-proportional approach to EUR 1,006 billion using the hedonic-capacity-based approach. Consequently, the net social balance remains positive across all three methodologies by one to three orders of magnitude.

Specifically, under the primary central estimates, each euro of producer cost generates EUR 40 of welfare improvement, yielding a benefit-cost ratio of 40:1 against the raw producer cost of EUR 0.25 per sow-crate-day.

While the welfare benefit exceeds producer costs by at least one order of magnitude across all three approaches—reflecting substantial uncertainty regarding interspecies moral weights—the demand-side willingness-to-pay estimate lies between the conservative neuron-based lower bound and the hedonic-capacity upper bound. The complete four-metric comparison (per sow-crate-day, per lactation, per sow per year, and benefit-cost ratio) is detailed in Annex B3 (Table B2, Figure B3).

4.10 Discussion of Combined Account

4.10.1 COMPARISON WITH PREVIOUS RESEARCH

Under the neuron-proportional approach (the primary estimate), each euro of producer cost buys EUR 40 of welfare improvement. This sits at the lower end of the non-anthropocentric welfare-economics literature: Bruers surveys five methodologies and finds optimal welfare levies on red meat ranging from roughly EUR 2 to EUR 800 per kg.[264] The robustness of the positive benefit-cost balance does not depend on resolving philosophical disagreement about species moral weight. It holds under the smallest published pig moral weight (1/44, cortical-neuron ratio) and would hold at values substantially below it.

264 S. Bruers, "Optimal Animal Welfare Levy: A Synthesis of Five Methodologies," working paper (2025).

Table 5: Full-cost account (discounted totals, 2025 to 2060)

Line	Neuron-proportional	Consumer WTP	Hedonic-capacity
Total welfare benefit (EUR bn)	44.4	417.1	1,006
Total producer cost (EUR bn)	1.11	1.11	1.11
Net social balance (EUR bn)	+43.3	+416.0	+1,005
Benefit-cost ratio	**40**	**376**	**908**

Lagerkvist and Hess confirm from the consumer side that willingness-to-pay premia for farm animal welfare are positive and statistically significant across methods and countries, consistent with a EUR 92.25 willingness-to-pay estimate.[265]

4.10.2 SCOPE AND DIRECTION OF ESTIMATION CHOICES

Both the economic and animal welfare modules make estimation choices that, where judgment was required, lean toward understating the benefit or overstating the cost of the ban. This section identifies the main directional choices in each module.

4.10.2.1 Scope of the Economic Module

The economic module counts only producer costs: the capital, operating, and adjustment expenses borne by pig farmers during the transition to free farrowing. It excludes several categories of cost and benefit that a full social accounting would capture.

Exclusion of consumer surplus effects. Free farrowing pork commands a higher price in markets where it is labeled and differentiated. A ban would create a level playing field across the EU, potentially lowering the welfare-related price gap as supply expands. The consumer surplus from wider availability of higher-welfare pork is not counted.

Exclusion of environmental co-benefits. Free-farrowing systems typically use more bedding material (straw), which alters manure composition and can improve soil carbon content when the manure is applied to cropland. These effects, while difficult to monetize, would appear on the benefit side of a full social account.

Exclusion of public-health effects. Reduced antibiotic use in less intensive housing systems and lower stress-related immunosuppression may reduce antimicrobial resistance risks. These effects sit outside the scope of the producer-cost module.

4.10.2.2 Welfare-Side Scope Restrictions

The animal welfare module is restricted in scope on four dimensions, each working in the direction of understating the welfare benefit.

1. **Sow-only scope.** The AQALY assessment covers the breeding sow during the 28-day lactation period, the phase when the sow would otherwise be confined in a farrowing crate. It does not count welfare gains for piglets, even though free-farrowing systems offer piglets more space, earlier socialization, and reduced tail-biting risk. Including piglet welfare would raise the benefit estimate.
2. **Lowest sentience weight.** The neuron-proportional approach, which produces the lowest benefit-cost ratio, sets the pig sentience weight at 1/44 of a human, based strictly on cortical neuron counts.[266] This is the lowest of the three estimates. The Rethink Priorities hedonic-capacity estimate (phi = 0.515) reflects a broader assessment of pig cognitive and affective capacities, including evidence of complex emotions, social cognition, and anticipatory behavior.[267] The neuron-count approach ignores these dimensions.

265 C. J. Lagerkvist and S. Hess, "A Meta-Analysis of Consumer Willingness to Pay for Farm Animal Welfare," European Review of Agricultural Economics 38, no. 1 (2011): 55–78.

266 S. Herculano-Houzel, "The Human Brain in Numbers: A Linearly Scaled-Up Primate Brain," Frontiers in Human Neuroscience 3 (2009): 31, https://doi.org/10.3389/neuro.09.031.2009.

267 Rethink Priorities, Moral Weight Project: Welfare Range Estimates (2023), https://rethinkpriorities.org/research-area/moral-weight/ (accessed 15 June 2026).

268 R. Espinosa, H. Browning, and N. Treich, "The Animal Quality-Adjusted Life Year (AQALY)," SSRN Working Paper No. 5255360 (2025).

3. **No gestation-period welfare.** Sows in conventional systems spend a significant part of their reproductive cycle in individual stalls during gestation. The welfare deficit of gestation-stall confinement is substantial but falls outside the scope of a farrowing-crate ban. A broader confinement ban covering both farrowing and gestation would yield a larger welfare delta.
4. **Twenty-eight-day lactation only.** The assessment counts welfare gains for the standard 28-day lactation period. In practice, many crate systems confine sows for longer (pre-farrowing entry plus post-weaning holding). The actual days of confinement avoided per cycle may exceed 28, but the assessment does not count the additional days.

Each of these scope restrictions works in the same direction: understating the welfare benefit. No corresponding scope restriction understates the producer cost.

4.10.3 REMAINING UNCERTAINTIES

Five sources of uncertainty sit outside the sensitivity architecture of either module and affect the combined account as a whole.

1. **Moral weight.** The 23-fold range in pig moral weight (section 4.6.3) propagates linearly into the benefit estimate. All three resulting benefit-cost ratios nonetheless exceed 1 by at least an order of magnitude, so the qualitative conclusion is robust even though the magnitude of net benefit varies substantially. The break-even moral weight, at which the welfare benefit exactly equals the producer cost, is 1/1,764 (0.057%), about one fortieth of the cortical-neuron proportion of 1/44.
2. **AQALY framework maturity.** The welfare delta rests on expert-elicited domain scores within the AQALY-4PD-9L framework.[268] The framework is recent and has not yet been replicated by independent expert panels. Future replications may shift domain scores, particularly in the Nutrition and Health domains where the crate-vs-free gap is smallest.
3. **Module independence.** The two modules share only the sow-crate-day denominator. No feedback loops are modeled: welfare improvements that might accelerate farmer adoption, or cost changes that might affect welfare investment, are excluded. This simplification is standard in regulatory impact assessment but means the combined account does not capture dynamic interactions between cost and benefit.
4. **Counterfactual adoption path.** The logistic S-curve governing voluntary adoption in the absence of an EU ban is the single parameter with the largest effect on aggregate cost. The 50% long-run floor assumption determines the magnitude of incremental sow-crate-days avoided by the ban. A lower floor (faster voluntary adoption) would reduce the incremental impact of the ban; a higher floor would increase it.
5. **Herd projection.** The sow population is assumed to decline at 1% per year throughout the assessment period. Structural shocks (disease

outbreaks, trade policy shifts, accelerated consolidation) could alter this trajectory. A faster decline would reduce both cost and benefit in absolute terms, though the benefit-cost ratio would remain broadly unchanged.

5. Policy Recommendations

Based on our animal welfare and economic assessment, we propose the following recommendations:

1 **Adopt an EU-wide legislative ban on the use of farrowing crates.**

Instead of the use of cages, free farrowing should be required as the minimum standard during birth and nursing. This measure responds to the "End the Cage Age" European Citizens' Initiative, is consistent with the European Commission's commitment (2021) to propose such a ban, and aligns with the scientific recommendations of EFSA on pig welfare, among other studies.

2 **Taking into account the aging equipment used in farms, adopt a cage ban in pig farming by 2028, while ensuring that the transition period is limited to the shortest possible timeframe and does not exceed 10 years.**

Imminent adoption reduces investment uncertainty for farmers who are currently operating aging infrastructure. Carpenter and Kanepajs (2026) report an average building age of 17.3 years and an average equipment age of 9.7 years, signalling that pig farms are older than expected, indicating low levels of investment and renewal during this period of policy uncertainty.

3 **Follow the scientific recommendations made by EFSA and mandate at least 6.6m² of space available to a sow in a free-farrowing system, equivalent to 7.8m² of total farrowing pen space.**

According to EFSA (2022), this pen size achieves the same piglet mortality as permanent crating. Legislative standards should explicitly specify a minimum usable area for the sow, as relying solely on total pen size risks limiting the effective space available to the sow and thereby compromising her welfare.

4 **Require free farrowing instead of temporary farrowing as a transitional standard.**

This responds to the scientific recommendations made by EFSA (2022) and is shown to be EUR 20 per sow per year more profitable than temporary confinement under our economic assessment of an EU-wide farrowing crate ban. This advantage stems from weaning-weight gains in free-farrowing systems that temporary confinement does not capture. Permitting temporary confinement as an EU-level minimum standard would channel investment toward a system that is both more costly economically and inferior on animal welfare grounds. The slow voluntary uptake of free farrowing in Non-legislators is not evidence against this ordering: status quo bias and risk aversion in farmer investment decisions produce a private-social wedge that keeps adoption slow.

5 Complement the EU-wide farrowing crate ban with targeted transition support for countries that have not yet adopted national bans or restrictions on farrowing crates.

With respect to farrowing crates, the 22 Member States that have not prohibited their use carry EUR 1.11 billion of the combined cost. Carpenter and Kanepajs (2026) find that a 35% capital-cost subsidy during the transition period would front-load investment into free-farrowing systems and materially accelerate the transition. An EU-level cost-share mechanism, calibrated to the free farrowing-vs-crate capital cost differential of EUR 59 per sow per year, would address the liquidity constraint most cited by farmers as a barrier to voluntary transition. Capital support alone, however, will not fully close the private-social wedge: transitional support should therefore also address the non-financial adoption frictions, including on-farm trialing for learning-by-doing under free farrowing, stockmanship training, and demonstration-farm networks to counter the status quo bias and peer-uncertainty effects documented in the farmer-adoption literature.

6. Conclusion

Sow stalls and farrowing crates are systems of restraint used for gilts and sows and are associated with severe animal welfare concerns. These include, but are not limited to, restricted freedom of movement, inadequate climatic conditions, injuries, the inability to separate the pen into functional areas, the prevention of nest-building and exploratory behaviors, and limited sow–piglet interaction. By confining female breeding pigs for a substantial proportion of their lives, these systems give rise to significant animal welfare and ethical concerns.

Although pigs are protected under EU law through Council Directive 2008/120/EC, the legislation fails to address one of the most significant welfare issues in pig production. While it has reduced the period during which gilts and sows may be confined in sow stalls during pregnancy, the routine use of farrowing crates remains lawful. However, some progress has been made at the national level. Five Member States have introduced prohibitions or restrictions on the routine use of farrowing crates, with most currently undergoing a transition toward alternative farrowing systems.

This paper sets out policy recommendations for the adoption of an EU-wide ban on farrowing crates. These recommendations are supported by an assessment of animal welfare outcomes in free-farrowing systems compared with conventional farrowing crates, as well as by an economic analysis of the cost of the transition. Together, these analyses lead to the following key findings:

1. **Economic evidence suggests that the transition away from farrowing crates can be viable, as the piglet-related benefits of free farrowing may offset much of the increase in production costs.**
   Our central estimate indicates that a transition to free farrowing would add just under 1 cent to the cost of producing 1 kg of pig meat (EUR 0.008), amounting to a total net policy cost of EUR 1.11 billion. The increase stems mainly from higher capital costs for sow housing and increased labor inputs, though these are partially offset by faster piglet growth.
2. **The net social balance is positive under every monetization approach.**
   Welfare benefits exceed producer costs by a factor of 40 (neuron-proportional), 376 (consumer willingness to pay), or 908 (hedonic-capacity-based). Even the lowest valuation places the benefit-cost ratio well above the threshold of 1.

3. **The positive welfare benefits of a farrowing crate ban remain substantial even with large parameter shifts.**
   The producer cost of EUR 0.25 per sow-crate-day would need to rise by a factor of 40 before the neuron-proportional benefit-cost ratio reached breakeven. Equivalently, estimated sow welfare gains would have to be 98% lower before the net social balance turned negative under the lowest monetization approach. Neither scenario is plausible given the evidence base.

