AN ASSESSMENT OF THE IMPACTS OF THE PHASING OUT OF CAGES IN EU LIVESTOCK FARMING: THE PIG AND LAYER SECTORS

FINAL REPORT

Institute of Agricultural Economics

EuroCARE AGRICULTURAL POLICY RESEARCH

FNEA FOUNDATION SCIENCE AND EDUCATION FOR AGRI-FOOD SECTOR

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Customer

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Content

Executive Summary

On 30 June 2021, the European Commission announced a policy initiative for phasing out the use of cages in EU livestock farming (C(2021) 4747 final). To gain insight into the complex socio-economic consequences of this policy initiative, a science-based assessment was conducted, aimed at quantifying the possible impacts and highlighting the economic risks at stake for the pig (sows) and egg (layer hens) sectors. The study's overall objective is to support a fair and balanced policy debate.

The research was based on an extensive literature review, farm-level surveys, and expert consultations in selected EU Member States, which provided data and information for conducting cost-benefit analyses and an impact assessment with the CAPRI (Common Agricultural Policy Regionalised Impact) model.

Most of the scientific literature on evaluating the performance of cage-free housing systems for sows and layer hens focuses on productivity, or productivity and economics combined, at the farm-level. In the case of sows, limited information is available on the environmental and farm management impacts of transitioning to free farrowing systems, as well as on the detailed real costs of the necessary investments. For layer hens, the alternative systems replacing enriched cages seem to have their own weaknesses in terms of animal welfare, egg yields per hen and square meter, and environmental sustainability. Based on the literature, in general, the major concerns related to cage-free housing systems include increasing piglet and laying hen mortality, increasing space and labour requirements, and increasing feed use.

In the literature reviewed, the representation and reliability of the data were often disputable. Authors frequently build on expert opinions and simplified assumptions. Therefore, conclusions, which range widely (in the case of sows sometimes even contradict), should be handled with caution. In this context, it is to note that investment in new housing systems and buildings might, after a learning and adaptation phase for farmers, improve the physical performance of livestock over time, explained by the application of more advanced equipment and genetics and by an improved working environment which is more motivating for both labour force and management.

Regardless of the technological and animal welfare related doubts, the share of laying hens kept in alternative housing systems has been systematically growing in the EU, currently reaching 55-60%. Legislative decisions taken in some EU Member States, introducing end dates for the permits of using enriched cages, had a significant impact on the pace of the progress of egg producers transitioning to cage-free housing systems. At the same time, decisive actions of the main players in the supply chain (retailers and food processors) who successively resign from trading 'caged' eggs, are observed in some countries. Certainly, the factor stimulating the transition to alternative systems has been the higher prices paid for cage-free eggs, especially from free-range and organic production.

The cost-benefit analyses were carried out at the farm level for both sows and layer hens, with an attempt to scale-up the results to the EU sector level. The farm-level assessments were based on farm surveys and supported by the literature review and consultations with experts and farmers' organisations. The focus was on the impacts of the upcoming ban on production volumes, production costs, investments related to transitioning to cage-free housing systems, and financial results.

It was concluded that the ban on farrowing crates would result in (1) a reduction in the sow population and piglet production in the EU, due to increasing space requirements for sows, (2) deteriorating production efficiency, and (3) significant investment needs. In the most realistic scenarios, which assume a moderate retreat of sow farmers and the prevalence of a market equilibrium price obtained from the CAPRI model, the number of sows is reduced to around 8.6 and 8.4 million heads, or by 20.7% and 22.7%, respectively, which are changes of similar magnitude as projected by the CAPRI model (below).

The ban on farrowing crates is expected to strengthen the concentration process in piglet production. Exits of small-scale producers without successors are very likely, and some of the farmers will switch to finishing only.

The cost of production is foreseen to increase during the farrowing period (including veterinary, labour and sow feed costs, costs related to the increased mortality of piglets and higher sow replacement rates). In those scenarios, which assume a moderate retreat of sow farmers and the prevalence of the CAPRI market equilibrium price, a 27% increase in selected production cost elements (variable costs, depreciation of existing buildings and new investments) is estimated from EUR 354 up to EUR 449 per sow, expressed in 2021 prices. As per weaned piglet, the increase is around 32%, from EUR 11.1 to 14.6 on average, also expressed in 2021 prices. The increase in production costs is anticipated to be higher in the EU-East (EU-13, or 'new' Member States), due to the lower efficiency of production and, on average, the smaller sow herds in those countries.

Transitioning to free farrowing systems will require significant investments in new pens and in the reconstruction of the existing buildings. Depending on the decision by farmers, investment costs range from around EUR 3.8 to 6.7 billion (in 2021 prices) in the different scenarios. Owing to the uneven geographical distribution of the EU sow herd, investment costs are expected to be substantially higher in the western EU Member States, where most of the sows are concentrated.

The vast majority (67%) of the 225 pig farmers surveyed in the various EU Member States, expressed very negative opinions about the ban on the use of farrowing crates, including a low score for the effects of the policy reform on the welfare of piglets and sows. Farmers stressed that it is difficult to meet three welfare goals of production without compromising each other, namely the welfare of the sows, of the piglets, and of the workers. It is clear that the main benefit from free farrowing stems from the sows' ability to express natural behaviour, e.g. rooting, nest building, etc. However, there are no commercialised pen designs yet, which can improve or even maintain the welfare of piglets (the main concerns are more frequent injuries, increasing mortality, and deteriorating hygienic conditions). On the other hand, the greater freedom of the sows increases the risks of injuries and time usage for workers.

In addition to the above, pig producers' organisations and breeders expressed great concerns about investment needs. The replacement of existing pens and the reconstruction of flooring will require massive capital expenditure, and reconstructions are likely to cause significant disruptions in the production cycle. The transition to free farrowing systems should be accompanied by adequate fundings from the EU to farmers, otherwise it will force many piglet producers to quit the sector.

Results of the farm-level assessment indicate that the ban on enriched cages will potentially reduce egg production in the EU. Significant investments in the egg sector will also be required.

The laying hen flock is estimated within the range of 330 million to 379 million after full transition. Its size will largely depend on the future decisions of farmers who now declared abandoning production because of the compulsory switch to alternative housing systems and the required investments in new capacities for egg production. Such exits are very likely and reasonable, especially in the case of small-scale, older farmers without successors.

Until the complete transition to alternative housing systems, egg production is likely to follow a decreasing trend, explained by the decline in the number of laying hens. Production will also be influenced by an expected slight reduction in egg yields per laying hen. When calculating with the new market equilibrium price obtained from the CAPRI model, assuming there will be new investments increasing the production potential of the sector, the production of eggs aggregated to the EU level might, however, surpass the 2021 base by 1%.

Financial results at the farm level, measured with the Gross Margin (production value minus variable costs and depreciation), fall below the current value for enriched cages (EUR 1.31 per kg eggs) in the most likely scenario based on the CAPRI market equilibrium price. Assuming a 3.7% price increase, as projected by CAPRI, the Gross Margins for eggs from the barn, free-range and organic production systems would be EUR 0.070, –0.143 and –0.239 per kg, respectively. It should be underlined that these calculations are made with 2021 prices, demonstrating exclusively the impacts of the ban on cages, irrespective of the price trends and shocks experienced at present by all agricultural sectors and the food processing industry in the EU.

The total value of the necessary investments, expressed similarly in 2021 prices, will also depend on the future decisions of farmers to abandon or continue with production. With around EUR 3.2 billion for the EU-27, investment needs could be the highest when calculating with the CAPRI market equilibrium price.

The ban on enriched cages is expected to strengthen the concentration process in the EU egg sector as well. Considering the progress in transitioning to alternative housing systems even before introducing a ban by the European Commission, it might be concluded that this process will continue, although at a slower pace. It is worth noting that early adopters benefit more from the transition due to more attractive prices. The followers might benefit less, because the more hens are kept in alternative housing systems, the lower the market prices for these eggs and thus farmers' benefits could be.

The CAPRI model was used to assess the impacts of the ban on farrowing crates for sows and enriched cages for laying hens on supply balances and prices, producer incomes, and selected macroeconomic and environmental indicators.

According to the CAPRI model results, the EU ban on cages is expected to impact most on the pig sector where the transition to cage-free housing systems lags conspicuously behind the layer sector. Pork meat production in the EU-27 is projected to decline markedly against the CAPRI baseline in most scenarios, with –23.6% representing the extreme in the case of an immediate transition, and a rate inversely proportional to the time frame envisaged for implementing the new policy.

Irrespective of the length of the transition period, the percentage decline in pork meat supply is considerably higher in the EU-East compared to the EU-West (EU-14, or 'old' Member States). The stronger resilience of the pig sector in the EU-West is well underlined by the changes in the trade indicators: the decline in production is better offset by the drop-back in exports, thus trade of EU-West countries with third countries acts more as a buffer, absorbing most of the loss. It is to note however, that even the EU-West barely retains its position as a net exporter of pork meat if immediate transition is forced on the sector.

The impacts of the new policy on the egg supply balance of the EU-27 are far less pronounced, with a decline in total production changing between 0.5-2.0% against the CAPRI baseline, depending on the length of the transition period. However, the ban impacts on egg production more in the EU-East, explained by the slower pace of transitioning to cage-free housing systems compared to the EU-West. This implies a more sizeable setback in egg exports from and consumption in this block of countries *vis-á-vis* the EU-14.

When a 10- or a 20-year long transition period is provided for, the current main suppliers of pork meat and eggs to the EU appear to be able to satisfy the increasing import demand from the EU with products which comply with the new EU policy. It is to note that a small uptake in poultry meat consumption is also observed in all CAPRI scenarios which counterbalances the decline in pork meat and egg consumption to some extent.

Pork meat average producer price surges by 47.4% but total profit in the pig sector of the EU-27 shrinks by a considerable 37.8% against the CAPRI baseline when no transition period is provided for, explaining the sizeable decline in pork meat production in the extreme situation. The profit loss in the pig sector is markedly higher in the EU-West compared to the EU-East; however, this position is expected to reverse over time owing to the improving relative competitiveness of the pig sector in the EU-West, accompanied by a faster non-EU policy driven transition in those Member States. Although the estimated impacts on profits in the EU-27 pig sector gradually erode over time, the 14.2% drop against the CAPRI baseline, when full transition is compulsory by 2035 and non-EU policy driven transition is taken into account, can still be judged as relatively high.

In the egg sector, due to the substantial advancement in transitioning to cage-free housing systems, the impacts are expected to be less severe with the average producer price of eggs increasing by 3.7% and profits melting by 0.9% in the case of an immediate transition. Again, the decline in profits seems more pronounced in egg production of the EU-East. The magnitude of the decline even increases over time, due to the considerable lag in transitioning to cage-free housing systems *vis-á-vis* the EU-West.

When no transition period is provided for, the total income of the EU-27 agriculture drops by 1.7% against the CAPRI baseline, explained primarily by the declining profits in pork meat and egg production. The total output of agricultural activities (EAA output) of the EU-27 increases by 5.8%, driven predominantly by the increase in producer prices in the sectors concerned. Tariff revenues grow by 7.0% because of increasing imports of livestock products. These impacts erode substantially when a 10- or 20-year long transition period is provided for, especially when the non-EU policy driven transition to cage-free housing systems continues as anticipated, which has a clear shock-smoothing effect.

The transitioning to cage-free housing systems has a negligible impact on consumer purchasing power and it does not burden taxpayers in any of the scenarios.

The environmental impacts are mainly driven by the decrease in pork meat and egg production, and by the decline in the physical performance of sows and layer hens in the alternative housing systems, which have the opposite effect. The ban on the use of cages in the EU pig and egg sectors would have a direct effect on the production and consumption of agricultural products in non-EU countries. As for GHG emissions, a 4.2% (or 5.76Mt CO_2 eq) increase in the GWP against the CAPRI baseline becomes apparent in non-EU pork meat production, driven by decreasing exports of and increasing import demand for pork meat from the EU-27. This compares to a 22.3% (or 7.94Mt CO_2 eq) drop in the GWP of pork meat production in the EU-27, resulting in a 1.3% decline in the GWP of the pig sector at the global level. GWP savings lessen steadily with the increase in the length of the transition period and the anticipated advancement in natural transition to cage-free housing systems in the pig sector both at the EU and the global level.

The changes in the GWP of the EU egg sector are at a lower scale and strongly correlate to the changes in the volume of egg production, with negligible non-EU leakage effects.

As a general conclusion, it can be stated that the impacts related to a scenario of immediate transition to cage-free housing systems appear to diminish substantially when a 10- or even a 20-year long transition period is provided for, thanks to the non-EU policy driven transition to such systems, which has a clear shock-smoothing effect.

Introduction

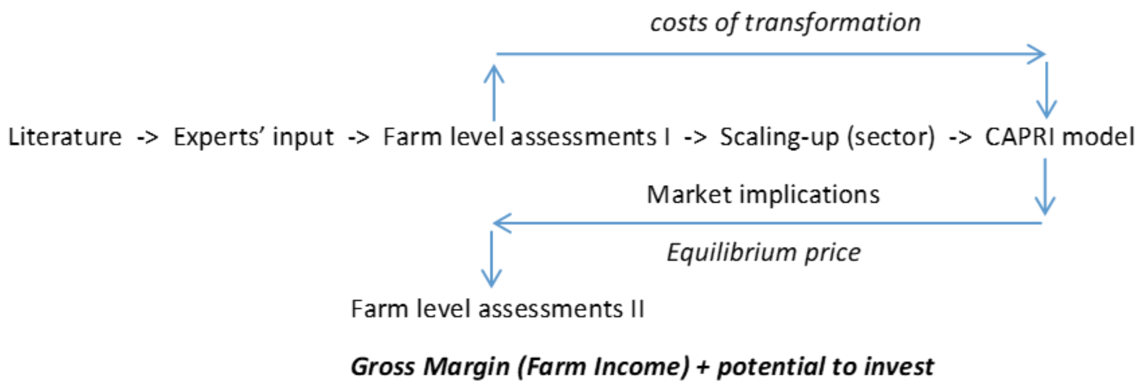
This report on the assessed impacts of the phasing out of cages in the EU pig and layer sectors is the final deliverable envisaged in the Contract Agreements between COPA-COGECA and the Institute of Agricultural Economics Nonprofit Kft. (AKI, Budapest, Hungary), furthermore between AKI and the Foundation Science and Education for Agri-Food Sector (FNEA, Warsaw, Poland), and AKI and the European Centre for Agricultural, Regional and Environmental Policy Research (EuroCARE GmbH, Bonn, Germany). This report is a summary of the various Technical Papers delivered by AKI, FNEA, and EuroCARE under the Contract Agreements.

On 30 June 2021, the European Commission announced a policy initiative for phasing out the use of cages in EU livestock farming (C(2021) 4747 final[1]), which may considerably impact several of the livestock sectors and product chains. The phasing-out transition period will be determined after the European Food Safety Authority (EFSA) prepares its opinion and the Commission delivers its official impact assessment (probably in the first quarter of 2023). The new legislative elements will be included in the revision of the animal welfare legislation, which the Commission will put on the table by the end of 2023.

To gain insight into the complex socio-economic consequences of this policy initiative, a science-based assessment was conducted at the farm level, national sector level, and EU level, aimed at quantifying the possible impacts and highlighting the economic risks at stake for the pig (sows) and egg (layer hens) sectors. The study's overall objective is to support a fair and balanced policy debate.

The impact assessment, drawing on extensive literature reviews, was carried out on two main paths (Figure 1): (1) through farm-level analyses based on farm-level surveys and expert consultations in selected EU Member States, with an attempt to scale-up the results to sector levels; and (2) sectoral analyses for the EU Member States and the entire EU with the use of the Common Agricultural Policy Regional Impact (CAPRI) model.

Figure 1: **Conceptual framework of the impact assessment**



Source: Annex I to the Contract Agreement between COPA-COGECA and AKI, AKI and FNEA, and AKI and EuroCARE

The CAPRI-based analysis included the impacts on EU trade with third countries, as well as macroeconomic and environmental impacts. On the one hand, the CAPRI scenarios were designed to make use of the outcome of the other impact assessment activities, the literature review, the expert consultations, and the farm-level surveys, as well as data for EU Member States from the InterPIG (a global network) database. On the other hand, the CAPRI simulations also provided input for the farm-level analysis, mostly through the estimation of producer price impacts.

[1] https://ec.europa.eu/transparency/documents-register/detail?ref=C(2021)4747&lang=en

This deliverable is structured as follows: Section 1 of this report gives an account of the findings from the literature review on the economics of keeping sows and laying hens in cage-free housing systems. Section 2 discusses the methodological approach of both the farm-level assessments and the CAPRI modelling exercise. Section 3 gives a succinct account of the main results of the research work.

1. Literature Reviews

1.1. Literature review on the efficiency of free farrowing systems in pig farming

There is a significant scientific literature on comparing the efficiency and economic performance of sows in different housing systems, but the results presented in these are mixed. This is explained by the specific conditions (i.e. breed, scale, feeding systems, assumptions, etc.) under which the assessments were conducted. In some cases, the description of the housing systems is generalised without detailed information on the designs.

Baxter, Lawrence, and Edwards (2011) differentiated between the following farrowing systems in pig farming:

1. Conventional farrowing crates
2. Modified farrowing crates: where sows are allowed greater freedom of movement (turning around throughout farrowing and lactation) within the existing footprint of a conventional crate, while retaining the ability to restrain, if necessary.
3. Farrowing pens: where the crate is absent.
4. Group housing systems: where sows and litters can mix before weaning.
5. Outdoor systems: where outside access is allowed.

They listed several indoor systems as alternatives to farrowing crates, including Simple, Designed, Sloped/Hill-side, and Mushroom for farrowing pens, and Ljungstrom, Thorstensson, Free access then group, Crated for farrowing, and Family pen for the group housing of sows.

1.1.1. Efficiency impacts

Bates, Edwards and Korthal (2003) compared the lactation and reproductive performance of sows (½ Yorkshire, ¼ Landrace, ¼ Duroc, with Hampshire boars for mating) housed in groups with electronic sow feeding in gestation (ESF-G) and lactation (ESF-L) to those housed individually in stalls in gestation (SG) and lactation (SL) in a commercial production system. In addition, sows housed in ESF-G had subsequently higher litter birth weight and higher litter wean weight than those housed in SG (Table 1). Gestating sows housed in groups with electronic sow feeding had either similar or improved performance compared with sows gestated in stalls. However, lactating sows had poorer litter weaning performance when housed in groups with electronic sow feeding compared with those housed individually in stalls.

Table 1: **Production performance of sows in different housing systems (piglets per litter)**

	No. of born alive	No. of stillborn	No. of mummies	No. of weaned	Litter birth weight (kg)	Litter wean weight (kg)
SG	9.77	0.62	0.16	8.66	16.7	56.2
ESF-G	9.77	0.53	0.12	8.45	17.7	57.1
SL	9.83	0.52	0.15	–	17.1	58.4
ESF-L	9.72	0.59	0.12	–	17.4	55.5

Source: based on Bates, Edwards and Korthal (2003)

McGlone *et al*. (2004) performed a series of meta-analyses on available data from scientific literature to determine whether sow behaviour, performance, or physiology differed in group pens or individual stalls. The authors concluded that average levels of productivity, oral-nasal-facial behaviours (ONF), and blood cortisol were statistically similar for sows in group pens and stalls. Immune parameters were largely not influenced by the choice of housing system. Overall, total ONF behaviours were comparable between gestation sow housing systems. Stall size and design can impact postural adjustments and inter-stall aggression of individually housed sows. Sows in stalls consistently had equal or greater reproductive performance compared with sows in other systems. The farrowing rate for sows in individual stalls was equal to or superior to sows in other systems. The farrowing rate was clearly superior among sows in stalls compared with group housing systems, where dynamic social groups were employed (Table 2). Sows in group housing systems, particularly with electronic sow feeder, had injury scores greater than sows in either stalls or tethers.

Table 2: **Production performance of sows in different housing systems**

		All studies[a]			Studies with both systems[b]		
		Pen	Stall	P	Pen	Stall	P
Farrowing rate	%	75.9 ±2.9	83.3 ±2.3	0.09	75.9 ±3.6	80.6 ±3.6	0.45
Piglet birth weight	kg	9.9 ±0.3	9.9 ±0.3	0.42	9.9 ±0.3	9.8 ±0.3	0.63
ONF	%	15.2 ±17.8	32.7 ±13.2	0.45			

[a] All studies include papers that did not necessarily have both systems (pen or stall).
[b] These studies had measures for both penned and stalled sows in each study.
Source: based on McGlone *et al*. (2004)

Anil *et al*. (2005) studied adult sows of the Yorkshire-Landrace crossbred (n = 382). The authors detected no significant differences in productivity and longevity between sows housed in pens with an electronic sow feeder (ESF) and sows housed in stalls regarding, litter size, number of pigs born alive per litter, number of stillborn pigs per litter (Table 3). Stall-housed sows had significantly fewer mummies per litter compared with sows in pens with an ESF. Pre-weaning mortality rate was significantly lower for pen-housed sows. For pen-housed sows, the proportion of sows culled was significantly higher, compared with the proportion culled for stall-housed sows. The proportion of sows culled for lameness in the pen system was also significantly higher, compared with the proportion of stall-housed sows culled for lameness. The major reasons for culling of sows in pens with an ESF were lameness and poor reproductive performance.

Table 3: **Longevity and production performance of sows in different housing systems**

	Pens with an ESF	Gestation stalls
Longevity (No. of sows)		
Total	206	176
Farrowed	154	144
Culled because of nonpregnancy*	33	26
Culled because of lameness	11[a]	1[b]
Aborted	2	1
Other[+]	6	4

	Pens with an ESF	Gestation stalls
Production performance++		
Litter size (No. of baby pigs)	10.88 ±0.27	10.98 ±0.29
Born alive/litter (No. of piglets)	9.10 ±0.28	9.36 ±0.28
Stillborn/litter (No. of piglets)	0.92 ±0.11	0.94 ±0.11
Mummies/litter (No. of mummies)	0.86 ±0.16	0.67 ±0.14
Litter weight at birth (kg)	14.39 ±0.41	14.80 ±0.40
Preweaning mortality (%)§	13.16 ±1.41[c]	16.24 ±2.22[d]
Farrowing rate (%)	74.76	81.81

* Sows were not pregnant because they returned to estrus after mating.
[+] Other includes sows that were excluded from the study because they were detected in estrus after breeding.
[++] Values reported are mean ± SE.
[§] Value calculated as follows: (No. of piglets died before weaning/No. of piglets born alive) X 100.
[a, b] Within a row, values with different superscript letters differ significantly (P = 0.05).
[c, d] Within a row, values with different superscript letters differ significantly (P < 0.01).
Source: based on Anil *et al.* (2005)

Karlen *et al*. (2006) focused on the welfare of gestating Landrace x Large White sows housed in either large groups on deep litter (Hoops) or conventional stalls (Stalls). 640 sows were studied, with 40 recently mated sows weekly entering each treatment over an 8-week period. Groups of 85 were formed using 40 experimental and 45 non-experimental animals. Sows in Hoops had a higher number of scratches, a higher return rate to oestrus after mating (13.2% versus 7.4%) and there was a trend for higher salivary cortisol concentrations in week 1 of gestation. Sows in Stalls had a higher incidence of lameness at weeks 9 and 15 of gestation (13.8% versus 0.8% at week 15). There was a trend for a lower reproductive failure in Stalls (14.5% versus 27.3%), farrowing rate was higher (76.8% versus 66.0%), and while sows in Stalls weaned fewer piglets per litter (8.31 versus 8.97), the average weaning weight of these piglets was higher (8.69 kg versus 8.01 kg). The combination of these reproductive parameters resulted in sows in Stalls weaning the equivalent of 39 more piglets per 100 mated sows. The results suggest that sows in large groups on deep litter faced greater welfare challenges in the early stages of gestation, possibly due to aggression. In contrast, sows in Stalls faced greater welfare challenges later in gestation based on a higher incidence of lameness and an increased neutrophil:lymphocyte ratio, possibly as a consequence of increased stress. From the data it can be concluded that the welfare advantages and disadvantages change over time in both housing systems. The number of weaned piglets per farrowed sow was lower in Stalls than in Hoops (Table 4). In contrast, the average piglet weight was higher in Stalls than in Hoops; however, piglets from sows in Hoops had on average 2 days less of lactation. The shorter lactation was due to a longer gestation in Hoops sows and the fact that all piglets in each replicate for both treatments were weaned on the same day. Sows in Stalls had more piglets per mated sow at farrowing, but the difference was not significant at weaning.