4. **Transition costs are small relative to welfare gains.**
   The aggregate NPV of producer transition cost is EUR 1.11 billion. This is a real cost borne by a specific set of economic actors (pig farmers in 22 Member States), and the policy design should address distributional effects through transition support, phased timelines, and market mechanisms. The welfare analysis does not diminish the adjustment burden on individual farms. It does, however, establish that the social return on that adjustment is large: between EUR 40 and EUR 908 of welfare benefit for every EUR 1 of producer cost.

The combined account confirms that a ban on farrowing crates passes the benefit-cost test by a wide margin under all three valuation approaches. The directional choices embedded in both modules mean the true net social benefit is likely larger than the estimates reported here.

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Annex A: Economic Methodology

A1. Key Variables and Sources

Table A1 summarises the key input variables, parameter values, and data sources used in this assessment. Cost parameters are drawn from AKI *et al*. (2023) and adjusted to 2025 EUR using the Eurostat HICP multiplier (2025c). The EU sow population total and the country-level sow populations (Sweden, Austria, Germany, Denmark, Finland) are taken from Eurostat (2025d), with the Non-legislators' total calculated by subtracting Front-runner sow populations from the EU total. Counterfactual and EU ban scenario parameters are calibrated to the sources indicated; see section 4.2 for the counterfactual construction and section 4.3 for the cost framework.

Table A1: Key input variables

Variable	Value	Source
Discount rate (main scenario)	3%	EC Better Regulation Toolbox (2025)
Discount rate (sensitivity)	2%, 5%	EC Better Regulation Toolbox (2025)
HICP multiplier 2021 to 2025	1.22	Eurostat HICP annual data
Cost per sow, crates (2021 EUR)	353.0	AKI *et al*. (2023), Table 46
Cost per sow, free farrowing (2021 EUR)	504.5	AKI *et al*. (2023), Table 46
Cost per sow, temporary crating (2021 EUR)	447.8	AKI *et al*. (2023), Table 46
AKI cost difference (2021 EUR)	151.5	= 504.5 - 353.0
AKI cost difference (2025 EUR)	184.8	= 151.5 x 1.22
Free farrowing cost increase vs crate (2025 EUR)	20	Cost-line build-up (section 4.3)
Temporary crating cost increase vs crate (2025 EUR)	40	Cost-line build-up (section 4.3)
Free farrowing minus temp. crating (2025 EUR)	−20	Section 4.3
Temp. crating vs free farrowing (2025 EUR)	69.1	= (504.5 - 447.8) x 1.22
EU sow population	10,272,770	Eurostat, 2025d
Remaining MS sow population	7,282,010	EU total minus Front-runners (Eurostat, 2025d)
National ban country sow population	2,884,420	AT + DE + DK + FI sum (Eurostat, 2025d)
Initial crate share (Non-legislators)	97.8%	Sow-weighted, 22 Non-legislators (AKI *et al*., 2023, T33)

Variable	Value	Source
Confinement length per litter	35 days (5 weeks)	AHDB (2019) pre-farrowing + AHDB (2024) lactation
Litters per sow per year	2.3	AHDB (2023)
Proportion of year in crate	22.0%	= (35 days x 2.3 litters) / 365 days
EU avg production cost (2025 EUR)	EUR 2.27/kg	Eurostat (2025e) x HICP 1.22
CF functional form	3-param logistic S-curve	Griliches (1957); Geroski (2000)
CF floor, main scenario (1-K)	50%	Own assumption (see section 4.2)
CF floor, fast (1-K_fast)	11.7%	AKI *et al*. (2023), Table 42, B2/C2 sow-weighted
CF status quo	Flat at 97.8%	AKI *et al*. (2023), Table 42, B1/C1 sow-weighted
Logistic steepness r	0.356	AKI *et al*. (2023), Table 42, B2/C2 calibration
Logistic midpoint t_m, main scenario	2033.6	Derived from CF (2025) = 0.978 constraint
Legislation year, EU ban	2028	Policy scenario
Ban year, EU ban main scenario	2038	Policy scenario

A2. Construction of the Counterfactual

The counterfactual distinguishes three country groups. Sweden is treated as fully transitioned (0% crates). For Austria, Germany, Denmark, and Finland, the counterfactual combines two mechanisms multiplicatively: a logistic S-curve representing voluntary transition (fitted to AKI *et al*. (2023) Table 42 sow-weighted data for these four countries, with $K = 1.0$, $r = 0.458$, $t_m = 2031.9$), and a national-ban overlay from the Carpenter and Kanepajs (2026) vintage model ensuring that crate use reaches zero at the national ban date of each country. For the remaining 70.9% of EU sows in countries without national bans, the counterfactual crate share follows a logistic S-curve: $CF(t) = 1 - K / (1 + \exp(-r (t - t_m)))$. The main scenario uses $K = 0.50$ (floor = 50%), $r = 0.356$, and $t_m = 2033.6$, derived from the constraint $CF(2025) = 0.978$. Two sensitivity scenarios are tested: fast voluntary ($K = 0.883$, floor = 11.7%, calibrated to AKI *et al*. (2023) Table 42 columns B2/C2) and status quo (flat at 97.8%, corresponding to AKI *et al*. (2023) Table 42 columns B1/C1).

EU-wide trajectories are computed as sow-weighted averages of the three country groups: Sweden (1.0%), the national-ban Front-runners other than Sweden (28.1%), and Non-legislators (70.9%). Shares are computed against the Eurostat (2025d) Nov–Dec 2025 EU total of 10,272,770 sows; the Non-legislators count (7,282,010) is the residual after subtracting the five Front-runners. All scenarios incorporate a 1% annual decline in the EU breeding-sow herd, extrapolating the Eurostat (2025d) 2015–2025 trend.

A3. Sourcing Principles

This annex collects the detailed rationale for the sourcing conventions introduced in section 4.2.3 (within-country within-study; conventional commercial practice; individual-pen scope) and for the capital-regression panel exclusions in section 4.3.2.

A3.1 WHY THIS ASSESSMENT DOES NOT USE CROSS-BORDER COST COMPARISONS

First, exchange-rate movements distort EUR-denominated cross-border cost comparisons over any multi-year window. InterPIG housing-and-finance costs in Sweden illustrate the problem: over 2020–2024, SEK-denominated housing-and-finance costs were essentially flat, but EUR-denominated figures fell roughly in proportion to the 9% SEK depreciation against the EUR (from approximately 10.49 to 11.61 SEK/EUR). Any cross-border EUR comparison over this window would read as a genuine Swedish cost advantage, when in fact much of the difference is due to exchange rate effects.

Second, construction and building-cost inflation varies markedly across the EU. Eurostat (2025a) construction-cost indices show between +11% and +80% cost inflation across Member States over 2021–2024, with significant dispersion driven by local material-price dynamics, labor availability and energy costs. Capital costs expressed in current EUR are therefore not comparable across countries without deflation by country-specific construction-cost indices, which few sources publish alongside their farrowing-system data.

Third, interest-rate and discount-rate effects on building-cost annualization differ by country. Housing and finance costs in InterPIG are sensitive to changes in central-bank monetary policy, amplifying cross-border divergence unrelated to the farrowing system.

Fourth, herd-health status, genetics and production intensity vary systematically across countries. The farrowing system in Sweden is 100% free farrowing, but Swedish pig production overall is also characterised by lower disease pressure, smaller average herd size and different genetics compared with Denmark, the Netherlands or Germany. Attributing observed cost or performance differences to the farrowing system alone is mis-specified in the presence of these confounders.

A3.2 COMMERCIAL/COMMON AND INDIVIDUAL-PEN SCOPE

Cost central estimates reflect conventional commercial practice (section 4.2.3.2 sourcing principle) within an individual-pen free-farrowing scope: single sow + litter per pen, excluding group / multi-suckling and outdoor / kennel architectures. Where a within-study source reports multiple pen designs, the central uses an arithmetic mean across designs (or commercial-prevalence weight) rather than the most favorable design alone. Operationally the section 4.3.2 labor line is built as a three-study cross-source mean (Baxter *et al*., 2012; Heidinger *et al*., 2018; Quendler *et al*., 2009), giving +1.479 hours per sow per year × EUR 15/hour = +EUR 22 per sow per year for free farrowing. Within the Pen category in Baxter *et al*. (2012), the Sloped/Hill-side (n = 5 prototypes from the 1980s/1990s, retrofitting crate infrastructure) and Mushroom (n = 1, BPEX 2004, not commercially deployed) designs are excluded. Group and multi-suckling systems are a distinct architectural category (Einarsson *et al*. 2014; AHDB 2020) and out of scope.

A3.3 CAPITAL-REGRESSION PANEL EXCLUSIONS

The capital regression panel covers six within-study primary sources (Guy 2012, AHDB 2019 swing-side, AHDB 2020a per-place, KWIN via AKI, Heidinger Pro-SAU via Baxter 2022, Baxter 2012 baseline-only), giving a working panel of N = 14 observations across G = 6 study clusters after excluding systems that would distort the slope: Guy 360° Farrower (same pen area as the crate baseline, contributing no slope information); Baxter Turnaround (the £/place figures in Baxter exclude the building shell, creating upward bias at larger pen areas; the conventional-crate baseline is kept as a zero-cost reference point); Baxter Hinged, Simple, Designed, Sloped, Mushroom (single-consultant averages across heterogeneous designs, sharing the shell-exclusion problem); and Malak-Rawlikowska (2024), a peer-reviewed restatement of AKI *et al*. (2023) data already in the panel. Under the preferred methodology the AKI *et al*. (2023) rows are also dropped as the only observations reporting capital with depreciation of existing buildings included (see Annex A, section A9 for the rationale). The resulting slope is +14.68 percentage points per m² (cluster-robust 95% confidence interval [–2.5, +32.1] pp/m²).

Table A2: Systems In and Excluded from the Capital-Regression Panel

Study	System	m²	% over crate	In regression?
Guy *et al*. (2012)	Conventional crate (baseline)	4.3	0	Yes
Guy *et al*. (2012)	360° Farrower	4.3	+15.8	No (Δm² = 0, no slope leverage)
Guy *et al*. (2012)	Danish	6.0	+20.0	Yes
Guy *et al*. (2012)	PigSAFE	8.9	+38.4	Yes
AKI *et al*. (2023) Fig 27	Conventional crate	4.2	0	Yes
AKI *et al*. (2023) Fig 27	S1 temporary crating	5.5	+61.0	Yes
AKI *et al*. (2023) Fig 27	S2 no-confinement	7.0	+96.6	Yes
Baxter *et al*. (2012)	Conventional crate	4.84	0	Yes
Baxter *et al*. (2012)	Turnaround crate	6.55	+58.0	No (shell-exclusion mismatch)
Baxter *et al*. (2012)	Hinged/Swing-side	7.23	+7.2	No (modified-crate category)
KWIN (via AKI 2023)	Conventional crate 4m²	4.0	0	Yes
KWIN (via AKI 2023)	Temporary crating 6.5m²	6.5	+18.8	Yes
KWIN (via AKI 2023)	Free farrowing 7m²	7.0	+24.0	Yes
KWIN (via AKI 2023)	Free farrowing 7.5m²	7.5	+29.2	Yes
Heidinger Pro-SAU via Baxter 2022	Conventional crate 4m²	4.0	0	Yes
Heidinger Pro-SAU via Baxter 2022	Temporary crating 5.5m²	5.5	+28.3	Yes

A3.4 PIGLET ECONOMIC EFFECTS

Pool A, Pool B and Pool C central estimates from sample-size-linear pooling (the Annex A, section A5 default; Pool C with 2-of-3 LOSO (Leave One Subject Out) sensitivity over the three within-study experimental panels Main 2004, Krahn (2024b) and Krahn (2024a)) together with temporary-crating scaling and computations for cost per sow per year, are in Annex A, section A5. The net piglet-effects line in the stack is approximately EUR 67 per sow per year of revenue for free farrowing (pre-weaning mortality zero at 7.8m² under EFSA 2022; grow-finish and post-weaning mortality benefits intact) and +EUR 6 per sow per year of cost for temporary crating (no growth benefit; section 4.3.6).

A3.5 LABOR POOL

The additional labor cost is EUR 22 per sow per year for free farrowing and EUR 10 per sow per year for temporary crating. The free-farrowing figure is derived from a three-study commercial pool: Baxter (2012) Pen-category Simple + Designed within-study mean (+3.005 h/sow/yr), Heidinger *et al*. (2018) Pro-SAU LK-Buchten pen-averaged (+0.68 h/sow/yr), and Quendler (2009) free-farrowing-vs-crate within-study mean (+0.752 h/sow/yr); the cross-study arithmetic mean is +1.479 hours per sow per year × EUR 15/hour. Temporary-crating labor cost depends on Heidinger *et al*. (no significant confinement-duration effect on labor was found). The plausible range is EUR 0–35 for free farrowing and EUR 0–20 for temporary crating, where the AHDB (2019) DST null anchors the lower bound and a Simple-pen-dominated commercial mix the upper.