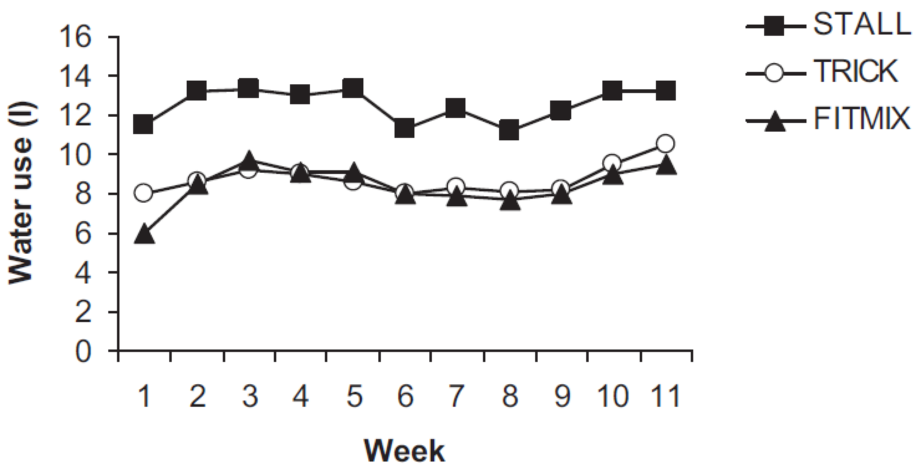
Table 4: **Effects of housing on sow productivity (means and SED presented)**

	Stalls	Hoops	SED
Number of piglets (per litter)			
Total born	11.2	11.1	0.384
Born alive	10.1	10.2	0.339
Still born	0.7	0.6	0.172
Mummified	0.3	0.3	0.074
Weaned	8.3[b]	9.0[a]	0.194
Birth to weaning piglet mortality[a] (%)	1.9	1.2	
Born alive per sow mated	8.3[a]	6.4[b]	0.363
Weaned per sow mated	6.0	5.6	0.454

Within rows, significant differences are indicated by different superscripts.
[a, b] P < 0.05
[a] Calculated as the difference between born alive and weaned.
Source: based on Karlen *et al.* (2006)

Chapinal *et al.* (2010) studied 180 pregnant Large White x Landrace sows, from first to ninth parity, selected and used in 3 different replicates (60 sows per replicate) on a commercial farm. The sows were housed from day 29 of pregnancy to 1 week before parturition in conventional stalls (STALL), in groups of 10 with trickle feeding (TRICKLE), and in groups of 20 with an unprotected electronic sow feeder (FITMIX). All sows were equally feed restricted. The average daily water use per sow was higher in the stalls compared with the group housing systems. The weekly evolution of daily water use is shown in Figure 2. The average daily amount of feed offered was 2.61 kg/sow in both the STALL and TRICKLE, and 2.56 kg/sow in FITMIX. No differences were found across the systems in the three liveweight measurements of sows carried out.

Figure 2: **Weekly evolution of average daily water use (litres) per sow in STALL, TRICK, and FITMIX**



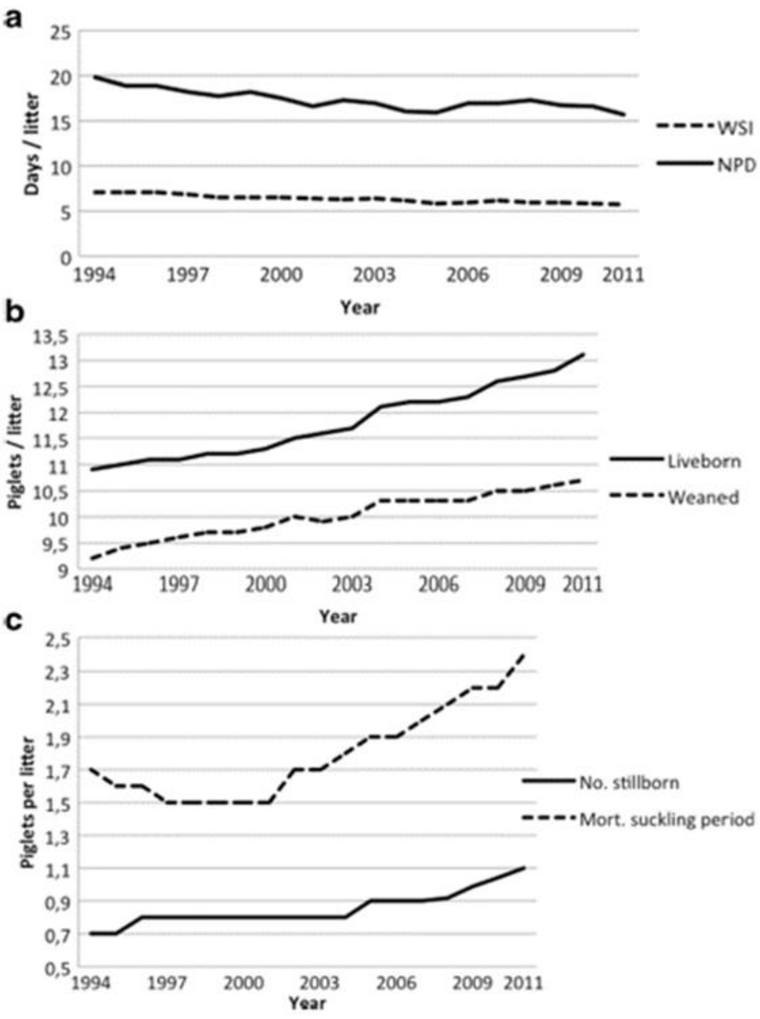
Source: Chapinal *et al.* (2010)

The number of piglets born dead per litter was lower in FITMIX than in the other systems (STALL = 1.24 ±0.18; TRICK = 1.04 ±0.17; FITMIX = 0.54 ±0.17). There were no differences in the number of piglets born alive or mummified in the total number of piglets produced, in the total weight of piglets produced, or in the total weight of piglets born alive.

By reviewing the relevant literature, Bench *et al.* (2013) point at the need for comparing individual feeding methods within group sow housing systems with different group sizes. Space allowance and feeder type interactions are of key importance for low-ranking sows.

In Sweden, outdoor and indoor systems exist, and in both, sows are often kept isolated at farrowing and mixed with other sows a few weeks later. According to Einarsson *et al.* (2014), piglet growth appears not to be affected by group housing as compared with conventional single-housing systems, while a higher pre-weaning mortality rate was noted among group-housed multiparous sows, which is likely related to an accelerated weaning process among older sows. There was a tendency to a lower number of weaned pigs per litter in farms where sows were kept in groups compared with farms where the sows were kept individually. Based on the information from a selected number of herds, recorded using the PigWin software, the weaning-to-service interval (WSI) and non-productive days (NPDs) per litter decreased, NPDs faster than WSI (Figure 3a). Since WSI is included in NPDs, this indicates that the number of days 'wasted' because of sows being empty and re-mating, is diminishing. The litter size increased substantially during the last 15 years, but the gap between the number of liveborn piglets and the number of weaned piglets grew over time (Figure 3b). This means that there was a slight increase in piglet mortality during the suckling period together with an increase in stillbirth rate (Figure 3c).

Figure 3: **Phenotypic trends in Swedish piglet production, based on data obtained from the PigWin herd monitoring software**



[a] Weaning to service interval (WSI) and number of non-productive days (NPD).
[b] Litter size, number of liveborn piglets (Liveborn) and number of weaned piglets (Weaned) per litter.
[c)] Piglet mortality, number of stillborn piglets (No. stillborn) and number of piglets died during suckling period (Mort. suckling period) per litter.
Source: Svenska Pig, quoted by Einarsson *et al.* (2014)

Hales *et al.* (2015) investigated piglet mortality in a commercial setting where sows were accommodated in a loose-housed system with an option to confine the sows for a few days at the time of farrowing and during early lactation. The study was conducted in a Danish pig farm with 2,139 farrowings. Sows were randomly allocated to one of 3 treatments: loose-loose (LL), loose-confined (LC), and confined-confined (CC). In LL, sows were loose-housed from the time they entered the farrowing pens to weaning. In LC, sows were loose-housed until farrowing was finished and then confined to day 4 after farrowing. In CC, sows were confined at day 114 of gestation to day 4 after farrowing. All sows were loose-housed from day 5 to weaning. Total piglet mortality was analysed at batch level to include piglets fostered by nurse sows, and at sow level to assess the effects of confinement during different time periods. Total piglet mortality was greater in LL (26.0%) and LC (25.4%) compared with CC (22.1%) as summarised in Table 5 below. The proportion of stillborn piglets was not different between the treatments, but a larger proportion was crushed in LL (10.7%) compared with LC (9.7%), which again was greater than CC (7.8%). Confinement reduced mortality from litter equalisation to day 4 (7.6% for LL versus 6.7% for LC) but more so in CC (5.6%) than in LC. From day 4 to weaning, LL had lower mortality (5.6%) than LC (6.9%) and CC (6.6%). A larger proportion of sows in CC were classified as 'low mortality' compared with LL and LC both before and after litter equalisation.

Table 5: **Performance results at batch level for loose-housed sows and for sows that had been confined for the first 4 days of lactation per 2 different confinement strategies**

	Loose-Loose	Loose-Confined	Confined-Confined	SE	P-Value
Batches no.	58	56	59	–	–
Farrowings/batch	12	11.8	11.5	0.18	0.10
Total mortality (%)[1]	26.0[a]	25.4[a]	22.1[b]	0.64	<0.001
Stillborn (%)[2]	5.8	5.2	5.2	0.35	0.21
Crushed piglets (%)[2]	10.7[a]	9.7b	7.8	0.53	<0.001
Liveborn mortality (%)[1]	21.4[a]	21.4[a]	17.9 [b]	0.57	<0.001

[a, b] Values with different superscripts differ significantly ($P < 0.05$).
[1] Total mortality = (stillborn + live born dead)/total born; live-born mortality = live born dead/live born.
[2] Calculated as percent of total born.
Source: based on Hales *et al.* (2015)

Chidgey *et al.* (2015) studied a commercial pig farm using two lactation systems. The objective was to examine the effect of pens with temporary crating until 4 days post-partum and farrowing crates for the duration of lactation on the productivity of sows (Large White, Landrace, Duroc, and the crosses of these) and piglets. Performance data was obtained from 394 sows (4706 live born piglets) in combination pens, and 338 sows (3987 live born piglets) in crates over 14 farrowing batches. Pre-weaning piglet mortality was significantly higher in the pen system (10.2%) than in the crate system (6.1%) (Table 6). Penned sows were released from the temporary crate on the day 4 of lactation. A greater proportion of piglets died in the combination pens (38.8%) than in the crates (30.4%) during the period extending from day 4 of lactation until weaning. Total pigs weaned per litter differed between pen (10.54 ±0.052) and crate systems (10.76 ±0.065). The accommodation in which a sow farrowed and lactated had no significant impact on subsequent reproductive performance.

Table 6: **A comparison of litter performance parameters between sows housed in combination pens or farrowing crates (LSMEAN±SE)**

	Pen LSMEAN (±SE)	Crate LSMEAN (±SE)	P (Parity)	P (System)	P (Batch)	P (System *Batch)
N Litters	394	338	–	–	–	–
N Piglets born alive	4 706	3 987	–	–	–	–
Average sow parity	4.07 (±0.114)	3.61 (±0.127)	–	0.0075	0.0002	<0.0001
Total born per litter	13.01 (±0.171)	13.14 (±0.196)	<0.0001	0.5796	0.0532	0.3474
Total born alive per litter	11.87 (±0.161)	11.91 (±0.185)	<0.0001	0.8481	0.0643	0.3916
Total weaned per litter	10.54 (±0.052)	10.76 (±0.065)	<0.0001	0.0024	<0.0001	0.3658
Litter weaning weight	82.70 (±0.122)	80.80 (±0.138)	0.2255	<0.0001	<0.0001	<0.0001
Piglet weaning weight	7.67 (±0.011)	7.50 (±0.013)	0.1376	<0.0001	<0.0001	<0.0001
Lactation length	27.32 (±0.103)	27.77 (±0.119)	0.9632	0.0028	<0.0001	<0.0001
Overall piglet mortality	10.2%	6.1%	–	<0.0001	0.0010	–
Piglet mortality to day 4	61.2%	69.6%	–	<0.0001	–	–
Piglet mortality after day 4	38.8%	30.4%	–	<0.0001	–	–

Source: based on Chidgey *et al.* (2015)

Ola *et al.* (2016) examined 43 Yorkshire lactating sows in Swedish organic production with piglets between week 1 and week 3, and evaluated the correlations between nursing-suckling interaction, piglet performance, and piglet mortality for three post-farrowing management routines, i.e. group housing at week 1, 2, or 3. Piglet performance was compared with a reference group of individually loose-housed sows with piglets. The authors found no statistically significant difference in nursing-suckling interaction and piglet performance parameters for the three management routines, piglet mortality being an exemption: when piglets were group-housed at the third week post-farrowing, mortality was 7 percentage points lower compared with group housing at the first week post-farrowing.

Overall piglet mortality positively correlated with mortality in the multi-suckling pen for piglets group-housed at the first week ($r = 0.61$; $P < 0.05$) and at the second week post-farrowing ($r = 0.62$; $P < 0.05$) but not for piglets group-housed at the third week post-farrowing (Table 7). In conclusion, overall piglet mortality could be reduced if sows and piglets are group-housed at the third week post-farrowing, and piglet survival could be improved in the case of group housing at the first-week post-farrowing.

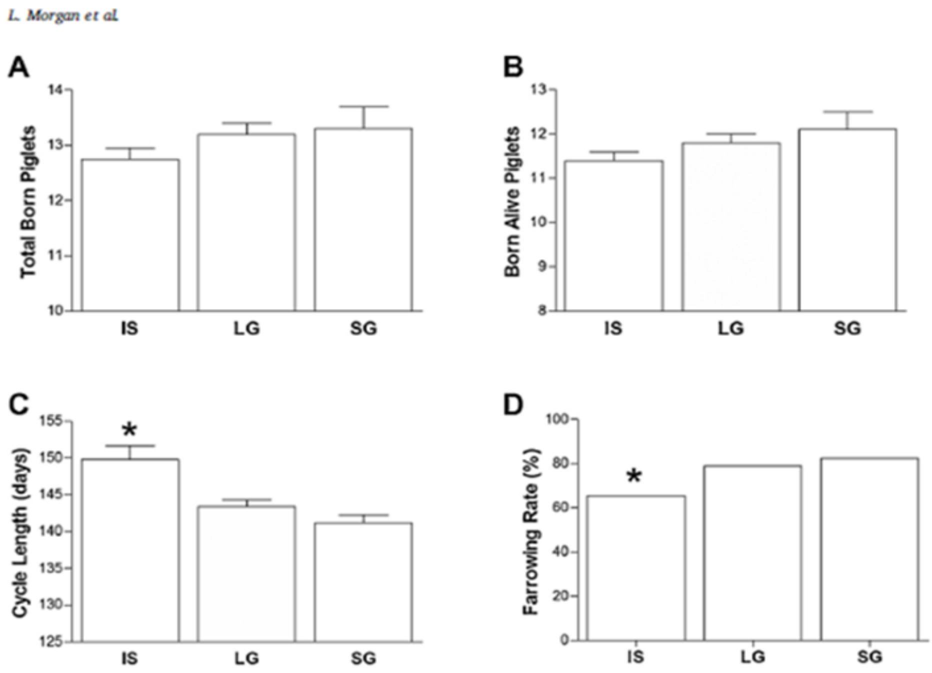
Table 7: **Piglet mortality at the sow level for three management routines**

	Management routine			
	WK 1	WK 2	WK 3	P-Value
Total mortality (%)	27.1	24.1	19.8	n.s.
In the individual farrowing pen (%)	17.3	19.8	18.1	n.s.
In the multi-suckling pen (%)	12.0	5.8	1.7	0.05

Source: based on Ola *et al.* (2016)

Morgan *et al.* (2018) studied the management of group housing of sows (mixed breed of Landrace, Large White, Pietrain, and Duroc, from parity three to eight) during gestation as an alternative to individual confinement stalls. The research had three specific objectives: (1) to compare parameters of production, reproduction, and welfare of sows housed in groups (either 30 or 7 sows/group; Large Group: LG, Small Group: SG, respectively) during gestation as compared with confinement stalls (IS); (2) to compare saliva cortisol of pregnant sows throughout gestation when housed in groups of three different sizes (either 7, 15, or 30 sows per pen group); and (3) to compare production and reproduction performances at the sow herd level, before, during, and after transforming from confinement stalls to group housing in a large commercial pig farm over a 6-year period. The mean cycle length (weaning to weaning) was found shorter in group housing as compared with confinement stalls, but gestation length did not differ among the three groups. Overall farrowing rate (sows farrowed of those inseminated) was higher for sows housed in groups (either SG or LG). Furthermore, there was a tendency towards a higher number of piglets born in total, and piglets born alive in group housing; however, it did not differ between the LG and SG groups. The injuries and lameness index (ILI) of sows improved significantly over the gestation period in group housing. Group saliva cortisol during gestation did not differ significantly among groups of 7, 15, or 30 sows, except for the first saliva sampling just after sows were mixed into groups, where cortisol level was significantly higher in sows housed in a pen of 30. Production and reproduction performances at the sow herd level before, during, and after transforming from confinement stalls to group housing improved significantly over the 6-year period: a shortened cycle length, an increased farrowing rate, and an increased number of piglets born in total and piglets born alive were observed (Figures 4). In conclusion, group housing management during gestation was associated with better reproduction, productivity, and welfare of sows, as compared with confinement stalls.

Figure 4: **Reproductive and production parameters of sows housed in groups (LG: 30 sows per group; SG: 7 sows per group) during gestation, as compared with individual confinement stalls (IS).**



* P < 0.05
Source: Morgan *et al.* (2018)

Zhang *et al*. (2020) found that piglets of Yorkshire x Landrace sows had similar birth weights and daily feed intake in three different farrowing systems (FC – farrowing crate, FFS – free farrowing pen with sloping walls, FFSN – free farrowing pen with sloping walls and nest materials). The weaning weight of piglets from the FFS group tended to be higher than of piglets from the other two farrowing systems. No statistical difference was found in the number of piglets born in total, born alive, and stillborn between the treatments (Table 8). The number of piglets crushed in the FFS and FFSN groups was respectively 0.6 ±0.7 and 0.9 ±1.1 which were numerically higher compared with the FC group, but without a statistical difference. Similar result was seen for the piglet crushing rate. The weaning number of piglets appeared lower in the FFSN group which was 7.7 ±1.8 compared with the FC and FFS groups, but still without a statistical difference. The FC group tended to have a lower total piglet mortality rate compared with the other two groups.

Table 8: **Piglet production and loss for sows in different farrowing systems**

	FC	FFS	FFSN	SD	p-Value
Average birth weight (kg)	1.5	1.6	1.5	0.2	0.83
Average weaning weight (kg)	6.3	6.8	6.3	0.5	0.08
Total born	10.5	11.4	9.6	2.2	0.24
Born alive	9.8	10.3	8.7	2.1	0.40
Stillbirth	0.8	1.1	0.9	0.9	0.67
Weaning number	9.6	9.4	7.7	2.1	0.12
Total mortality (%)	7.5	17.1	19.6	12.5	0.07
Crushing number	0.1	0.6	0.9	0.8	0.40
Crushing rate (%)	1.0	5.5	9.6	9.5	0.25

SD: Standard deviation
Source: based on Zhang *et al.* (2020)

Buoio and Costa (2020) investigated the relationship between space allowance and survival rate in conventional (CFC) and welfare farrowing crates (WFC), with larger space allowance in the WFC after day 15 of birth. The study was conducted in two phases, with the first having 329 sows lodged in CFC and 293 sows in WFC, and the second having 71 sows lodged in WFC with larger space allowance. The sows were of Landrace and Large White breeds. The first trial showed that the number of total crushed piglets was higher in WFC (1.17 versus 0.95) with significant consistency from day 3 to weaning (0.40 versus 0.32). The second trial showed that the management strategy to provide more space allowance in WFC increased the crushing rate of piglets after day 15 from 0.06 to 0.23.

Ko *et al.* (2022) compared the welfare and performance of sows and piglets in three different farrowing systems (farrowing crate (FC) and farrowing pens with temporary crating (TC), i.e. the SWAP and the JLF15). One batch of crossbred Duroc was followed in every season. There were 18 sows (183 piglets) in FC, 23 sows (243 piglets) in the SWAP TC, and 23 sows (237 piglets) in the JLF15 TC.

The crating period lasted for 5-6 days in the TC and for 32 days in the FC. The average number of weaned piglets per litter was the highest in the FC, 3-6% higher than in the case of TC (Table 9). The difference was even greater for the crushing rate, it was 2-4 times higher in the case of TC (Table 10). However, there are advantages to the SWAP and JLF15, as well. The average daily gain in the first 19 days was higher in the TC compared with the FC (Table 11).

Table 9: **Crating period, equalised litter size, and selected reproductive parameters of sows by three farrowing systems: the conventional farrowing crate (FC), and two commercially available farrowing pens with temporary crating (SWAP and JLF15)**

	FC	SWAP	JLF15	P-value
Number of sows	18	23	23	–
Crating period (number of days)[a]	31.8 ±0.5	6.0 ±0.4	5.3 ±0.3	< 0.0001
Number of total piglets born per litter	11.2 ±0.6	11.7 ±0.5	12.4 ±0.6	0.29
Number of piglets born alive per litter	10.6 ±0.6	11.0 ±0.5	11.3 ±0.6	0.69
Number of stillborn piglets per litter	0.6 ±0.2	0.6 ±0.2	0.8 ±0.2	0.27
Equalized litter size[b]	10.4 ±0.5	10.3 ±0.2	10.2 ±0.3	0.83
Number of piglets weaned per litter	9.6 ±0.4	9.0 ±0.3	9.3 ±0.3	0.34

[a] Crating period was not different between SWAP and JLF15 (P = 0.28).
[b] Establishment of the litter size (within 72 hours after birth) after cross-fostering.
Source: based on Ko *et al.* (2022)

Table 10: **Numbers of crushing events in the three farrowing systems from November 2018 to July 2019**

	FC	SWAP	JLF15
Number of crushed piglets	6	28	15
Number of live born piglets	191	252	259
Crushing rate (%) in each system	3.1	11.1	5.8

Source: based on Ko *et al*. (2022)

Table 11: **Body weight (kg) on day 3 (BW_3) and day 19 (BW_{19}), and average daily gain ($ADG_{3–19}$) (g/day) of piglets in the three farrowing systems during the lactation period**

	Farrowing system	n	Mean	SEM	P-value
Using piglet as the experimental unit					
BW3, kg	FC	183	2.02	0.03	0.71
	SWAP	243	1.88	0.03	
	JLF15	237	1.97	0.03	
BW19, kg	FC	175	5.11	0.08	0.28
	SWAP	209	5.21	0.09	
	JLF15	219	5.15	0.08	
ADG3–19, g/day	FC	175	176.88	4.20	0.23
	SWAP	206	189.49	4.77	
	JLF15	219	179.99	4.38	

Source: based on Ko *et al*. (2022)

Glencorse *et al*. (2019) performed random effects meta-analyses of several publications on crates versus pens for the number of piglets born alive, the number of stillborn piglets, pre-weaning mortality, and the number of piglets weaned (Table 12). In addition, variations in length of confinement (no confinement from loading until weaning, or partial confinement for shorter periods of time in the early stages post parturition), enrichment (no enrichment, or enrichment provided), and pen size (small, medium, or large) were also examined. There was a 14% increase in the relative risk of piglet mortality in farrowing pens compared with crates. The number of stillborn per litter was not different between pens and crates. However, when providing enrichment in the pens, there was an increase in the number of stillborn in farrowing crates versus pens. No overall effect on the number of piglets born alive or weaned was observed.

Table 12: **Piglet farrowing performance (born alive per sow, number of stillborn, total piglet mortality, number of piglets weaned) for each publication included in the meta-analysis**

First author	Year	Farrowing crate				Farrowing pen			
		Born alive	Stillborn	No. weaned	Total piglet mortality	Born alive	Stillborn	No. weaned	Total piglet mortality
Blackshaw *et al*.	1994	10.75	7		15	13.13	5		34
Chidgey *et al*.	2015	11.91		10.76	246	11.87		10.54	478
Collins *et al*.	1987	10	32	8.7	71	10.5	25	8.9	77
Condous *et al*.	2016	11.9	66	9.9	97	12.2	14	9.9	36
		11.9	66	9.9	97	12.9	32	10.3	68
		11.9	66	9.9	97	12.1	10	9.5	57
		11.9	66	9.9	97	12.5	28	9.8	82
Cronin & Smith	1992[a]								12
Cronin & Smith	1992[b]	9.1	5	8.2	11	9.4	4	7.9	9
Cronin *et al*.	2000	10.7	64	9.4	150	10.7	46	9.4	109
Gu *et al*.	2011	11.2	7		7	10.5	3		16
		11.2	7		7	10.6	3		6
Hales *et al*.	2014	15.2	102		130	15.1	440		590
		15.6	376		506	15.4	381		579
		14.8	416		470	14.7	266		382
Hales *et al*.	2015	17.1	30		88	17.1	32		97
		17.1	30		76	16.6	30		107
Illmann *et al*.	2016				23				30
Ison *et al*.	2015	12.72	7		24	9.83	6		16
Lambertz *et al*.	2015	12.8	44		80	12.8	43		89
		12.8	44		80	12.8	47		100
Lou & Hirnik	1994	8.4	45	7.15	76	8.91	24	7.54	64
McGlone & Blecha	1987	9.6	8	7.1	31	8.8	7	8	9
Melišová *et al*.	2014				25				30
Morrison *et al*.	2015	11.7	114	9.2	280	11.6	120	9.2	332
Moustsen *et al*.	2013	14.8	92	12	34	14.5	138	11.5	75
		14.8	92	12	34	14.7	125	12.1	38
		14.8	92	12	34	14.6	120	12.3	31
Payne *et al*.	2009	11	156	9.8	118	11	187	10.3	115
Pedersen, L. J. *et al*.	2011	13.34	43			14.94	35		
Yun *et al*.	2014	12.2	24		19	11.3	26		19

Source: based on Glencorse *et al*. (2019)

1.1.2. Efficiency and economic impacts combined

Quendler *et al*. (2009) evaluated physical performance, labour time requirements, and the economic performance of 8 different pen systems (3 farrowing pens (FS) and 5 farrowing cates (KS)) (Figure 5) on a large-scale piglet farm in Austria. They reported the existence of differences in litter size, piglet mortality and weight between the sow pens and the farrowing crates. The number of piglets weaned per litter varied between 8.87 (FS1) and 9.73 (KS5), and piglets were characterised by weight differences of up to 0.28 kg. In terms of labour demand, sow pens had the highest time requirements for routine, special and monitoring tasks, totalling to between 4.20 (KS4) and 5.99 (FS1) hours per sow a year. The difference in the labour time for sow pens was as high as 22.3%, while for farrowing crates, it was less than 10% which could be attributed to more efficient work operations. The output per sow or piglet varied with litter size and piglet weight, with systems related gross margins ranging from EUR 318 (FS1) to EUR 412 (KS1) per sow a year, or EUR 16.5 (FS1) to EUR 19.6 (KS1) per piglet sold. Remarkable gross margin differences of up to 29.3% for keeping sows in these systems were observed attributable to differences in the designs. Gross margin differences of up to 29.3% were recorded for sow pens and up to 7.7% for farrowing crates (Table 13). The research concluded that the sow pens available on the market could not guarantee the same productivity and financial performance as farrowing crates.