Table A3: Labor-hour premium by source (free farrowing vs conventional crate)

Study	Country	Pen designs	Crate baseline (h/sow/yr)	Free-farrowing arm (h/sow/yr)	Δh	Source
Baxter *et al*. (2012)	UK	Simple + Designed	6.96	Simple 12.76; Designed 7.17; mean 9.97	+3.005	Table 5, Animal 6(1)
Heidinger *et al*. (2018)	AT	LK-Buchten 5.5m² (3 designs)	implicit 4m² ref	LK-Buchten avg 0.68 (derived)	+0.68	ALVA 2018, pp. 17-23
Quendler *et al*. (2009)	AT	Free-farrowing systems 1-3	Crate systems 1-5, mean 4.37	Free 1: 5.99; Free 2: 4.66; Free 3: 4.71; mean 5.12	+0.752	8-system Austrian study
Cross-study mean	—	—	—	—	+1.479	(3.005 + 0.68 + 0.752) / 3
Lower bound: AHDB (2019) DST	UK	CCPSHF vs PSNHF	£77.17/sow/yr (both)	identical	0	UK institutional model

Notes: Own calculations on three within-study within-country primary sources, weighted by an equal across-study mean per the section 4.2.3.2 commercial/common rule. Wage reference EUR 15/hour (rounded; Eurostat (2025b); EU-27 agricultural factor income gives roughly EUR 11.8/hour volume / EUR 14.6/hour nominal). Heidinger *et al*. (2018) report labor cost in EUR per sow per year; the 0.68 hours per sow per year figure is derived from EUR 10 / EUR 14.70 = 0.68. Baxter *et al*. (2022) cites pen-averaged Heidinger *et al*. figures of +1.25–1.33 hours per sow per year; our pool uses the figure from Heidinger *et al*.

A3.6 FULL COST STACK

Table A4 below presents the full six-state cost stack for all farrowing systems against the conventional crate baseline.

Table A4: Cost stack vs conventional crate (2025 EUR per sow per year)

Cost line	Crates (4.2m²)	Temporary crating (5.5m²)	Free farrowing (7.8m²)	Source basis
Capital + depreciation + maintenance	112	+21.4	+59.2	Regression β = 14.68 pp/m²; baseline EUR 112 (section 4.3.2)
Labor	0	+10.0	+22.0	Baxter/Heidinger/Quendler pool (section 4.3.3)
Veterinary	0	0	0	AHDB 2019 DST; Quendler 2009 (section 4.3.4)
Feed (sow lactation)	0	0	0	AHDB 2019; Cheon 2022; Dumniem 2023 (section 4.3.5)
Other variable (bedding, maintenance)	0	+2.5	+5.5	AHDB 2019 DST composite, energy excluded (section 4.3.6)
Pre-weaning piglet mortality	0	+5.8	0	EFSA (2022) (section 4.3.7)
Faster grow-finish	0	0	−60.0	Radtke 4-arm × d/kg pool (section 4.3.7)
Post-weaning mortality (Collins 2017)	0	0	−7.0	Collins (2017) × Δ weaning weight (section 4.3.7)

Cost line	Crates (4.2m²)	Temporary crating (5.5m²)	Free farrowing (7.8m²)	Source basis
Premium over crate	0	+39.7	+19.7	
Free-farrowing-vs-temp.-crating diff.			−19.9	Free farrowing cheaper by EUR 20/ sow/yr (central)
Free-farrowing-vs-crate (non-legislator)			+20	Non-legislators: crate to free farrowing directly

Notes: Own calculations. See section 4.3.7 and Annex A, section A5 for evidence-pool tables; section 4.5.1 Discussion and Annex A, section A9 for comparison against the EUR 184.8 free-farrowing-vs-crate engineering estimate in AKI *et al*. (2023). Retrofit conversion costs (approximately EUR 3.82 per sow per year, Table A11) cancel in the counterfactual-vs-EU-ban delta at steady state and are therefore excluded from this stack.
The cost stack assumes new-build pen construction. For retrofit conversions of existing crate housing, capital costs are approximately 10% lower (AKI *et al*., 2023).

Central estimate. The central estimate for free-farrowing-vs-crate cost increase is EUR 20 per sow per year (2025 EUR), about 88% lower than the EUR 184.8 engineering estimate in AKI *et al*. (2023). Free farrowing is EUR 20 per sow per year cheaper than temporary crating, because temporary crating carries the capital and labor overheads of mandatory structural change, retains elevated pre-weaning mortality (EUR 6 per sow per year at 5.5m²), while forfeiting the whole faster-growth benefit of free farrowing (see section 4.3.7). This reverses the policy reading of the Front-runner contribution from a cost (under the AKI *et al*. (2023) framing, where free farrowing is more expensive than temporary crating) into a net benefit (under our build-up, where free farrowing is cheaper).

A4. EU Ban Scenario Modeling and Capital Cost Regression

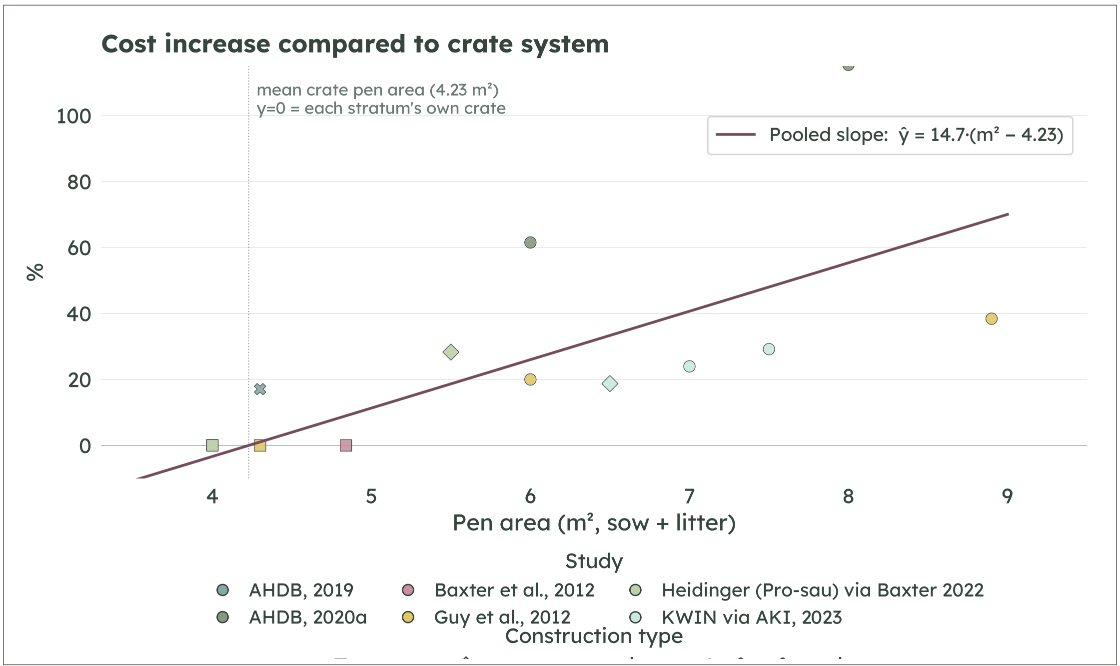
A4.1 VINTAGE-BASED EU BAN SCENARIO MODEL

The EU ban scenario for Non-legislators is computed using the Carpenter and Kanepajs (2026) vintage-based investment-decision model, which tracks four sow-housing states (crates, retrofitted crates, new free farrowing, retrofitted free farrowing) with starting shares calibrated to Eurostat (2025d) data. At the legislation year (2028) transition spikes occur; at the ban year (2038, main scenario) conversion becomes mandatory. The crate share at each year equals the sum of the crate and retrofitted-crate stocks.

A4.2 CAPITAL COST REGRESSION

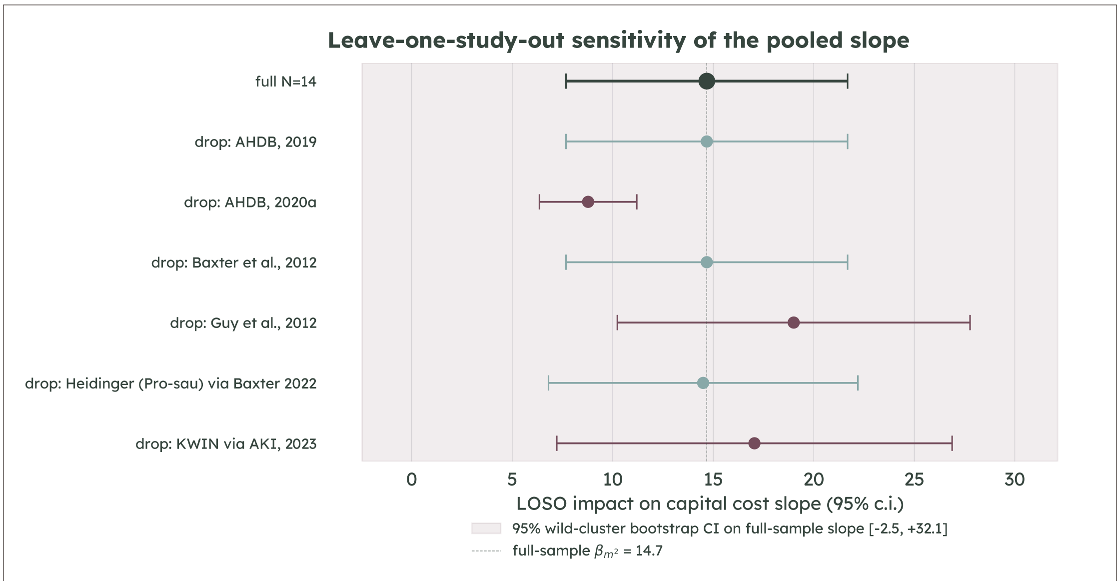
The panel regression (Annex A, section A3.3) gives a slope of +14.68 percentage points per m² (cluster-robust 95% confidence interval [−2.5, +32.1] pp/m²). Anchored on the equal-weight four-source crate baseline of EUR 112 per sow per year (KWIN-via-AKI EUR 98, AHDB 2019 EUR 108, AKI *et al*. (2023) EUR 144, Moustsen/Seddon EUR 98), the predicted free-farrowing capital cost increase at 7.8m² is EUR 59 per sow per year; for temporary crating at 5.5m², EUR 21 per sow per year. The confidence interval includes zero, reflecting the penalty for having only six study clusters rather than evidence of a negative slope: if taken at face value, a zero slope would imply that free farrowing carries the same capital cost per sow as the crate, strengthening the economic case for transition (see Annex A, section A10).

Figure A1: Capital premium vs pen area



Notes: Own regression on N=14 within-study observations across 6 strata (Guy 2012, Baxter 2012 baseline-only, AHDB 2020a per-place, AHDB 2019 swing-side, KWIN-via-AKI 2021–2022, Heidinger Pro-SAU 2018). Uncertainty on the slope is characterised through LOSO sensitivity (Figure A2) rather than a regression confidence band (see Annex A, section A10).

Figure A2: Leave-one-study-out sensitivity of the pooled slope



Notes: LOSO sensitivity, dropping each study in turn; pooled slope sign positive in every replicate.

The regression slope is robust under Frisch-Waugh-Lovell partial-regression, residuals-vs-fitted, Q-Q, and leverage/influence diagnostics.

A4.3 CRATE BASELINE COST DERIVATION AND LOSO SENSITIVITY

The capital regression in section 4.3.2 and Annex A, section A4.2 bases the predicted free farrowing and temporary-crating costs on an equal-weight four-source crate baseline of EUR 112 per sow per year (2025 EUR), derived from four independent published sources:

Table A5: Capital costs of farrowing crates

Source	EUR/sow/yr	Derivation
KWIN-via-AKI 2023	98	EUR 4,644/pen (NL 2021-22), annualised 5% CRF, 4.5 sows/place/yr
AHDB 2019 DST	108	Depreciation + maintenance = GBP 77.02, HICP x FX to 2025 EUR
AKI *et al*. 2023 Fig 27	144	EU-27 survey (225 farms); HICP from EUR 118 (2021)
Moustsen 2023 / Seddon 2013	98	GBP 3,246/place (DK, Hansen 2022), annualised 5% CRF; FX+HICP
Equal-weight central	112	Arithmetic mean of four sources

The pooled regression slope is beta_m2 = +14.68 percentage points per m², so the predicted free-farrowing cost at 7.8m² is 53 pp x EUR 112 = EUR 59 per sow per year and the predicted temporary-crating cost at 5.5m² is 19 pp x EUR 112 = EUR 21 per sow per year.