Table 13: **Performance, labour, and economic aspects of different farrowing systems**

Physical performance								
System	FS1	FS2	FS3	KS1	KS2	KS3	KS4	KS5
Piglets weaned per litter	8.87	9.05	9.29	9.68	9.43	9.56	9.62	9.73
Weight weaned per piglet	6.08	6.26	6.10	6.08	6.10	5.98	6.09	6.04
Piglet losses (%)	23.12	20.96	19.09	15.75	17.91	16.10	15.54	18.83
Labour time requirements (hour/sow/year)								
Routine task	2.95	2.06	2.27	1.97	1.98	1.98	1.98	1.99
Special task	2.38	2.06	1.96	1.86	1.85	2.18	1.88	2.05
Monitoring task	0.66	0.54	0.48	0.4	0.52	0.42	0.33	0.42
Total task	5.99	4.66	4.71	4.24	4.35	4.58	4.20	4.47
Economic performance								
Gross margin/sow/year (EUR)	318	375	377	412	391	382	404	403
Gross margin/piglet sold (EUR)	16.5	19.1	18.7	19.6	19.1	18.4	19.4	19.1
Gross margin differences (%/sow/year) (related to KS4, (Δ = 0))	–29.3	–9.7	–9.3	0	–5.4	–7.7	–1.9	–2

Source: based on Quendler *et al*. (2009)

Figure 5: **Differences in the farrowing systems evaluated by Quendler *et al*. (2009)**

Source: Quendler *et al*. (2009)

Baxter, Lawrence, and Edwards (2011) conducted an intensive literature review on the suitability of existing alternative housing systems. The main goal of the review was to establish the nexus between sustainability, pig welfare and replicability at commercial levels. They concluded that for widespread commercial implementation, alternative housing systems should equal or surpass survival rates in conventional systems while performing consistently across a range of farm circumstances. Ease of management, operator safety and economic sustainability are also key factors to consider. They outlined 12 existing alternative indoor systems which were compared against each other, conventional crates, and outdoor systems. High total piglet mortality (23.7%) in indoor group systems *vis-à-vis* conventional crates (18.3%) and outdoor systems (17.0%), together with the added capital cost (92.0% over conventional crates, 249.0% over commercial outdoor huts), resulting from extra building space provided per animal led to questioning their feasibility to deliver from an economic perspective (Table 14).

Table 14: **Performance, labour, and economic aspects of different farrowing systems**

System	Physical performance				Labour	Economic performance
	Litter Size	Born alive	Total mortality (%) as corrected for by litter size of 11	Live-born mortality (%) as corrected for by litter size of 11	Hours/ sow/ year	Cost/sow place (£)
Crate						
Conventional	11.1	10.4	18.1	11.3	6.96	1,843
Modified						
Turnaround/Ellipsoid	10.0	8.9	18.3	13.4	–	2,912
Hinged/Swingside	11.9	10.9	15.6	9.9	6.27	1,976
Pen						
Simple	11.7	11.3	19.3	12.8	12.76	1,989
Designed	11.8	10.8	15.0	10.2	7.17	2,165
Sloped/Hill-side	10.7	10.1	20.2	12.8	–	1,298
Mushroom	12.0	11.3	15.4	–	–	2,047
Group						
Ljungstrom	12.5	11.9	25.0	19.3	36.00	2,094
Thorstensson	12.1	11.3	21.5	17.0	18.10	3,543
Free access then group	10.5	10.9	19.7	18.0	15.10	2,349
Crated for farrowing	11.1	11.0	16.8	18.3	–	2,367
Family pen	13.0	10.8	18.3	14.8	44.94	4,593
Outdoor						
Kenel, Solari	11.7	108	19.0	13.6	–	1,856
Outdoor	11.9	9.2	15.2	15.0	–	1,014

Source: based on Baxter, Lawrence, and Edwards (2011)

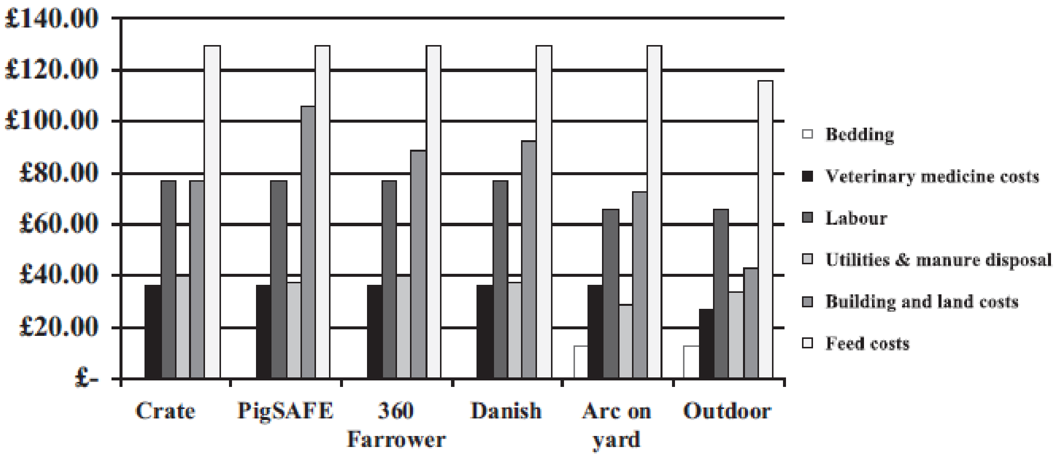
Seddon *et al.* (2013) constructed a production cost simulation model for comparing the different non-cage farrowing systems (PigSAFE, 360° Farrower, Danish, Arc on yard, Outdoor) with the application of standard farrowing crates in the UK. In each system, the pre-weaning mortality rate was 12.0%. The highest difference (+3.5%) in the cost of production per sow was calculated for PigSAFE *vis-á-vis* the farrowing crate, which relates to the larger place allowance for sows in the case of the former (Table 15). For the outdoor system, the production cost per sow was estimated 14% less compared to the farrowing crate, which can be explained by the almost 50% lower cost of buildings and land (Figure 6).

Table 15: **Total production cost calculated for different farrowing sow systems in the UK**

Systems	Crate	PigSAFE	360° Farrower	Danish	Arc on yard	Outdoor
Sow (£/sow)	790.56	817.82	802.67	803.55	776.29	682.00
Weaner (£/ 8 kg weaner)	34.87	36.08	35.41	35.45	34.24	31.64

"Crate assumes part slatted floor system, 360° Farrower assumes fully slatted. A straw yard with scrape through passage and dump feeding was used as a common gestation sow system for indoor herds."
Source: based on Seddon *et al.* (2013)

Figure 6: **The evolution of variable costs per sow in different farrowing sow systems in the UK**



Source: Seddon *et al.* (2013)

The research by the Agricultural and Horticultural Development Board (ADHB, 2020) on the implications of adopting different farrowing systems across the British pig sector presented mixed results. Research evidence showed that in some cases it is possible to achieve pre-weaning mortality rates comparable with conventional farrowing crates, whereas in others, rates are higher. But achieving comparable pre-mortality rates alone is not enough as production cost is a derivative of other factors too. Most housing system designs require additional floor space and thereby increase the cost of production. It was assumed that production cost will increase due to the increasing use of straw/bedding and the increases in feed consumption. AHDB presented theoretical estimates for the cost of pig production, based on the InterPIG methodology, using three mortality rates (12.3%, that is the actual for 2019, and two alternative systems with 14.0% (S1) and 18.0% (S2)). It was concluded that pre-weaning mortality rates above 14.0%, irrespective of the system, could challenge the long-term economic viability of indoor pig production Table 16).

Table 16: **Economic impacts of the changes in pre-weaning mortality**

	2019 actual	S1	S2
Pre-weaning mortality	12.34%	14.00%	18.00%
Transfer weight from breeding to rearing unit	7.3kg	7.3kg	7.3kg
Sow feed	1,370kg	1,370kg	1,370kg
Cost/purchase price of gilts	£220	£220	£220
Cost of building/sow (incl. for farrowing, lactation, and dry)	£2,100	£2,100	£2,100
Cost of straw and bedding/sow	£31.85	£31.85	£31.85
Cost of disposal of dead animals/sow	£12.89	£12.89	£12.89
Cost of production, p/kg deadweight			
Feed	89.76	90.04	90.75
Other variable costs	11.39	11.55	11.94
Labour	12.47	12.62	12.99
Building, finance & miscellaneous	34.92	35.17	35.4
Total costs	148.54	149.37	151.51
Increase from base	–	0.83	2.97

Source: based on AHDB (2020)

Besides pre-weaning mortality, other physical performance metrics – likely to be influenced by the transition to alternative farrowing systems – were also elaborated on (Table 17). The associated changes could still challenge the long-term economic viability of pig farming.

Table 17: **Economic impacts of the changes in other key physical performance metrics**

	2019 actual	Constant mortality	S1	S2
Pre-weaning mortality	12.34%	12.34%	14.00%	18.00%
Transfer weight from breeding to rearing unit	7.3kg	7.6kg	7.6kg	7.6kg
Sow feed	1,370kg	1,470kg	1,470kg	1,470kg
Cost/purchase price of gilts	£220	£220	£220	£220
Cost of building/sow (incl. for farrowing, lactation, and dry)	£2,100	£2,100	£2,100	£2,100
Cost of straw and bedding/sow	£31.85	£32.34	£32.34	£32.34
Cost of disposal of dead animals/sow	£12.89	£12.89	£13.33	£14.41
Cost of piglet creep feed/sow	–	£1.37	£1.35	£1.28
Cost of production, p/kg deadweight				
Feed	89.76	90.64	90.94	91.70
Other variable costs	11.39	11.39	11.55	11.94
Labour	12.47	12.47	12.62	12.99
Building, finance & miscellaneous	34.94	34.98	35.26	35.98
Total costs	148.54	149.48	150.36	152.61
Increase from base	–	0.94	1.81	4.06

Source: based on AHDB (2020)

In terms of alternative housing costs, AHDB concluded that alternative indoor farrowing systems are more expensive than conventional farrowing crates, explained by the requirement for extra floor space. According to the study, farrowing crates of 4 m^2 floor space per sow were estimated to cost £3000-£3500 (including the cost of buildings). Alternative farrowing systems requiring 6 m^2 floor space per sow were estimated £2000 over the base cost, while those requiring 8 m^2 were estimated £4000 over the base cost. These additional costs of buildings significantly increase the cost of pig production. A 6 m^2 pen adds around 2p/kg deadweight to the base cost while an 8 m^2 pen adds twice as much. With margins averaging only 1 p/kg deadweight over the past decade, this could represent a significant challenge to the economic viability, especially when combined with higher pre-weaning mortality rates and other additional costs (Table 18).

Table 18: **Economic impact of the changes in floor space**

Key costs and physical performance metrics							
	2019 actual	Constant mortality		S1		S2	
		6m²	8m²	6m²	8m²	6m²	8m²
Pre-weaning mortality	12.34%	12.34%	12.34%	14.00%	14.00%	18.00%	18.00%
Transfer weight from breeding to rearing unit	7.3kg	7.6kg	7.6kg	7.6kg	7.6kg	7.6kg	7.6kg
Sow feed	1,370kg	1,470kg	1,470kg	1,470kg	1,470kg	1,470kg	1,470kg
Cost/purchase price of gilts	£220	£220	£220	£220	£220	£220	£220
Cost of building/sow (incl. for farrowing, lactation, and dry)	£2,100	£2,570	£3,040	£2,570	£3,040	£2,570	£3,040
Cost of straw and bedding/sow	£31.85	£32.34	£32.34	£32.34	£32.34	£32.34	£32.34
Cost of disposal of dead animals/sow	£12.89	£12.89	£12.89	£13.33	£13.33	£14.41	£14.41
Cost of piglet creep feed/sow	–	£1.37	£1.37	£1.35	£1.35	£1.28	£1.28
Cost of production, p/kg deadweight							
	2019 actual	Constant mortality		S1		S2	
		6m²	8m²	6m²	8m²	6m²	8m²
Feed	89.76	90.64	90.64	90.94	90.94	91.70	91.70
Other variable costs	11.39	11.39	11.39	11.55	11.55	11.94	11.94
Labour	12.47	12.47	12.47	12.62	12.62	12.99	12.99
Building, finance & miscellaneous	34.92	36.80	38.63	37.12	38.98	37.93	39.88
Total costs	148.54	151.31	153.13	152.22	154.08	154.56	156.51
Increase from base	–	2.77	4.59	3.67	5.53	6.01	7.96

Source: based on AHDB (2020)

Wageningen University (KWIN Veehouderij 2021-2022) estimated slightly lower costs. According to their calculations, a conventional farrowing pen costs EUR 4,644, whereas a free farrowing pen (7 m^2) costs EUR 5,757. Marginal investment per square meters amounts to EUR 485, resulting in an expected investment of EUR 5,515 at 6.5 m^2 and EUR 6,000 per farrowing pen at 7.5 m^2. Skipping the installation of a fixation system saves about EUR 300 per farrowing pen. In the case of a 7.0 m^2 farrowing pen (EUR 5,757) the additional EUR 1,123 cost means a 24% more expensive structure than a conventional pen and about EUR 30 per sow or EUR 1 per piglet additional annual housing cost.

The transition is foreseen to impact the cost of both homebred and purchased gilts. Although breeding companies might be able to absorb the additional costs, it is uncertain whether they would be willing to do so, whereas those breeding their own gilts for replacement would be expected to incur the additional costs (Table 19).

Table 19: **Economic impacts of the changes in the cost/price of gilts**

Key costs and physical performance metrics							
	2019 actual	Constant mortality		S1		S2	
		6m²	8m²	6m²	8m²	6m²	8m²
Pre-weaning mortality	12.34%	12.34%	12.34%	14.00%	14.00%	18.00%	18.00%
Transfer weight from breeding to rearing unit	7.3kg	7.6kg	7.6kg	7.6kg	7.6kg	7.6kg	7.6kg
Sow feed	1,370kg	1,470kg	1,470kg	1,470kg	1,470kg	1,470kg	1,470kg
Cost/purchase price of gilts	£220	£223	£225.50	£223	£225.50	£223	£225.50
Cost of building/sow (incl. for farrowing, lactation, and dry)	£2,100	£2,570	£3,040	£2,570	£3,040	£2,570	£3,040
Cost of straw and bedding/sow	£31.85	£32.34	£32.34	£32.34	£32.34	£32.34	£32.34
Cost of disposal of dead animals/sow	£12.89	£12.89	£12.89	£13.33	£13.33	£14.41	£14.41
Cost of piglet creep feed/sow	–	£1.37	£1.37	£1.35	£1.35	£1.28	£1.28
Cost of production, p/kg deadweight							
	2019 actual	Constant mortality		S1		S2	
		6m²	8m²	6m²	8m²	6m²	8m²
Feed	89.76	90.64	90.64	90.64	90.94	91.70	91.70
Other variable costs	11.39	11.47	11.53	11.62	11.69	12.02	12.09
Labour	12.47	12.47	12.47	12.62	12.62	12.99	12.99
Building, finance & miscellaneous	34.92	36.80	38.63	37.12	38.98	37.93	39.88
Total costs	148.54	151.39	153.27	152.30	154.22	154.64	156.66
Increase from base	–	2.84	4.73	3.75	5.68	6.10	8.12

Source: based on AHDB (2020)

AHDB found that production benefits, such as lower rearing mortality and/or an extra piglet born alive per litter, might be achieved in well-managed alternative indoor farrowing systems. They highlighted the need for training of stockpersons and sows, and the consistent use of the new farrowing system of choice for gaining experience as potential management pathways to optimise productivity. Implementing sound and sustainable management practices could help offset additional costs associated with the increased floor space per sow.

In their economic analysis of the pig industry's transition to group sow housing, Mitchell *et al*. (2017) compared different forms of housing in the Netherlands, Spain, and Brazil. These case studies, based on data from 'typical farms' (employing the *agri benchmark* TIPI-CAL production and accounting model) and coupled with Focus Groups of producers to validate the results, demonstrated that group sow housing systems are viable in terms of economics and productivity. Often-cited perceptions of a negative impact on efficiency, higher operating costs or lower profits were not found. Investment costs are affected as the adoption of group housing implies several changes in the system, but some of these changes, such as the introduction of electronic sow feeding, could also increase efficiency. Evidence from the individual case studies showed better productivity for group housing, with more piglets at higher weights. In general, because of higher productivity and roughly similar/slightly lower feed costs and labour input across group housing systems, group housing offered a higher level of profitability.

1.1.3. Environmental impacts

Bandekar *et al*. (2019) evaluated the impact of alternative management strategies, i.e. the use of gestation pens versus individual stalls, on greenhouse gas (GHG) emissions, cumulative energy demand, and cumulative water consumption in the US pig industry by applying Life Cycle Assessment (LCA) methodology. They observed lower GHG emissions, energy and water use for pens and concluded that the use of group gestation pens rather than individual stalls resulted in a decrease in the global warming potential (GWP), as well as in energy and water consumption. Further reductions were observed for CH_4 emissions by 2.9% and N_2O emissions by 2.1%. The use of gestation pens reduced overall feed consumption by 1.9%, or 37,758 kg of feed a year for a herd of 500 sows; however, due to the space requirements for sows in stalls compared to pens, the barn infrastructure requirements for pens are 65% larger. This additional infrastructure requirement increases the GWP, which, amortised over an expected 10-year life of the barn, partially offsets the lower operational GWP.

1.1.4. Farm management impacts

No literature on the farm management impacts with reference to education and age of the farm manager, participation in vertical coordination, etc. was found.

1.1.5. Expert consultation

Since animal welfare issues and the technology associated with them change and develop at a rapid pace every year, the scientific literature is not able to keep up with several aspects, therefore, it is useful supplementing the information with expert knowledge. We consulted Robert Hoste, pig production economist from Wageningen Economic Research, who has a comprehensive insight into the latest technologies and various local solutions.

Pre-weaning piglet mortality

Expert observations meet the findings of the literature: the main hardship to overcome is the higher pre-weaning piglet mortality in free farrowing systems than in conventional ones. However, there are examples with opposite results, e.g., Danish pig farmer Asgar Krogsgaard started a free farrowing system 4 years ago. In his experience, pre-weaning mortality and sow mortality are lower in this system than in a conventional system. Moreover, labour pleasure of the employees has improved significantly. On the farm of Theo Vernooij in Nijkerk, Netherlands, sows are no longer confined as of 5 days post-partum. The farmer experienced a reduction in mortality. There are technological efforts to solve the problem of crushing, e.g., the pig farm of Aeres Agricultural College in the Netherlands applies the WellFarrowing free-range farrowing pen. This pen has a movable 'balance floor'. When the sow stands up, sensors give a signal inducing the floor to lift, so the piglets cannot reach the sow. After the sow lies down, the floor declines back. According to Gerben Nooijen from Nooijen Flooring, piglet mortality can be reduced by confining the sow for up to 1 week and/or applying a 'balance floor'. Bart Hooijer, the Director of Vereijken Group claims that the application of a 'balance floor' is expected to reduce the number of crushings. It can only be applied in a farrowing pen where the sow is confined during some days around farrowing. However, the installation cost of balance floor is relatively high, amounting to some EUR 500-600. However, new stables are typically associated with higher performance. New stables are clean, have up-to-date technology and layout, and these factors may be responsible for the reduction in mortality, regardless of whether the stable is a free farrowing or a conventional system.

Weaning weight and suckling

There is positive feedback on the weaning weight of piglets in free farrowing systems. Anita Hoofs, senior animal welfare researcher at Wageningen Livestock Research found a 500-gram heavier weaning weight of the piglets in the Pro Dromi system. However, Gerben Nooijen estimates this to be lower. Higher weaning weight results in a higher daily gain in the rearing (both because the piglets are healthier/stronger and to the fact that daily gain is higher anyhow at a higher living weight). In the Welsafe free farrowing system of ACO Funki (Denmark) sow is confined during and only in the first few days after farrowing, and they claim a 1 kg higher weaning weight compared to conventional systems. The reason behind the higher weaning weight might be the better quality of milk and the stronger milk let down of the sows. Furthermore, free walking of the sow leads to more frequent suckling. Pedersen, M. L. *et al.* (2011) compared the milk intake and weight gain of piglets and the duration of milk let down of the sows in farrowing crates and farrowing pens. They observed a longer duration of milk let down of sows and higher weight on the 28th day of piglets in farrowing pens.

Application of free farrowing system

The exFree farrowing systems have larger space demand than conventional ones. The required minimal area per sow differs in the legislation of countries, and neither there is a consensus among experts. Anita Hoofs is an ambassador to the minimal area of 7 or 7.5 m^2 per sow in free farrowing. She claims that this area is necessary for integrating all functions: room to eat, move and defaecate, as well as for piglets to eat, drink and sleep. Reconstruction of existing stables to apply free farrowing pens is a possible solution, as long as an additional place can be constructed for the extra required living area. Trying to execute the transition within the existing building is hardly possible, since the number of sows has to be reduced then, and the manure pit and ventilation design do not fit the new system. Specific situations are conceivable where farmers outsource e.g., the piglet rearing to gain room in the existing stable for reconstruction towards free farrowing. If a sow farm, however, has to apply it within the existing barn, without the ability to extend the barn, costs are much higher. Apart from the value loss of the existing barn, consequently, fewer places will be available within a given construction, and the existing manure pits, floor types, ventilation system, etc. do not suit larger free farrowing pens. Probably existing farrowing rooms will be used, but also some part of the area for pregnant sows and rearing piglets has to be taken into account to cover the need for an area for the enlarged farrowing rooms. In the most optimal situation, a reduction of sow numbers of just 10% has then to be taken into consideration. This leads to a higher production cost since fixed costs (incl. labour) will be covered by fewer animals.

The human workforce plays a more significant role in free farrowing systems than in conventional ones. Experience from Poland shows that where performance is concerned, the hygiene in the pens is a crucial factor, and due to the free moving of sows in the free farrowing-lactating pens, keeping the piglet drinker, the floor and the piglet corner clean requires almost constant supervision.

1.1.6. Consumer price impacts

No literature on the direct impact on pork consumer prices was found. The countries in Europe, where strict animal welfare legislation has already been implemented, are characterised by high consumer purchasing power, and can therefore be considered unique (e.g. Switzerland or Sweden). Therefore, the applicability of the lessons from these countries is limited for many of the EU Member States, especially for those with lower consumer purchasing power. From the EUPig entries of the EU Pig Investigation Group (2018), it can be concluded that premium consumer markets and the expectation of higher prices for piglets are major incentives for pig farmers to invest in loose farrowing systems. However, an EU-wide ban on the use farrowing crates (and gestation stalls) would result in a completely different market situation by affecting all segments of the EU pork market. Although it is difficult to assess the response by consumers, it could be anticipated with a high probability that the cost of the additional investments and the increased cost of production will be internalised in the consumer price of pork.

1.1.7. Technological parameters analysed in the literature

Below is a list of the physical efficiency and production cost indicators used in the literature, supplemented by further indicators for consideration, as suggested by professional experts.

Production efficiency indicators	References
Unsuccessful fertilizations [%]	Anil *et al*. (2005); Chapinal *et al*. (2010)
Farrowings versus successful fertilizations [%]	Anil *et al*. (2005); Chapinal *et al*. (2010)
Early miscarriages [%]	Anil *et al*. (2005)
Litters/sow/year Length of inter-farrowing period and decreased number of litters per sow per year	Chidgey *et al*. (2015); Quendler *et al*. (2009)
Lactation period [days]	Chidgey *et al*. (2015)
Empty period [days]	Einarsson *et al*. (2014); Morgan *et al*. (2018)
Average weight of gilts at first breeding [kg]	suggested by consulted professionals
Average sow parity	Chidgey *et al*. (2015); Zotti *et al*. (2017); Buoio – Costa (2020); Mazzoni *et al*. (2018), Hales *et al.* (2014)
Average weight of sows housed [kg]	suggested by consulted professionals
Sow mortality [%]	Karlen *et al*. (2007)
Sow replacement rate [%]	suggested by consulted professionals
Piglet mortality [%] / Piglet survival - pigs born dead per litter or per sow - pigs born alive per litter or per sow - pigs mummified per litter or per sow - pre-weaning mortality [%]	Chidgey *et al*. (2015); Zotti *et al*. (2017); Buoio – Costa (2020); Mazzoni *et al*. (2018); Hales *et al*. (2014); Anil *et al*. (2005); Einarsson *et al*. (2014); Karlen *et al*. (2007); McGlone *et al*. (2004).; Morgan *et al*. (2018); Glencorse *et al*. (2019); Ko *et al*. (2022); Zhang *et al*. (2020)
Number of crushed piglets - at first day - from 1-3 days - 3 days to weaning Total crushed	Buoio – Costa (2020); Karlen *et al*. (2007); Zhang *et al*. (2020)
Number of weaned piglets per sow	suggested by consulted professionals
Average weight of piglets at birth [kg]	Zotti *et al*. (2017); Karlen *et al*. (2007); McGlone *et al*. (2004); Ko *et al*. (2022)
Average mortality weight of piglets [kg or age (day)]	suggested by consulted professionals
Weaned piglets [piglets/sow, kg/sow, piglets/m^2, kg/m^2]	Chidgey *et al*. (2015); Quendler *et al*. (2009); Glencorse *et al*. (2019)
Rearing mortality [%]	suggested by consulted professionals
Labour [work hours/sow/year]	Baxter *et al*. (2011); Quendler *et al*. (2009)
Feed consumption [kg/day/sow]	Chapinal *et al*. (2010); Karlen *et al*. (2007)
Feed consumption of weaners [kg/day/weaner]	suggested by consulted professionals
Average breastfeeding time [days]	suggested by consulted professionals
Average weight of spent sows [kg/sow]	suggested by consulted professionals
Production scale: numbers of sows, piglets, weaners, fatteners	suggested by consulted professionals
Surface area for farrowing [m^2]	Glencorse *et al*. (2019); Ko *et al*. (2022)
Space allowance per sow in the farrowing pen [m^2 per sow per farrowing pen]	suggested by consulted professionals
Change in the rotation rate in the farrowing pen (when the size of the farrowing area is not enlarged)	suggested by consulted professionals
Surface area for gestation [m^2]	suggested by consulted professionals
Stocking density [sow/m^2]	Bench et al. (2013)
Predator threat in some alternative systems (increase in injuries and mortality)	suggested by consulted professionals
Pressure from ecto- and endoparasites in some alternative systems	suggested by consulted professionals