Table A6: LOSO sensitivity for capital cost regression

LOSO drop	Three retained	Crate baseline (EUR/sow/yr)	FF capital line at 7.8m²	NPV implied (EUR bn)
Drop AKI	KWIN + AHDB + Moustsen	101	+53	~0.68
Drop AHDB	KWIN + AKI + Moustsen	113	+60	~0.98
Drop KWIN	AHDB + AKI + Moustsen	116	+61	~1.07
Drop Moustsen	KWIN + AHDB + AKI	117	+62	~1.07
(Equal-weight central)	All four	112	+59	~1.11

LOSO range: EUR 101 – 117 around the baseline EUR 112 (about +/-10% one-sided). NPV range under LOSO: EUR 0.68 – 1.07 bn around the baseline EUR 1.11 bn.

A5. Piglet Economic Effects

This annex gives the full derivation of the piglet economic effects line (section 4.3.7, Table 1 rows 6-9), including sample-size-weighted pool central estimates and the sensitivity range. Pools A-D use sample-size-linear weighting across within-study primary sources; between-study heterogeneity is surfaced via leave-one-study-out (LOSO) ranges.

A5.1 PIGLET EVIDENCE POOLS

Four within-study primary-evidence pools underpin the piglet-effect calculations in section 4.3.7. Pool A (pre-weaning mortality) enters the model as a sensitivity input only: the central estimate adopts the EFSA (2022) expert-elicitation finding of zero excess pre-weaning mortality at the 7.8m² pen specification (Annex A, section A5.2). Pools B and C set the baseline weaning-weight and grow-finish parameters. Pool D provides the temporary-crating pre-weaning mortality (Annex A, section A5.3):

- **Pool A:** pre-weaning mortality delta, free farrowing vs crate: sample-size-linear mean → +3.70 pp (Hales 2015a approximately 68% weight; k = 6 inclusive pool, N = 3,146). The 4-study experimental sub-panel (Hales, Radtke, AKI, Kinane only; excluding Weber and Canario) gives +3.89 pp. 1-of-4 LOSO sensitivity range on the experimental sub-panel: [+3.70, +4.03] pp (drop-Radtke gives the lower bound, drop-AKI the upper). The sample-size-linear mean rests on the Danish hyperprolific (Hales) and UK commercial (Radtke) experimental cores.
- **Pool B:** weaning-weight gain, free farrowing vs confinement (kg): Radtke 2026 L-vs-C+4

(73%), Nevrkla 2024 Free-vs-Combined (18%), Pedersen 2011b pen-vs-crate (9%) → sample-size-weighted +0.349kg (n_total = 456). Bridged to free-farrowing-vs-permanent-crate via the Goumon 2022 temporary-crating-vs-permanent-crate literature null (13/19 null at min-n filter, plus four well-powered post-Goumon nulls). Sensitivity range: lower bound +0.15kg (Nevrkla 2024 Free-vs-Combined alone, n=80); upper bound +0.80kg (Pedersen 2011b alone, n=42; parturition-only temporary crating treated as near-free-farrowing). Per-study evidence tables below.

- **Pool C:** days per kg of weaning weight (post-weaning grow-finish): three within-study experimental panels (Main 2004, Krahn (2024b), Krahn (2024a). Sample-size-linear → 4.91 d/kg (Main 67% weight, Krahn (2024b) 18%, Krahn (2024a) 15%; N = 7,168). 2-of-3 LOSO range 4.73–5.00 d/kg. Out-of-sample corroboration: Douglas *et al*. (2013) retrospective two-database analysis at 4.7 d/kg below the WW = 7.52kg breakpoint, n = 5,217 pigs in the dataset-2 subset with both weaning and final weight (Table 1), consistent with the experimental-panel mean but not pooled with it on design-exchangeability grounds (see Pool C evidence table below). Krahn 2024b covers grow-finish from day 57 post-weaning to market weight (131.5kg), finding 2.25 fewer days to market per 0.45kg of weaning-weight advantage (roughly 5.0 d/kg, consistent with the pool central). The companion nursery paper (Krahn 2024a, n = 1,054) shows nursery duration is fixed at 42 days regardless of weaning weight, so grow-finish days are the only post-weaning day-saving channel.
- **Pool D:** temporary-crating mortality scaling (share of the crate mortality benefit captured by 4-5 days of post-farrowing confinement): Radtke *et al*. (2026) 4-arm RCT (UK, n = 666 sows, 33-37%) and AKI *et al*. (2023) expert survey (EU-27, 225 farms, 73%). Temporary-crating pre-weaning mortality is taken from EFSA (2022) expert elicitation: 15.6% at a day-4 crate opening against a 14.2% permanent-crate baseline, an excess of 1.4 pp (Annex A, section A5.4). Full per-study evidence in Annex A, section A5.3.

Per-study evidence tables

Table A7: Pool A - pre-weaning mortality delta, free farrowing vs crate (pp)

Study	Country	n	Δ pp	Design
Hales *et al*. 2015a	DK	2,139	+3.9	RCT-like; 26.0% vs 22.1% (P<0.001)
Radtke *et al*. 2026	UK	666	+4.6	4-arm RCT; L 16.4% vs C+4 11.8%
AKI *et al*. 2023	EU-27	225 farms	+2.2	Expert survey; 12.9% vs 10.7%
Kinane *et al*. 2021	IE	46 litters	+1.53	RCT; 15.95% vs 14.42% (n.s.)

Excluded: Weber (2007, observational) and Canario *et al*. (2022, France organic n = 30, opposite-direction outlier). Inclusive 6-study mean: +3.70 pp; 4-study experimental sub-panel: +3.89 pp.

Table A8: Pool B - weaning-weight gain, free farrowing vs confinement (kg)

Study	Country	n	Δww (kg)	Contrast
Radtke 2026 (L vs C+4)	UK	334	+0.34	Free farrowing vs temp. crating (d0-d4)
Nevrkla 2024 (Free vs Combined)	CZ	80	+0.15	Free farrowing vs combined temp. crating
Pedersen 2011b (pen vs crate)	DK	42	+0.80	Sow loose throughout lactation

Central: +0.349kg (Radtke 73%, Nevrkla 18%, Pedersen 9%; n = 456). 2-of-3 LOSO: [+0.30, +0.39] kg. Single-study extremes: Nevrkla alone +0.15kg (lower); Pedersen alone +0.80kg (upper, sign flip).

Table A9: Pool C - finishing days saved per kg weaning weight (d/kg)

Study	Country	n	d/kg
Main *et al*. 2004	US	4,838	~5.0
Krahn *et al*. 2024b	US	1,276	5.0
Krahn *et al*. (2024a)	US	1,054	~4.4

Central: 4.91 d/kg (Main 67%, Krahn (2024b) 18%, Krahn (2024a) 15%; n = 7,168). 2-of-3 LOSO: [+4.73, +5.00] d/kg. Out-of-sample: Douglas *et al*. (2013) at 4.7 d/kg (n = 5,217).

Table A10: Pool D - temporary-crating mortality scaling

Study	Country	n	Scaling (%)	Note
Radtke 2026	UK	666 sows	33–37%	Direct 4-arm RCT
AKI *et al*. 2023	EU-27	225 farms	73%	Expert survey

Temporary-crating pre-weaning mortality is taken directly from EFSA (2022) expert elicitation: 15.6% at a day-4 crate opening against a 14.2% permanent-crate baseline, an excess of 1.4 pp (Annex A, section A5.4).

A5.2 COST PER SOW PER YEAR COMPUTATION (FREE FARROWING, BASELINE ESTIMATE)

Constants: 27.17 piglets weaned per sow per year (2022 EU average; AHDB, 2023); HICP 2021→2025 = 1.22; piglet weaner valuation EUR 12.43 (2021 EUR); post-weaning finisher valuation EUR 45 (2021 EUR); daily finishing cost EUR 1.29/pig/day (2025 EUR, Eurostat, 2025e; AHDB, 2023); AHDB (2024) EU post-weaning mortality baseline 3.5% (cap).

- **Pre-weaning mortality cost:** EUR 0 per sow per year (2025 EUR). At the 7.8m² pen area, EFSA (2022) expert knowledge elicitation finds that pre-weaning mortality in free-farrowing systems equals crate mortality. The Pool A within-study mean of +3.70 pp is retained as an upper-bound sensitivity representing outcomes at smaller pen designs.
- **Faster grow-finish benefit:** –0.349kg × 4.91 d/kg × EUR 1.29/day × 27.17 = –EUR 60.0 per sow per year (2025 EUR).
- **Post-weaning mortality reduction (Collins *et al*., 2017):** –0.349 × 0.0134 (pp/kg) × 27.17 × EUR 45 × 1.22, capped at 3.5% baseline (cap factor = 1.00) = –EUR 6.98 per sow per year (2025 EUR).
- **Post-weaning system delta (independent of Δww):** 0 (no within-study primary evidence).

Net piglet effects, free farrowing: EUR 0 – 60.0 – 6.98 = approximately –EUR 67 per sow per year (2025 EUR).

A5.3 SCALING FOR TEMPORARY CRATING

Temporary crating (5.5m², 4–5 days post-farrowing confinement) cannot be scaled pro-rata on confinement days because the piglet effects are non-linear. The pre-weaning mortality line is read directly from EFSA (2022) expert elicitation (see below); the weaning-weight line is scaled to zero. Weaning-weight scaling (0%): the Radtke *et al*. (2026) C+4 and L+4 arms show indistinguishable weaning weight, corroborated by the Goumon *et al*. (2022) 19-comparison review (13/19 null at min-n filter, with positive findings concentrated in studies with n<50) and four post-Goumon nulls (Cheon 2022, Ko 2022, Nevrkla 2024 within-study Cage-vs-Combined, Loftus 2020). Under the EFSA-derived approach, temporary-crating pre-weaning mortality is read directly from the EFSA (2022) elicited interpolation of mortality against day of crate opening: 15.6% at a day-4 opening against a 14.2% permanent-crate baseline, an excess of 1.4 percentage points. This gives EUR 6 per sow per year for the mortality line and a net temporary-crating piglet effect of EUR 6 per sow per year.

Table A11: Radtke 2026 4-arm RCT (UK, n = 666 sows)

Treatment	Days crated	Weaning weight (kg)	Pre-weaning mortality (%)
L (loose throughout)	0	8.78	16.4
L+4	4 (d0–d4)	8.46	13.5
C+4	4 (d0–d4)	8.44	11.8
C+2	2	8.62	14.9

Four days of confinement captures approximately 94% of the weaning-weight loss vs loose-throughout (L minus C+4 = 0.34kg vs L minus L+4 = 0.32kg) but roughly 70–85% of the mortality protection.

The 0% temporary-crating weaning-weight scaling rests on two complementary lines of evidence. First, the Radtke *et al*. (2026) L-vs-L+4 within-study contrast directly tests the day-4 closure mechanism: C+4 weaning weight (8.44kg) is effectively equal to L+4 (8.46kg), both below L (8.78kg). Second, the broader literature comparing temporary crating and permanent crates corroborates the same null at scale: the Goumon *et al*. (2022) review finds 13 of 19 weaning-weight comparisons null at the minimum-n filter, with positive findings concentrated in studies with n<50; four post-Goumon nulls reinforce the pattern. The numerically higher weaning weight in Kinane (2021) in the Free arm (temporary-crating-like, n = 46) was not statistically significant and is consistent with the literature null. The remaining single-study dependency is the Radtke *et al*. (2026) L-vs-L+4 contrast specifically, testing whether the weaning-weight gain re-opens after day 4; independent replication of that specific 4-arm contrast would reduce this dependency materially.

A5.4 SENSITIVITY RANGE (INCLUDING A ‘NO EFFECT’ EXTREMUM AND THE POOL B SINGLE-STUDY BRACKETS)

Widening bands to capture the uncertainty in all three pools and the generalisability of the Radtke *et al*. (2026) 4-arm design to EU-wide contexts:

Table A12: Sensitivity analysis for piglet effects

Scenario	Δmort	Δww	d/kg	Cost scale	T scale	F net	T net
No piglet effect	0	0	—	1.0	0/0	0	0
Low-benefit	5.0	0.20	3.5	0.7	0.50/0	-10	+10
Pool B lower (Nevrkla, n=80)	0	0.15	4.91	1.0	EFSA/0	−33	+6
Central (3-study Pool B, EFSA 0 pp)	0	0.349	4.91	1.0	EFSA/0	−67	+6
Pool B upper (Pedersen, n=42)	0	0.80	4.91	1.0	EFSA/0	−145	+6
Linear-in-days	3.70	0.349	4.91	1.0	0.86/0.86	−52	−55
Generous	1.0	0.43	5.5	1.25	0.25/0.86	−105	−75

Under the EFSA (2022) baseline, excess free-farrowing pre-weaning mortality at 7.8m² is zero; temporary-crating mortality is read directly from EFSA (2022) expert elicitation at a day-4 crate opening (see Annex A, section A5.3). The 'no piglet effect' case collapses all piglet effects to zero. The 'linear-in-days' case scales temporary-crating effects at 86% of free-farrowing values, assuming linear accrual with loose-time (contrary to the Radtke *et al*. (2026) 4-arm finding).