Source: own elaboration

Production cost and revenue indicators	References
Housing and inventory investment costs [euro/m^2]	AHDB (2020)
Investment costs [euro/sow place]	Baxter *et al*. (2011), AHDB (2020)
Costs of securing farms against predators in some alternative systems	suggested by consulted professionals
Costs of maintaining outdoor runs in some alternative systems	suggested by consulted professionals
Other additional costs for the maintenance of alternative systems	suggested by consulted professionals
Cost of depreciation of existing buildings over time	suggested by consulted professionals
Land rents (euro/m^2), price of land (euro/m^2)	suggested by consulted professionals
Cost of guilts (euro/sow)	AHDB (2020)
Feed cost (euro/sow)	suggested by consulted professionals
Labour cost (euro/sow)	suggested by consulted professionals
Veterinary costs (euro/piglet)	suggested by consulted professionals
Cost of antimicrobials and medicines, including of those mixed in feed (euro/piglet)	AHDB (2020)
Cost of disposal and removal of animal carcasses (euro/sow or euro/piglet)	AHDB (2020)
Cost of cleaning and disinfection (euro/sow, euro/m^2)	suggested by consulted professionals
Cost of water (euro/sow, euro/m^2)	suggested by consulted professionals
Cost of electricity (euro/sow, euro/m^2) Heating of piglets (energy costs)	suggested by consulted professionals
Litter cost (Straw&Bedding) (euro/m^2)	AHDB (2020)
Cost of manure disposal (euro/sow, euro/m^2)	suggested by consulted professionals
Cost of natural and artificial insemination (euro/sow)	suggested by consulted professionals
Fixed costs (euro/m^2)	suggested by consulted professionals
Selling price of piglets (euro/piglet, euro/kg)	Mitchell *et al*. (2017)
Selling price of spent sows (euro/sow, euro/kg)	Mitchell *et al*. (2017)
Gross margin/sow/year	Quendler *et al*. (2009)
Gross margin/piglet sold/year	Quendler *et al*. (2009)

Source: own elaboration

1.1.8. Examples for best practices in free farrowing systems

Examples for top 5 best practices in free farrowing systems in the European Union evaluated by the EU Pig Innovation Group (Vandelannoote *et al*., 2018) are described briefly below, with specific features focused on.

WellFairPenn – Denmark

The practice consists of a special farrowing pen with a pendulum installed to prevent crushing of the piglets. The sows are loose throughout the period from insertion to weaning.

Space allowance	The pen is easily accessible for the sow and the staff, and it provides 7.7 m² i.e., 65% more space than the more classic systems.
Vet & med costs increase for piglets and decrease for sows	The pendulum prevents the sow from rolling over, but it does not hinder it in getting up or lying down. Due to the solid floor, less sows with shoulder sores are observed. On the other hand, piglets in pens with solid floor in part of the lying area have often more knee injuries. A hygiene powder is recommended.
Litter	Litter material needed.

Free lactating sows in group – France

Room for 8 sows enables to raise the sows either alone, or in groups of 2 or 4. Sows are raised restrained from the first day in the room and then have access to the backside pen (3.7 m² surface) from 3 to 7 days after farrowing. Piglets can access the free-range pen half a day before the sows.

Performance	Weaning performance is similar to classic systems (11-12 piglets weaned/sow). With group lactating sows, the only decreasing performance indicator is weaning weight (cross suckling is not in favour of growth).
Crates	Sows farrow in traditional farrowing crates.

Be Free animal welfare farrowing pen for sows – Austria

Sows are allowed to move freely in the farrowing pen after temporary fixation around farrowing to protect new-born piglets from crushing. In the standard situation, the crate is closed during farrowing and opened several days after. The sow has room to turn around, but not enough to separate lying and dunging.

Space allowance	Unique patented geometry with 4.2 m² for lying and movement, 6 m² pen area in total.
Performance	Enhanced safety of new-born piglets, but no performance data available.
Labour	This pen has advantages that facilitate daily care and animal welfare.

Free lactating sows in low-energy building – France

Sows are kept loose in a low-energy building. Piglet nests in the farrowing room only heat up the equivalent of 10% of the room + nests in post-weaning. A wood boiler is used to produce heat. The air scrubbers account for 30% of the total energy consumption of the farm, operating 8,000 hours a year. Solar panels of 650 m² surface produce electricity. Before farrowing, fences of the farrowing crate are open. They close the sow cage two days before the estimated birth.

Space allowance

Boxes of 5.76 m² per sow (square of 2.40 m), four boxes set up forming a star.

Performance

Individual box management for increased piglet weights, 0.4-0.5 piglets crushed per litter on average.

Birth management for the success of loose farrowing systems – Austria

The farm is equipped with the Pro Dromi loose-farrowing system.

Space allowance

7.5 m² space is offered per sow with the possibility for temporary confinement, and a big creep where piglets can be locked.

Performance

Loss of piglets during lactation averaged 25% in the first 3 years, 50% of these were caused by crushing. By changing the genetics from Austrian pure large white to Swiss pure large white, optimising feeding, providing soaked linseed 5 days prior to and for 3 days after birth, cleaning troughs thoroughly, locking up piglets in creep on day of birth while feeding sows, taking care of piglets during feeding on the second and third day by watching sows, providing jute bags and hay as nesting material on floor in addition to a hay rack, using skin drying agents and bedding material in the creep and on the floor, losses were reduced to 15%.

Benefits

- number of litters per sow a year increased by 9% from 2.2 to 2.4
- mortality parameters declined significantly: pigs born dead decreased by 21% and pre-weaning mortality fell by 38% from 25.2% to 15.6%, sow mortality decreased by 2%
- rearing daily weight gain increased by 14% from 448 to 511 g/day

Costs

- new birth management strategies led to the increase in time usage per sow by 20% a year
- sow feed consumption increased by 15% up to 1150 kg per sow a year
- initial investment cost related to changing the genetics from Austrian pure large white to Swiss pure large white amounted to EUR 13,230 (per ca. 140 sows, depreciated in three years), breeding permission costs EUR 1,932 a year, and additional enrichment and bedding material is assumed to cost EUR 5 per sow a year.

1.1.9. General observations

Data challenges, especially representation and reliability, make most of the literature reviewed depend on expert opinion and simplifying assumptions, therefore conclusions should be handled with caution.

Specifically, limited or no information are available regarding

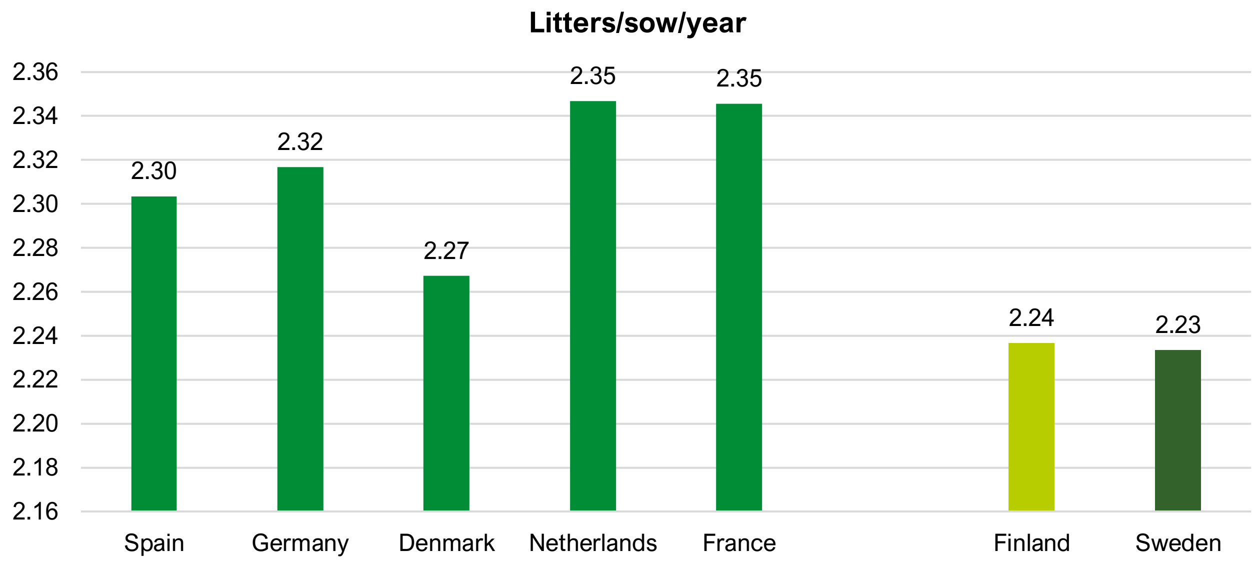
- production efficiency and economic impacts of the different pig breeds in different housing systems
- the amount of feed used in the different housing systems, and supplementary feed used for piglets in group housing
- veterinary treatments in group housing (e.g., treatment of group housing injuries, etc.)
- the amount of litter used in the alternative housing systems where the floors are partly or wholly covered with e.g., straw
- fertility index, percentage of pregnancies, replacement rate of sows in the different housing systems
- labour use in the different housing systems
- the detailed real costs of the necessary investments for transitioning.

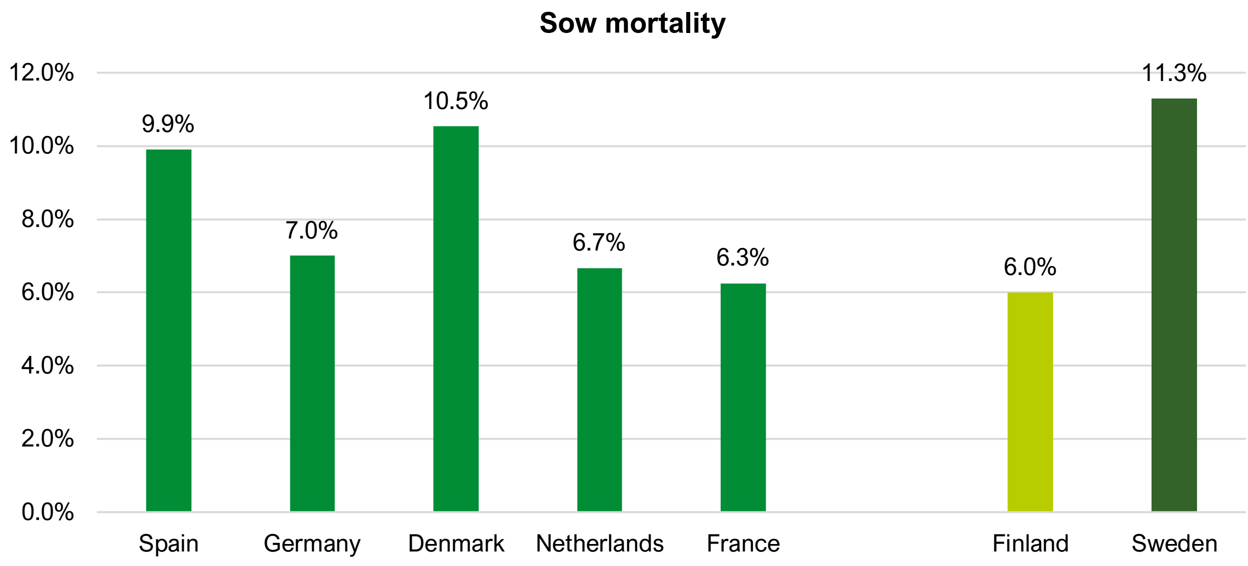
There is a high likelihood for the existence of an imperfect relationship between economic and environmental performance measures, with profitability tracking well with resource efficiency (feed, space allowance), but indirectly with emission intensity.