A5.5 IMPLICATIONS FOR CENTRAL NPV

Mapping the piglet-effect scenarios through our build-up and scenario model:

Table A13: Central NPV under piglet-effect scenarios

Scenario	F net	T net	F-vs-T	NPV (EUR bn)
No piglet effect	+EUR 87	+EUR 34	+53	+4.17 (cost)
Low-benefit	+EUR 77	+EUR 33	+43	+3.70 (cost)
Pool B lower (Nevrkla, Δww=0.15)	+EUR 66	+EUR 40	+26	+2.59 (cost)
Central (Pool B, Δww=0.349; EFSA 0 pp)	+EUR 20	+EUR 40	−20	+1.11
Pool B upper (Pedersen, Δww=0.80)	−EUR 63	+EUR 40	−103	−2.78 (benefit)
Linear-in-days	+EUR 37	−EUR 8	+45	+1.68 (cost)
Generous	−EUR 18	−EUR 59	+41	−0.90 (benefit)

Notes: All NPV values use the rational-farmer framework (AT/DE/DK = 0; section 4.1.2). All non-central scenarios are exact model reruns at their respective parameter values. Under the regulatory-channeling alternative, rows where free farrowing is more expensive than temporary crating would carry an additional AT/DE/DK component, increasing the no-piglet-effect case from EUR 4.17 to EUR 5.85 bn and the linear-in-days case from EUR 1.68 to EUR 3.12 bn.

A5.6 ADDITIONAL UNCERTAINTIES

The 'linear-in-days' reading produces an internally-consistent alternative: if temporary crating buys most of the piglet-outcome benefit of free farrowing pro-rata on days loose, then temporary crating captures roughly 86% of the weaning-weight and post-weaning mortality benefits. The free-farrowing-vs-temporary-crating differential could narrow enough to flip the ranking under some parameterizations, and the EU ban at Austria/Germany/Denmark would become a cost rather than a benefit. Under this reading the EU ban is a meaningful net cost, substantially above the central estimate of EUR 1.11 bn.

No piglet effect at all raises combined NPV to EUR 4.2 bn (large cost) and the per-sow-crate-day cost-effectiveness to EUR 0.55. However, while the exact size of the piglet effects is uncertain, the best available evidence points to large and material effects.

A6. Calculation Method

Annual cost computation: Cost_t = CF(t) × bc(t) × 7.282M sows × c_adj, where c_adj = EUR 20 per sow per year (free-farrowing cost build-up, section 4.3.2) and CF and bc are defined in section 4.4.1 / Annex A, section A4.1. Non-legislators are the only group of countries affected by the policy in the central estimate. Under the rational-farmer assumption (section 4.1.2), the Austria, Germany and Denmark Front-runner contribution is EUR 0 billion by construction (their counterfactual and EU-ban trajectories converge on the same destination, free farrowing, given that temporary crating is more expensive than free farrowing). Under a regulatory-channeling alternative (Austria, Germany and Denmark farmers route via temporary crating before transitioning to free farrowing in 2038), the Front-runner component adds roughly EUR 0.6 billion in benefit.

Table A14 presents the cost of the EU farrowing crate ban under seven alternative scenarios, each varying one parameter from the main scenario. The main scenario uses the main counterfactual (logistic S-curve, 50% floor), a ban date of 2038, and a 3% discount rate.

Table A14: Cost of the EU farrowing crate ban under alternative scenarios (2025 EUR, 2025-2060)

Scenario	Combined NPV (EUR bn)	sow-crate-days avoided (bn)	EUR per sow-crate-day
Main scenario (central CF, ban in 2038, 3%)	+1.11	7.63	+0.145
Fast voluntary CF (floor=11.7%)	+0.61	3.65	+0.167
Status quo CF (flat at 97.8%)	+1.83	13.16	+0.139
Fast transition (ban in 2035)	+1.25	8.39	+0.149
Slow transition (ban=2045)	+1.02	7.14	+0.144
Discount rate 2%	+1.31	7.63	+0.171
Discount rate 5%	+0.82	7.63	+0.107

Notes: Own calculations. Combined NPV = Non-legislators S1 component (central c_adj = EUR 20 per sow per year, free-farrowing cost increase under the EFSA no excess mortality at 7.8m²; sow herd declining at 1% per year). Front-runner contribution = EUR 0 bn by construction under the rational-farmer central (section 4.1.2), because the free-farrowing-vs-temporary-crating differential is EUR 20 per sow per year in favor of free farrowing. All scenarios fall between EUR 0.61 and EUR 1.83 bn combined NPV – all net costs. Each alternative scenario varies one parameter from the main scenario. Assessment period 2025–2060, all costs in 2025 EUR.

Table A15 translates the adjusted and unadjusted per-sow cost differences into per-kilogram metrics for comparison with production cost benchmarks.

Table A15: Cost per unit of output

Metric	Central	AKI unadjusted
Free-farrowing-vs-crate cost increase (EUR/sow/yr)	19.7	184.8
Free-farrowing-vs-temp.-crating diff. (EUR/sow/yr)	–19.9 (benefit)	+69.1 (cost)
Cost per kg pork (EUR/kg HCW, free farrowing vs C)	0.0075	0.07
Share of EU avg production cost (EUR 2.27/kg)	0.3%	3.1%

Table A16 shows the sensitivity of the central NPV estimate to each of the six cost adjustments individually, holding the other five constant at their central values. This isolates the contribution of each adjustment to overall uncertainty. Two further cost lines (veterinary, EUR 0 central / EUR 10 upper bound; and other variable costs, EUR 5.5 central / EUR 8 upper bound) are excluded because their change in NPV even at the upper bound is modest relative to the capital and labor ranges.

Table A16: One-dimensional sensitivity of combined NPV to cost-line ranges

Cost line	Central (Free farrowing / Temporary crating)	Lower bound	Upper bound	NPV at lower	NPV at higher
1a. EFSA pen-area (5.7/11.0m²)	+59 / +21	5.7m²: +25 cap, +19 mort	11.0m²: +112 cap, 0 mort	+0.18 (5.7m²)	+3.48 (11.0m²)
1b. Capital LOSO central estimate	+59 (EUR 112)	drop AKI (101, +53)	drop Moustsen (117, +62)	+0.68	+1.07
2. Labor (F / T)	+22 / +10	AHDB null (0/0)	Upper (+35/+20)	−0.11 (benefit)	+1.57
3. Pre-wean mortality (pp, F)	0 pp (EFSA at 7.8m²)	0 pp	+3.70 pp (Pool A)	+1.11	+1.68
4. Grow-finish (Δww) LOSO	+0.349	0.303 (drop Pedersen)	0.391 (drop Nevrkla)	+1.33	+0.60
4b. Grow-finish (Δww) extremes	+0.349	0.15 (Nevrkla alone)	0.80 (Pedersen alone)	+2.59	−2.78 (sign flip)
5. Post-wean mortality (Collins)	−7.0	0	−15	+1.28	+0.56
6. Feed (sow lactation)	0 / 0	EUR 0	EUR +25 (AHDB 2020)	+1.11	+2.15
7. Sow population growth	−1%/yr	0%/yr (flat)	−2%/yr	+1.11 (flat)	+0.81 (−2%)

Notes: Own calculations. Rows 1b, 2, 3, 5, and 6 are exact linear scalings of the free-farrowing cost increase and the free-farrowing-vs-temporary-crating differential ; rows 1a, 4, 4b, and 7 are separate model reruns. Low/high bounds derive from within-study plausible ranges detailed in the annex text above each cost line. (i) The net-cost result is robust under the LOSO sensitivity test. (ii) Capital cost is the dominant uncertainty source. (iii) The Pool B LOSO range (EUR 0.78–1.57 bn) is much narrower than the single-study extremes in row 4b (EUR −3.01 to +3.18 bn). (iv) The EFSA pen-area sensitivity takes combined NPV from near break-even (5.7m²) to roughly EUR 3.6 bn (11.0m²).

A7. Sensitivity Tests

We test the central estimate across three dimensions: (i) the counterfactual crate share for Non-legislators (fast voluntary / status quo bracketing the central logistic S-curve with a 50% floor); (ii) the EU ban transition speed (faster ban 2035 / slower ban 2045 bracketing the central 2038); and (iii) the social discount rate (2% / 5% bracketing the central 3% EC Better Regulation Toolbox rate). Across all six one-dimensional sensitivities and the central estimate, combined NPV remains in net-cost territory, ranging from EUR 0.61 to EUR 1.83 billion, and the cost-effectiveness ratio stays within EUR 0.11 to EUR 0.17 per avoided sow-crate-day (all costs).

The counterfactual dimension moves the central estimate materially: from EUR 0.61 bn (fast voluntary, where much of the transition happens without the ban) to EUR 1.83 bn (status quo, where almost no transition happens without the ban). Transition speed moves it between EUR 1.02 bn (2045) and EUR 1.25 bn (2035). The discount-rate band moves combined NPV from EUR 1.31 bn (2%) through EUR 1.11 bn central estimate (3%) to EUR 0.82 bn (5%). Per-scenario values are in Table A14 (Annex A6); the sensitivity bar chart is Figure 6.

A8. EU-Ban Interpretation for Austria/Germany/Denmark

Under the rational-farmer assumption (section 4.1.2), Austria, Germany and Denmark are excluded from active calculation: their counterfactual and EU-ban trajectories converge on the same destination (free farrowing) and their contribution to combined NPV is EUR 0 by construction. Denmark is a partial exception: its national ban takes effect in April 2041, three years after the modeled EU ban in 2038. If the EU ban includes a 2-year derogation for Denmark, the delay adds approximately EUR 43 million (about 4% of the central cost estimate).

A9. Comparison with AKI *et al*. (2023) Estimates

AKI *et al*. (2023) report a free-farrowing-vs-crate engineering cost estimate of EUR 184.8 per sow per year (2025 EUR). The central estimate in this assessment is EUR 20 per sow per year (all four piglet-effect pools sample-size-linear or judgment-anchored; see Annex A, section A5). This section compares the two estimates by cost line.

Table A17: Comparison of cost stacks: AKI *et al*. (2023) engineering estimate and the primary-source estimate in this assessment (2025 EUR per sow per year, free farrowing at 7.8m²)

Line	AKI (2023)	This assessment	Δ	NPV impact at Δ	Primary-source basis
Capital + depreciation	+139	+59	+80	+4.49	Regression β = 14.68 pp/m² (§3.2)
Labor	+36	+22	+14	+0.79	3-study pool (§3.3)
Veterinary	+6	0	+6	+0.34	AHDB/Cheon/Dumniem null (§3.4)
Feed	+11	0	+11	+0.62	AHDB/Cheon/Dumniem null (§3.5)
Other variable	+10	+5.5	+4.5	+0.25	AHDB 2019 DST, energy excluded (§3.6)
Pre-wean mortality	+10	0	+10	+0.56	EFSA (2022) at 7.8m² (§3.7)
Faster growth	0	−60	+60	+3.37	Radtke 2026 pool (§3.7)
Post-wean mort	0	−7	+7	+0.39	Collins *et al*. (2017) (§3.7)
NET	+185	+20	+165	+9.27	Calculated

Notes: AKI line-item values are mapped from AKI *et al*. (2023) Table 46 categories and do not sum to the NET aggregate. NPV impact at Δ = how much combined NPV would shift if AKI *et al*. (2023) inputs were used directly on that one line, holding all other lines at the central estimates in this assessment. Computed by scaling Δ by the same linear factor that maps the central free-farrowing cost increase to the headline combined NPV, under the 1% per year sow herd decline. Full derivation in Annex A, section A9 below.

Approximately 95% of the EUR 165 gap between AKI *et al*. and this assessment traces to cost lines where the two approaches differ in primary evidence (capital, faster growth, veterinary, feed, and other variable costs). On these lines, this assessment draws on within-study comparisons from published trials; AKI *et al*. use engineering-specification assumptions or credit no revenue effect. With AKI *et al*. inputs at face value, the central estimate would be approximately +EUR 10.4 bn (vs the current +EUR 1.11 bn), a roughly tenfold shift. Two structural differences drive roughly 90% of the gap. First, the capital cost increase at 7m² reported by AKI *et al*. (2023) (+96.6 pp over own-study crate) is about 1.8× the peer-based regression prediction at 7.8m² (+53 pp from β × 3.6m²) when applied to the equal-weight four-source crate central estimate of EUR 112. Second, AKI *et al*. do not account for the combined EUR 67 piglet economic effect (faster growth and the Collins *et al*. (2017) post-weaning mortality benefit), because the framework in AKI *et al*. (2023) does not model heavier weanings. The remaining gap comes from the unsourced +7.5% vet and +7.3% feed survey coefficients in AKI *et al*. (2023). AHDB 2019 DST, AHDB 2020 and Quendler *et al*. (2009) all hold the vet line at zero; AKI *et al*. label their +7.5% vet figure as 'consulted professionals' without published citation. The feed line is mixed: AHDB 2019 DST, Cheon *et al*. (2022) and Dumniem *et al*. (2023) report no significant difference, but AHDB 2020 assumes +100kg of sow lactation feed per year (roughly EUR 25 per sow per year), and their +7.3% feed coefficient is itself a re-expression of that AHDB 2020 +100kg figure (which AKI *et al*. attribute to AHDB (2020) in their CAPRI section) rather than independent evidence (section 4.3.4, 4.3.5). The labor line in this assessment is now built on a three-study commercial pool (section 4.2.3.2), which narrows the remaining labor-line gap with the implied EUR 36 in AKI *et al*. (2023).

The assessment sets the crate central estimate at the equal-weight four-source mean of EUR 112 per sow per year (KWIN-derived EUR 98 + AHDB 2019 EUR 108 + AKI *et al*. (2023) EUR 144 + Moustsen/Seddon EUR 98, all 2025 EUR), reflecting that each source has known but partial limitations and equal-weighting is the agnostic prior. The free-farrowing cost increase is derived from the cross-study slope (+14.68 pp/m²) applied to this equal-weight central estimate. LOSO sensitivity (drop one source, average the remaining three) is in Annex A, section A4.3.

Depreciation of existing buildings is excluded, which is a key methodological difference from AKI *et al*. (2023). This assessment treats the depreciation of existing crate buildings as a sunk cost: the EU farrowing-crate ban does not change whether existing buildings continue to be depreciated, only what gets built next (retrofit or new-build) when they reach end-of-life. The marginal cost of the ban is the cost of the next-built free-farrowing system minus the cost of the next-built crate that would have happened in the no-ban counterfactual: a within-vintage-cohort comparison handled by the Carpenter and Kanepajs (2026) vintage model (Annex A, section A6), which tracks four states (crate, retrofit crate, new-build free farrowing, retrofit free farrowing) calibrated to the EU sow-stock vintage distribution. Retrofit transitions carry only the equipment-cost delta (EUR 3.82 per sow per year, adjusted to 2025 EUR using HICP); new-build transitions carry the EUR 59 per sow per year free-farrowing capital line from section 4.3.2.

AKI *et al*. (2023, section 4.3.4 methodology, p. 87 ff., Tables 44 and 46) include the depreciation of existing crate buildings in the cost stack: depreciation of existing buildings (over 25 years) plus depreciation of new pen construction (15-year life on EUR 1700) plus a 10% reconstruction premium on the existing-building depreciation. Of the six studies in the capital regression panel, AKI *et al*. (2023) is the only one whose capital figures include the depreciation of existing buildings. Guy *et al*. (2012) and Baxter *et al*. (2012) report capital as one-time investment per sow place (Guy GBP/sow place with 8% / 20-year amortization, Baxter explicitly "GBP/sow place capital, not annualised"), that is, new-build construction cost only, with no existing-building depreciation. KWIN via AKI (2023) reports Dutch standards-reference capital as EUR per sow place (one-time investment per pen). Heidinger Pro-SAU via Baxter (2022) reports a relative cost index. AHDB (2020a) reports depreciation plus maintenance of existing UK systems; it includes existing-building depreciation but omits equipment investment.

The within-AKI slope is dominated by depreciation of existing systems. AKI *et al*. (2023) Table 44 reports two stacks side by side: depreciation of existing buildings only (crates 5.2, temporary crating 7.3, free farrowing 9.2 EUR per piglet weaned; SAMPLE row), and depreciation of existing buildings plus depreciation of new investment in pens (crates 5.2, temporary crating 8.6, free farrowing 10.5 EUR per piglet weaned). The Block 2 minus Block 1 differential (the new investment depreciation alone) is EUR 1.3 per piglet weaned for both temporary crating and free farrowing.

AKI *et al*. (2023) is not directly included in the main regression panel, because their capital figures are the only panel observations reporting capital with the depreciation of existing buildings included. AKI *et al*. (2023) values already enter the assessment indirectly through the KWIN-via-AKI data point in the equal-weight crate baseline (EUR 98 per sow per year; see Annex A, section A4.3). The six remaining studies (Guy 2012 / Baxter 2012 baseline-only / AHDB 2020a per-place / AHDB 2019 swing-side / KWIN-via-AKI / Heidinger Pro-SAU) report new-build construction cost only, the cost basis we want for the area-elasticity slope. Their pooled slope is β_{m^2} = +14.68 pp/m² (working panel N = 14, G = 6 clusters). Applied to the equal-weight four-source crate baseline (EUR 112 per sow per year; see Annex A, section A4.3) at the 7.8m² EFSA pen baseline, this gives a free-farrowing capital line of EUR 59 per sow per year, a temporary-crating capital line of EUR 21 per sow per year, a free-farrowing stack net of +EUR 20 per sow per year, and combined NPV of EUR 1.11 bn.

We test for sensitivity of the exclusion by including AKI *et al*. (2023) in the panel. Re-including the three AKI *et al*. (2023) rows on their own cost basis (depreciation of existing buildings, depreciation of new investment, and a 10% reconstruction premium) raises beta_m2 above the central +14.68 pp/m². The lower-bound sensitivity (AKI *et al*. (2023) included with the depreciation of existing buildings stripped from their rows) approximately coincides with the central, because the flat EUR 1,700 per-pen new-investment cost in AKI *et al*. (2023) gives a within-cluster slope close to zero once depreciation of existing buildings is stripped.

Practical sensitivity range for the capital line is estimated through a four-source LOSO sensitivity assessment, which gives an NPV range of EUR 0.68 – 1.07 bn around the central estimate (see Annex A, section A4.3). AKI *et al*. (2023) is retained as a sensitivity reference rather than discarded entirely, because it carries the broadest EU-27 geographic coverage and corroborates the direction of the slope.

A10. Uncertainty and Limitations

The within-study sourcing convention (section 4.2.3.1) yields k = 3–6 studies per parameter pool and N = 14 observations across G = 6 clusters for the capital regression. Each underlying study carries substantial internal sample sizes (n = 42 to 4,838), but pools are constructed from study-level estimates with sample-size weighting: within-study standard errors, which would permit formal inverse-variance meta-analysis, are not consistently reported across sources. At these pool sizes, formal confidence intervals would be unreliable; uncertainty is instead characterised through leave-one-study-out (LOSO) sensitivity ranges, single-parameter sensitivity analysis (Table A16), scenario analysis spanning zero-effect to generous extremes (Tables A14–A16), and a joint-parameter Monte Carlo (Annex A, section A10.4).

Table A18: Plausible ranges for each cost line (2025 EUR per sow per year, free farrowing at 7.8m²)

Line	Central	Low	High	Source of range
Capital + maintenance	+59	+53 (LOSO drop-AKI)	+62 (LOSO drop-Moustsen)	LOSO on four-source central estimate (section 4.3.1, Annex A, section A4.3)
Labor (F / T)	+22 / +10	0 / 0	+35 / +20	3-study pool; AHDB null low (section 4.3.2)
Vet	0	0	+10	Robust null; AKI +7.5% upper
Feed	0	0	+25	AHDB 2019 null; AHDB 2020 upper
Other variable	+5.5	0	+8	AHDB 2019 DST range, energy excluded
Pre-wean mortality	0	0	+15	EFSA 0 at 7.8m²; Pool A +3.70 pp upper
Faster grow-finish	−60	−100	−20	Low-benefit to high-benefit Δww × d/kg
Post-wean mortality	−7	−15	0	Collins 0.5-2.0 pp/kg × Δww
Retrofit cost	+3.82	0	+7.6	Cancels at steady state (NPV ≈ 0)

A10.1 PER-COST-LINE PLAUSIBLE RANGES

Compounded NPV range (additive one-at-a-time from Table A18 LOSO bounds). Summing Table A18 one-at-a-time deviations from the central (capital, labor, pre-weaning mortality, Pool B grow-finish, Collins *et al*. (2017) post-weaning mortality), the additive range spans approximately EUR -2.5 bn (benefit, all cost lines at their low-cost end) to +EUR 5 bn (cost, all at their high end), with the most plausible sub-range under realistic parameter choices in the +EUR 0.5 to +EUR 1.8 bn range. Under the alternative regulatory-channeling reading, the Austria/Germany/Denmark contribution of approximately EUR 0.6 bn in benefit shifts the range modestly toward benefit without changing the order of magnitude.

A10.2 COUNTERFACTUAL AS THE DOMINANT SINGLE UNCERTAINTY

The counterfactual crate share for Non-legislators ranges across scenarios: for fast voluntary, 11.7% floor; for main scenario, 50% floor; for status quo, 97.8% flat. The 50% floor is an assumption informed by the EU egg-sector experience (cage-free 12% → 62% 1999-2024, Compassion in World Farming 2024) and a downside reference in the US gestation-crate regulatory experience (approximately 3% of herd after two decades of campaigning, USDA ERS 2023). A country-by-country voluntary-adoption analysis would refine this, but a large uncertainty can be expected to remain.

A10.3 DIRECTION OF REMAINING BIASES

The stack cost estimate is built on a commercial/common pool for the labor line (section 4.2.3.2), which corrects a prior best-practice design basis that understated free-farrowing labor. Two factors still suggest the costs may be overstated rather than understated.

First, the Collins *et al*. (2017) slope of mortality against weaning weight (1.34 pp/kg) is a class-mean derivation from three data points; a proper panel regression with standard errors could widen or narrow the point estimate but is not available.

Second, technology improvement in pen design and management over a 10-year transition will likely lower the free-farrowing-vs-crate cost delta further than the baseline static-technology assumption allows for.

A10.4 JOINT-PARAMETER MONTE CARLO

Monte Carlo analysis is a standard component of regulatory impact assessment sensitivity testing (European Commission, 2025, Better Regulation Toolbox). It is used here as a transparency tool, not as the basis for headline estimates, for three reasons. First, simultaneous parameter variation gives a more interpretable picture of joint uncertainty than one-at-a-time sweeps: readers can see how cost lines interact rather than reading 12 separate sensitivity rows. Second, the input distributions are not calibrated to observed probabilities; the uniform and triangular families tested below reflect plausible ranges from the literature, not fitted parametric models, so the output percentiles should be read as illustrative bounds rather than calibrated confidence intervals. Third, anchoring headline numbers on the deterministic build-up (section 4.5) with one-at-a-time and LOSO sensitivity (Annex A, section A5) is the more defensible choice given the small evidence base; the Monte Carlo analysis complements this by showing that the direction of the central estimate survives joint perturbation.

Latin Hypercube sampling with N=20,000 draws over 12 cost-line parameters (Table A18 ranges), evaluated at the rational-farmer central (Front-runner Austria/Germany/Denmark contribution = EUR 0 by construction; section 4.1.2). The free-farrowing-vs-temporary-crating differential cannot fall below zero in the simulation: if free farrowing becomes more expensive than temporary crating in a given draw, the rational farmer routes directly from crate to free farrowing regardless. Two distributional families are tested: uniform (each parameter value equally likely between its bounds) and triangular (peak probability at the central estimate, declining linearly toward the endpoints).

Table A19: Percentile range, combined NPV (bn 2025 EUR)

Percentile	Uniform	Triangular	Interpretation
P5	−0.74	−0.07	Deep-tail benefit
P10	−0.14	+0.37	Strong-tail benefit
P25	+1.07	+1.21	Lower quartile
P50 (median)	+2.60	+2.20	Above central estimate EUR 1.11 bn
P75	+4.25	+3.28	Upper quartile
P90	+5.76	+4.33	Strong-tail cost
P95	+6.61	+4.96	Deep-tail cost
Mean	+2.71	+2.28	Above central estimate (asymmetric ranges)

Net-cost direction preserved in 94% of triangular draws / 89% of uniform draws. The floor constraint (free-farrowing cost floored at temporary-crating cost) binds in 42–61% of draws. The median sits above the one-at-a-time central estimate of EUR 1.11 bn because several component ranges are right-skewed (vet, feed, pre-weaning mortality modes at or near zero). The 80% triangular interval spans approximately EUR +0.4 to +4.3 bn, which is a larger range than one-at-a-time sensitivity testing produces, without changing the sign.

Annex B: Welfare Methodology

Domain-level grades are converted to welfare coefficients through non-linear interpolation of coefficients taken from Table A2 of Espinosa *et al*. (2025), merged sample (N = 1,062). At integer grades, the coefficients are measured values from discrete choice experiments combined with time-trade-off elicitation; at fractional grades (which arise from averaging subdomain scores), coefficients are obtained through non-linear interpolation.

The AQALY value is:

$$AQALY = 1 + SUM\_d[\ c\_d(g\_d)\ ]$$

where c_d(g_d) is the interpolated coefficient for domain d at domain-average grade g_d. An AQALY of 1.0 represents the reference state in which all domains are at their best possible level (grade 1, each coefficient zero). As severity increases, coefficients become more negative, reducing the AQALY below 1.0. Values can fall below zero when multiple domains are severely compromised.

The conversion from sow-crate days to monetized AQALY values is formulated as:

$$EUR/sow\text{-}crate\text{-}day = delta\_AQALY \times (1/365) \times phi\_pig \times EUR\_QALY$$

where EUR_QALY is EUR 147,000 (reference value for a human quality-adjusted life year; Tehard *et al*., 2020, via Espinosa *et al*., 2025), and phi_pig is the neuron count ratio (1/44). The same formula is used to obtain results with hedonic capacity weights (Rethink Priorities, 2023) by setting the value of phi_pig to 0.515.

The monetization approach based on willingness to pay for animal welfare takes on a different formulation:

$$EUR/sow\text{-}crate\text{-}day = cost\_SCD \times (WTP\_kg / cost\_kg)$$

where cost per sow-crate-day is EUR 0.25 (section 4.3.8), willingness to pay per kg is EUR 2.83, and cost per kg hot carcass weight is EUR 0.0075.

B1. Subdomain Evidence Base

This section presents the 18 subdomain scores for each system with supporting evidence. Scores are assigned independently for the farrowing crate and the free-farrowing pen. All evidence citations are expanded in the full subdomain table below.

B1.1 NUTRITION

- **Water and food intake (FC 1 / FF 1).** Both systems provide ad libitum water and a nutritionally complete lactation diet. No material compromise in either system.

- **Foraging material (FC 7 / FF 4).** Crated sows have no access to manipulable foraging material; the metal bars and slatted floor provide no outlet for rooting behavior. In the Swedish-model pen, straw and jute sacks serve as partial foraging substrate; the material is present but limited relative to species-typical rooting in soil. The free-farrowing score reflects the Swedish legislative requirement for bedding material under the 1988 Animal Protection Ordinance.
- **Fibre diet (FC 9 / FF 9).** Commercial lactation diets in both systems contain insufficient dietary fibre relative to the physiological requirements of the sow for gut health and satiety. This is a feed-formulation constraint, not a housing-system difference.

B1.2 ENVIRONMENT

- **Thermal conditions (FC 8 / FF 3).** The farrowing crate environment is set for piglet thermoregulatory needs (30-34 degrees Celsius at the creep area), creating chronic heat stress for the lactating sow whose thermoneutral zone is 16-22 degrees (EFSA, 2007). The sow cannot move to cooler zones. In a free-farrowing pen, the sow can move between warmer and cooler areas; though ambient temperature remains a compromise, the sow retains behavioral thermoregulation capacity.
- **Substrate (FC 7 / FF 3).** Crated sows typically stand and lie on slatted or part-slatted concrete or metal flooring with no bedding. The hard surface contributes to pressure sores and locomotory discomfort (EFSA, 2022). Free-farrowing pens provide straw or equivalent bedding, which serves substrate, nest-building, and comfort functions simultaneously.
- **Confinement (FC 9 / FF 2).** The farrowing crate restricts the sow to an area in which she cannot turn around. Physical confinement for the full lactation period (28 days or more) represents the most severe environmental constraint. The BVA and PVS (2025) conclude that individual farrowing crates fail sows across four of the five welfare domains, including physical environment, and that 'the system has to be changed'. EFSA (2007) lists confinement as a primary welfare hazard. In the free-farrowing pen, the sow moves freely; a voluntary-use crate may be available but is not imposed.
- **Air, noise, and light (FC 9 / FF 6).** Crated sows in intensive farrowing houses are exposed to continuous artificial lighting regimes, mechanical ventilation noise, and air quality determined by stocking density and manure management. The sow has no agency over her sensory environment. Free-farrowing systems reduce but do not eliminate these exposures; stocking density is lower but indoor systems still use artificial light and mechanical ventilation.
- **Environmental monotony (FC 8 / FF 4).** The farrowing crate provides a near-unchanging environment for the duration of confinement: same visual field, same surface, same micro-climate. Free-farrowing pens with substrate, nest material, and the ability to move between zones offer more environmental complexity.

B1.3 HEALTH

- **Disease and injury (FC 8 / FF 3).** Crated sows develop pressure sores (decubital ulcers), urinary tract infections, and locomotory disorders at elevated rates (EFSA, 2007; EFSA, 2022). Limb injuries from bar contact, shoulder lesions from lying on hard surfaces, and constipation from inactivity are common. Free-farrowing sows face lower injury rates on bedded surfaces; the main health risk is sow-on-piglet overlay, which is a piglet welfare issue rather than a sow welfare issue.
- **Body condition and fitness (FC 7 / FF 4).** Prolonged confinement leads to muscle wastage, cardiovascular deconditioning, and reduced bone density (EFSA, 2022). The sow exits the

crate in poorer physical condition than she entered. Free-farrowing sows maintain locomotory fitness; body condition loss during lactation is a physiological norm but is not exacerbated by immobility.

B1.4 BEHAVIOR

- **Locomotory behavior (FC 9 / FF 3).** The crate prevents locomotion; the sow can stand, sit, and lie but cannot take a single step or turn. This is the defining constraint of the farrowing crate. In the free-farrowing pen, the sow walks, turns, and moves between functional zones. The pen size still limits full locomotory expression relative to outdoor systems.
- **Foraging behavior (FC 9 / FF 4).** The crate provides no material to root in and no space for forward movement during rooting. The sow cannot express the core foraging behavior. Free-farrowing pens with straw allow partial rooting and oral manipulation; the behavior is expressed but in limited form.
- **Nest-building behavior (FC 8 / FF 4).** Pre-farrowing nest building is a strongly motivated behavior driven by hormonal changes in the 24 hours before parturition (EFSA, 2022; Wischner *et al*., 2009). The farrowing crate prevents the full behavioral sequence: the sow cannot gather, carry, or arrange nesting material, and cannot select a nest site. Where jute sacks or similar are provided, oral manipulation of the material is possible but the spatial components (site selection, material transport, nest shaping) are blocked. Frustrated nest-building motivation is associated with elevated cortisol and longer farrowing duration (Oliviero *et al*., 2010). Free-farrowing sows with straw can build a functional nest; the behavior is expressed but the pen setting constrains full spatial expression.
- **Maternal behavior (FC 8 / FF 2).** The crate restricts the ability of the sow to respond to piglet distress calls, to nurse in preferred lateral or semi-recumbent postures, and to reposition to accommodate the litter. Sow-piglet physical contact is limited to what occurs through the crate bars (Hales *et al*., 2014). In the free-farrowing pen, the sow can approach, nose, and nurse piglets with full postural freedom. Temporary crating during the first few days after farrowing, as practised in some systems, reduces crushing risk while still offering more maternal contact than the permanent crate (Hales *et al*., 2015b).
- **Social behavior (FC 7 / FF 7).** Both systems house sows individually during lactation. Neither permits sow-to-sow social contact beyond auditory and olfactory signals. The free-farrowing pen does not improve social conditions relative to the crate in this respect.
- **Escape and exploratory behavior (FC 8 / FF 3).** Crated sows exhibit sham chewing, bar biting, and other stereotypic behaviors indicative of frustrated motivation to explore and escape (Zhang *et al*., 2017). The crate eliminates any ability to retreat from disturbances or to investigate novel stimuli. Free-farrowing sows can move away from disturbances and explore the pen environment.
- **Resting behavior (FC 7 / FF 3).** Crated sows rest on hard surfaces in a fixed position; lateral lying space is restricted by bar width. The sow cannot adopt all preferred lying postures and may experience disturbed rest from contact with cold or wet surfaces (EFSA, 2022). Free-farrowing sows choose resting location and posture, with bedded surfaces providing thermal and physical comfort.
- **Comfort behavior (FC 7 / FF 4).** Self-grooming, stretching, and postural adjustment are restricted in the crate by bar proximity. The sow cannot roll, fully extend, or scratch against structures. Free-farrowing pens permit these behaviors but pen furniture may still limit some comfort movements.

B1.5 DOMAIN AVERAGES AND AQALY COMPUTATION

Domain averages and AQALY values are presented in Table 4 (section 4.7.1).

Figure B1: Domain-level welfare heatmap (AQALY-4PD-9L, 1-9 scale)

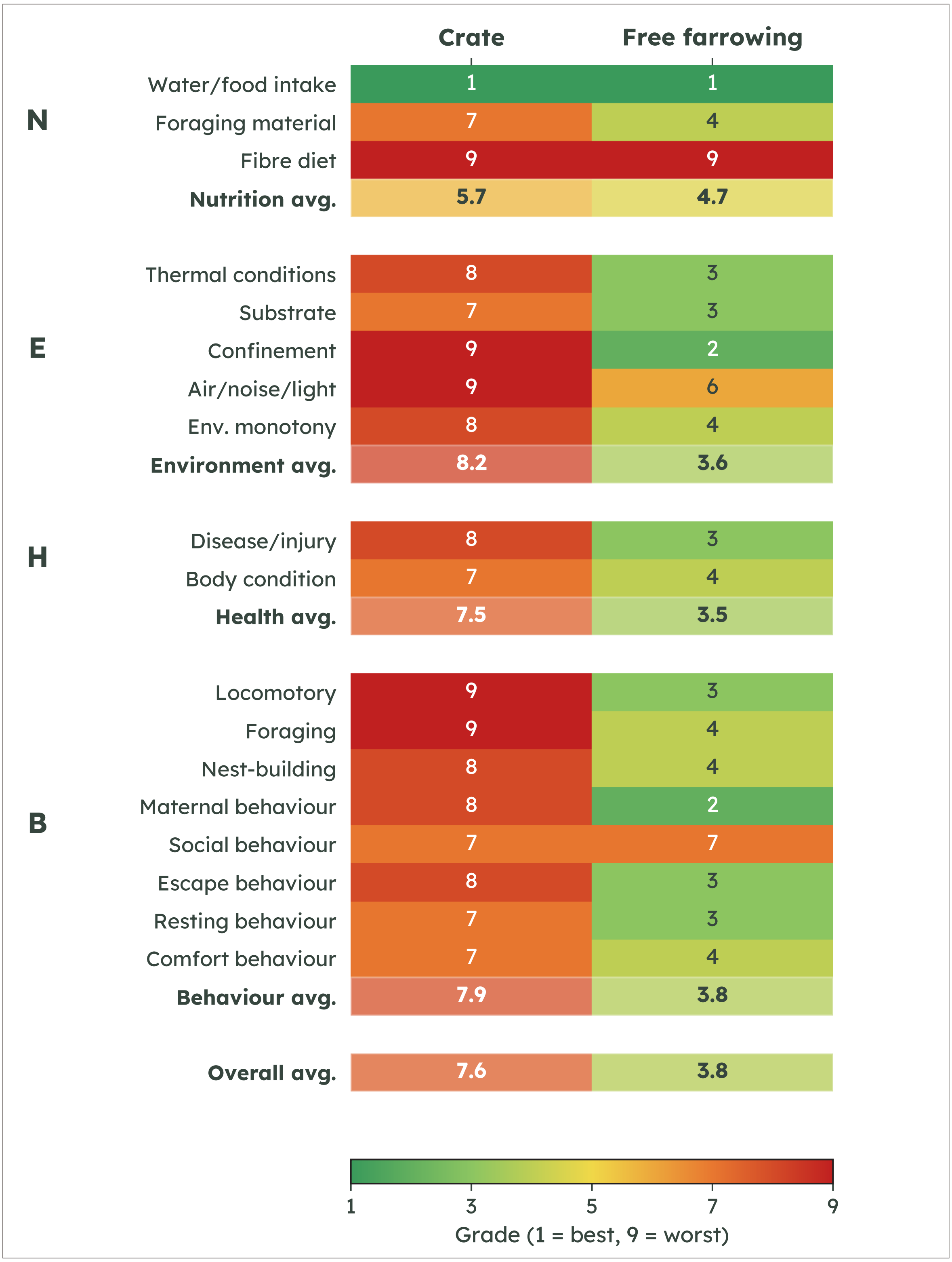


Table B1. PCHIP coefficients by domain and grade (Table A2, Espinosa, Browning & Treich, 2025)

Grade	N (Nutrition)	E (Environment)	H (Health)	B (Behavior)
1	0.0000	0.0000	0.0000	0.0000
2	-0.0593	-0.0981	-0.0173	-0.0546
3	-0.1025	-0.1627	-0.0454	-0.1148
4	-0.1267	-0.1910	-0.0875	-0.1837
5	-0.1502	-0.2179	-0.1440	-0.2529
6	-0.1840	-0.2659	-0.2058	-0.3034
7	-0.2399	-0.3422	-0.2976	-0.3697
8	-0.4128	-0.4977	-0.5099	-0.5604
9	-0.7148	-0.7392	-0.8502	-0.8806

B2. PCHIP Coefficient Derivation

The AQALY coefficients at integer severity grades 1-9 are taken from Table A2 of Espinosa, Browning and Treich (2025), merged sample (N = 1,062). The coefficients represent the welfare decrement associated with each severity grade relative to grade 1 (the reference category, coefficient = 0).

Grades marked (M) in the source are measured directly from discrete choice experiments combined with time-trade-off elicitation; grades marked (P) are PCHIP-interpolated by the original authors. All nine grades in the merged-sample table carry measured or PCHIP status from the source; see Espinosa, Browning and Treich (2025), Table A2 for the full provenance of each cell.

Interpolation method. At integer grades, the coefficients above are used directly. At fractional grades (which arise when subdomain scores within a domain average to a non-integer), the PCHIP method (Fritsch & Carlson, 1980) is applied. PCHIP is a monotone cubic Hermite interpolation that guarantees no overshoot between data points: if consecutive coefficients are monotonically decreasing (as they are in all four domains), the interpolated values are also monotonically decreasing.

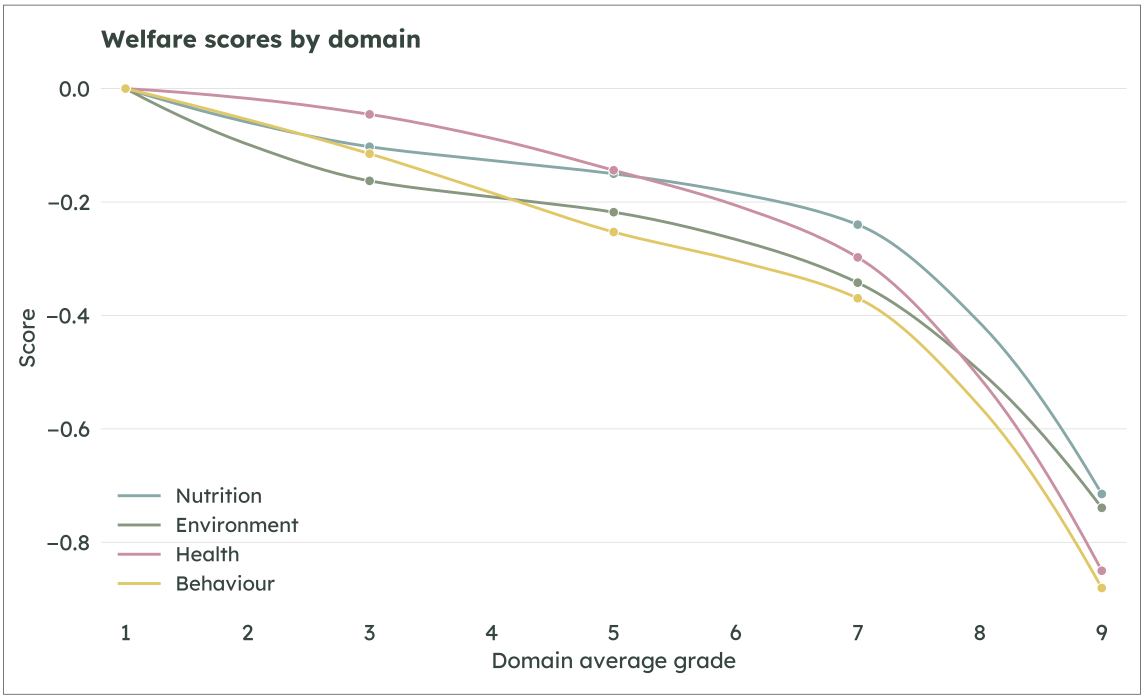
The algorithm computes derivative estimates at each knot point using the harmonic mean of adjacent finite differences, with boundary conditions set by one-sided formulae. The cubic Hermite basis functions then provide C1-continuous interpolation at any fractional grade.

The choice of PCHIP over linear interpolation affects the central estimate by approximately 2.8%. Linear interpolation produces a delta of 1.104 versus the PCHIP delta of 1.073. The difference arises because the slope is relatively small in the mid-range (grades 4-7) and steep near the endpoints (grades 7-9); linear interpolation overestimates the coefficient magnitude where the curve flattens.

B3. Aggregation Method Sensitivity

The central computation uses arithmetic averaging of subdomain scores within each domain, followed by non-linear interpolation at the domain-average grade. Two alternative aggregation approaches are considered.

Figure B2: PCHIP interpolated curves by domain



Notes: Dots mark measured coefficients at integer grades from Espinosa *et al.* (2025). Curves show the PCHIP interpolant used for fractional domain-average grades. The steeper slope at high severity grades (7-9) explains why crate-system perturbations have a larger effect on the AQALY delta than free-farrowing perturbations.

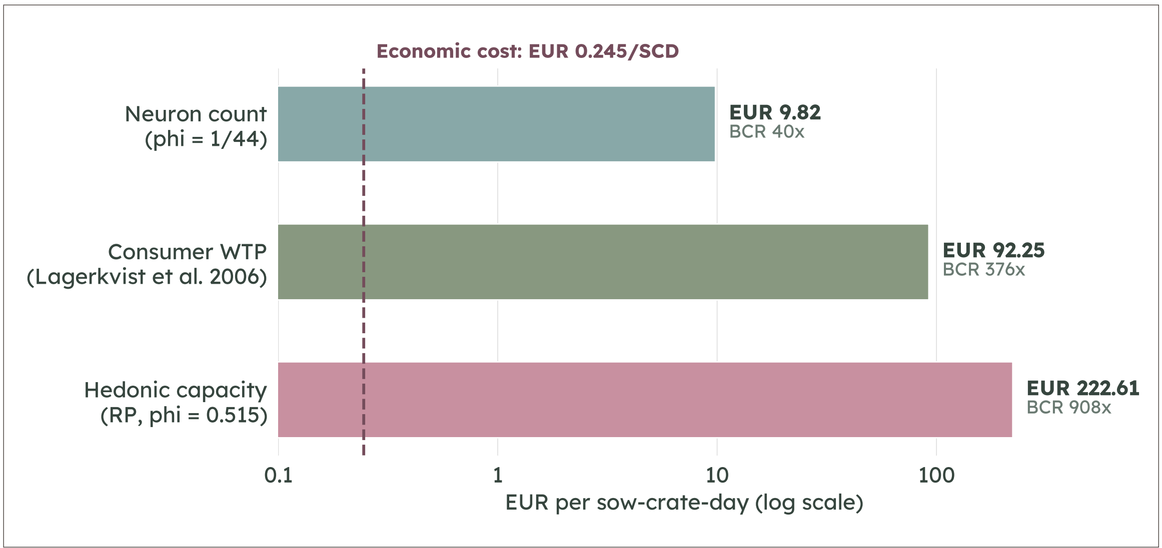
1. **Equal-weight linear interpolation.** Replacing non-linear interpolation with linear interpolation between the integer-grade coefficients in Table B1. Linear interpolation overestimates the magnitude of coefficients at fractional grades where the non-linear curve is concave, and underestimates where it is convex. The net effect is a 2.8% overstatement of the delta (1.104 under linear versus 1.073 under non-linear interpolation). The difference is small enough that the benefit-cost ratio ranking is unchanged.
2. **Alternative domain weights.** The AQALY framework treats subdomain scores as equal weight in the within-domain averaging step. An alternative would weight domains by the sum of their discrete-choice-experiment-derived coefficients at the maximum grade (effectively giving more weight to domains with steeper preference functions). The Behavior domain has the steepest curve (coefficient at grade 9: -0.8806); Environment is second (-0.7392). Reweighting by maximum-grade coefficient magnitudes increases the delta by approximately 5-8%, because the domains with the largest crate-free gaps (Environment, Behavior) also carry the largest maximum-grade coefficients.

Neuron-proportional is the primary approach; consumer willingness to pay and hedonic-capacity serve as sensitivity bounds.

Table B2: Monetized welfare value per sow-crate-day: three approaches

Metric	Neuron-proportional (primary)	Consumer WTP (sensitivity)	Hedonic-capacity (sensitivity)
EUR per sow-crate-day	9.82	92.25	222.61
EUR per sow per lactation (28 days)	275.07	2,583.09	6,232.99
EUR per sow per year (2.3 litters)	632.65	5,941.11	14,335.89
Benefit-cost ratio	40	376	908

Figure B3: Benefit-cost ratios under three monetization approaches

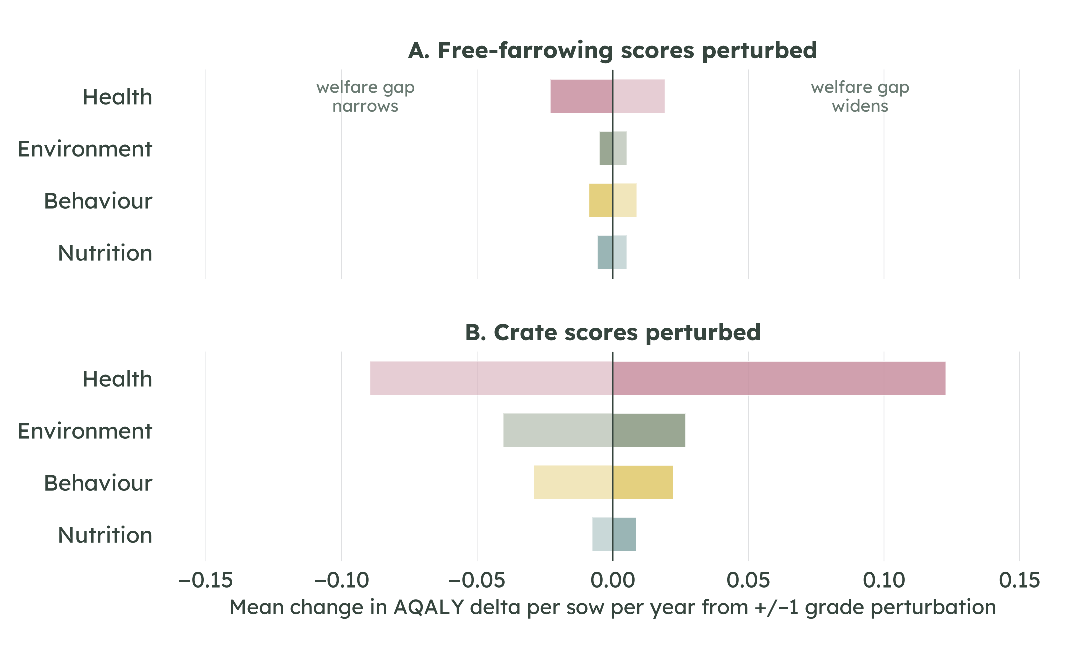


Notes: Own calculations. Three monetization approaches applied to the same AQALY delta (1.073 per sow per year): neuron-proportional (primary, pig moral weight = 1/44), consumer willingness to pay (Lagerkvist *et al.*, 2006), and hedonic-capacity-based (Rethink Priorities, 2023). All three produce benefit-cost ratios above 1.

B4. Scoring Sensitivity

Each bar in Figure B4 shows the mean change in the AQALY delta (per sow per year) when subdomain scores within one domain are perturbed by plus or minus one grade, one subdomain at a time, all others held constant. For crates the effects are several times larger than for free farrowing because crate scores cluster at grades 7-9 where the estimated welfare decline is steepest, while free-farrowing scores cluster at grades 2-4 where the curve is flatter. The asymmetry between panels is informative: the result is far more sensitive to how bad crate conditions are than to how good free-farrowing conditions are. However, the effect of the largest single-domain change (Health, +0.12) is less than 12% of the central AQALY delta estimate of 1.073, meaning that the difference between the two systems is very robust to adjustments to welfare gradations.

Figure B4: Scoring sensitivity (subdomain perturbation impact on AQALY delta, per sow per year)



Notes: Each bar shows the mean change in the AQALY delta (per sow per year) when subdomain scores within one domain are perturbed by plus or minus one grade, one subdomain at a time, all others held constant. Panel A perturbs crate scores; Panel B perturbs free-farrowing scores on the same x-axis scale.

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