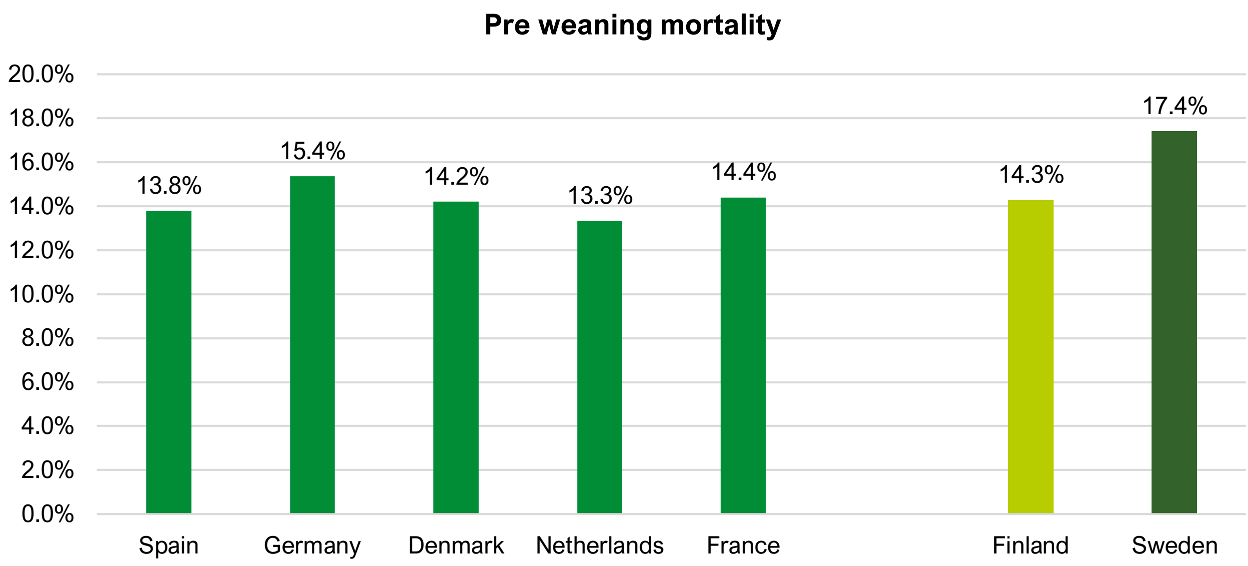
The lack of a universally accepted weighting system and methodology in the development of welfare indices makes it difficult to defining which is the superior system across all situations.

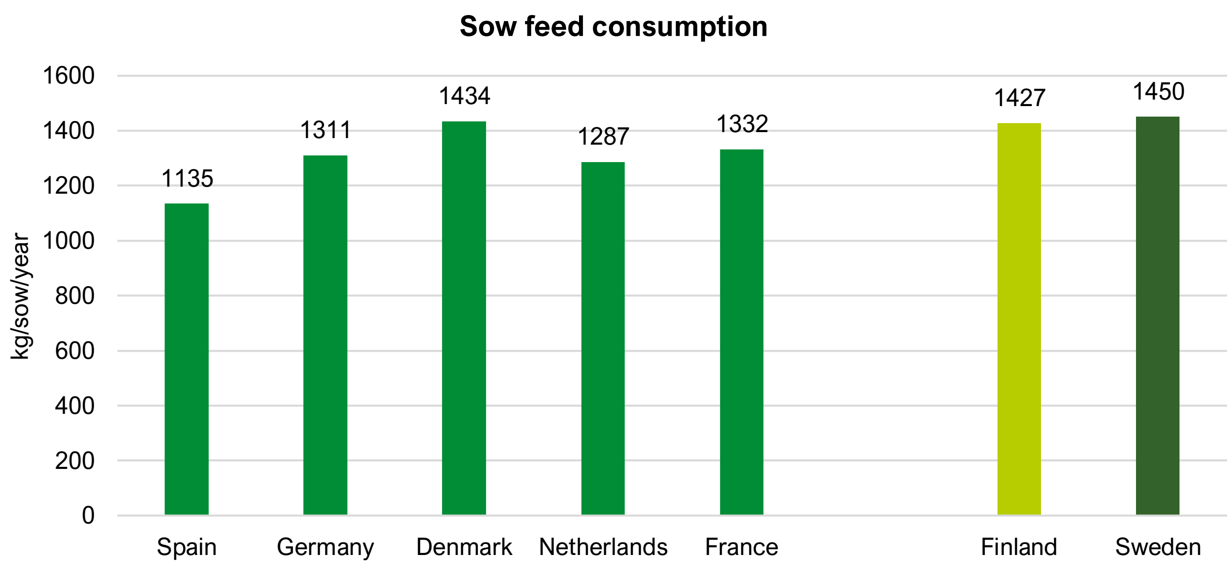
1.1.10. Comparison based on the InterPIG database

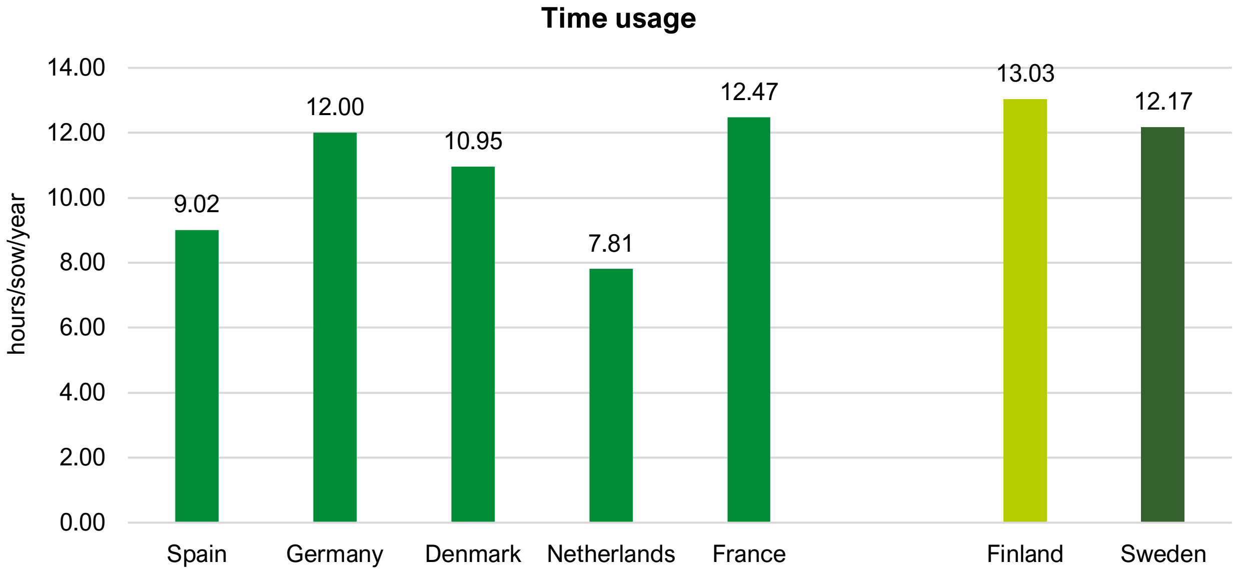
The figures below represent the average values for period 2017-2019. The last year for which data is available, 2020 was excluded from this analysis because of the extreme market situation. The countries for benchmarking are Sweden and Finland. In Sweden routine fixing of sows during farrowing has not been allowed since 1993, Swedish farmers are thus well adapted to the free farrowing system. In Finland, free farrowing is relatively widespread. Around 40% of the sows coordinated by Atria, one of the leading meat and food companies in Northern Europe, which provides data for InterPIG are kept in the free farrowing system.

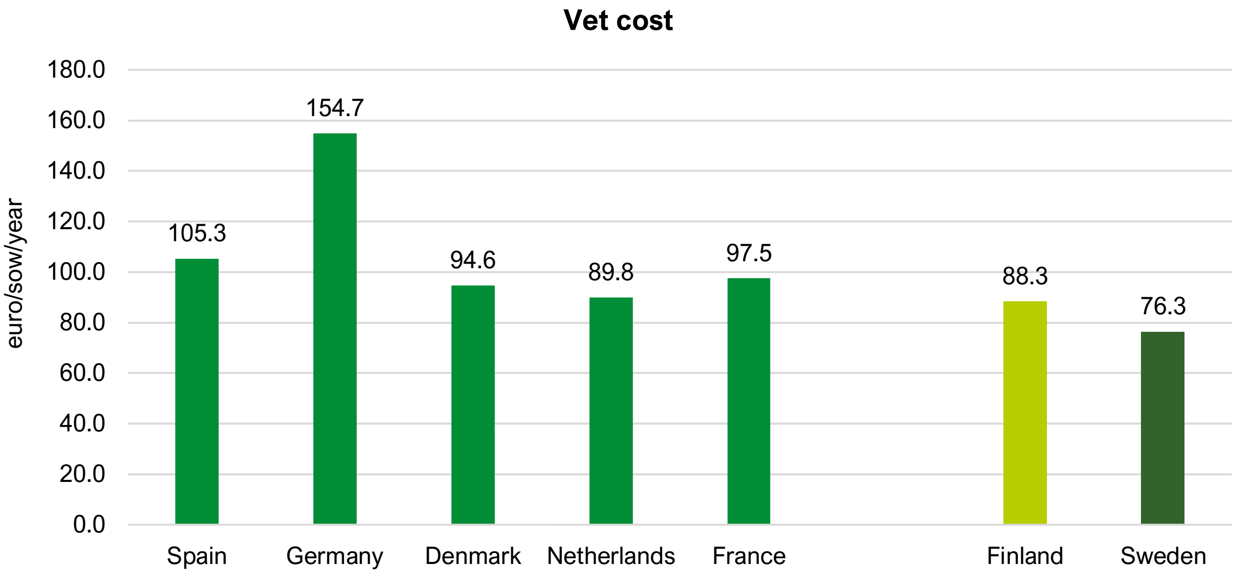


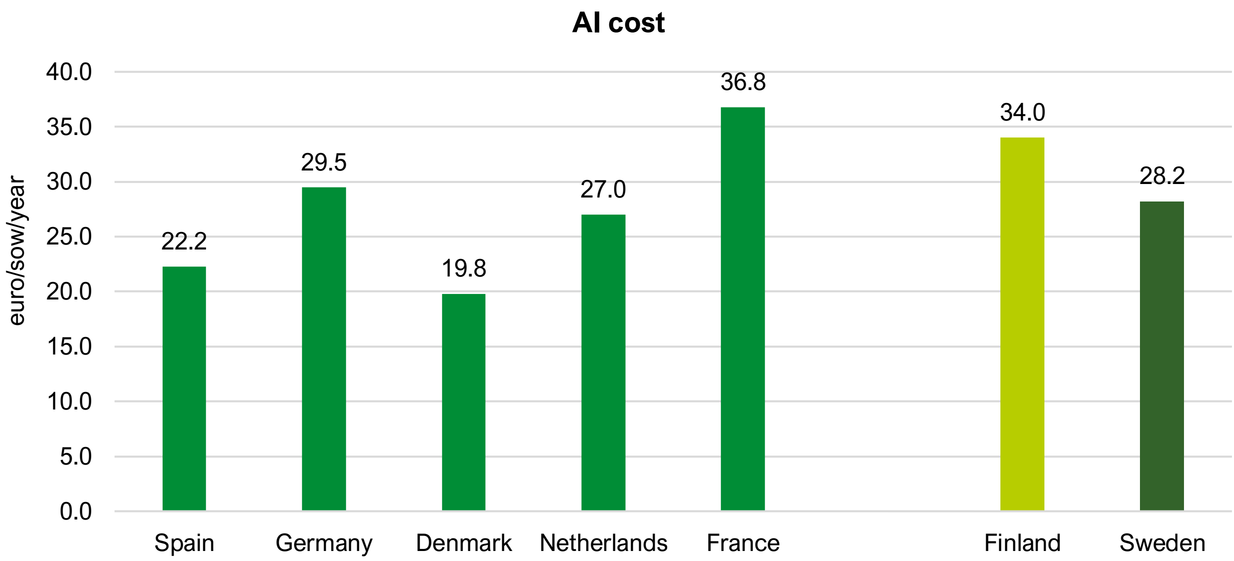

Sow mortality
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
9.9%
7.0%
10.5%
6.7%
6.3%
6.0%
11.3%
Spain
Germany
Denmark
Netherlands
France
Finland
Sweden


Pre weaning mortality
20.0%
18.0%
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
13.8%
15.4%
14.2%
13.3%
14.4%
14.3%
17.4%
Spain
Germany
Denmark
Netherlands
France
Finland
Sweden


Sow feed consumption
kg/sow/year
1600
1400
1200
1000
800
600
400
200
0
1135
1311
1434
1287
1332
1427
1450
Spain
Germany
Denmark
Netherlands
France
Finland
Sweden


Time usage
hours/sow/year
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
9.02
12.00
10.95
7.81
12.47
13.03
12.17
Spain
Germany
Denmark
Netherlands
France
Finland
Sweden


Vet cost
euro/sow/year
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
105.3
154.7
94.6
89.8
97.5
88.3
76.3
Spain
Germany
Denmark
Netherlands
France
Finland
Sweden


AI cost
euro/sow/year
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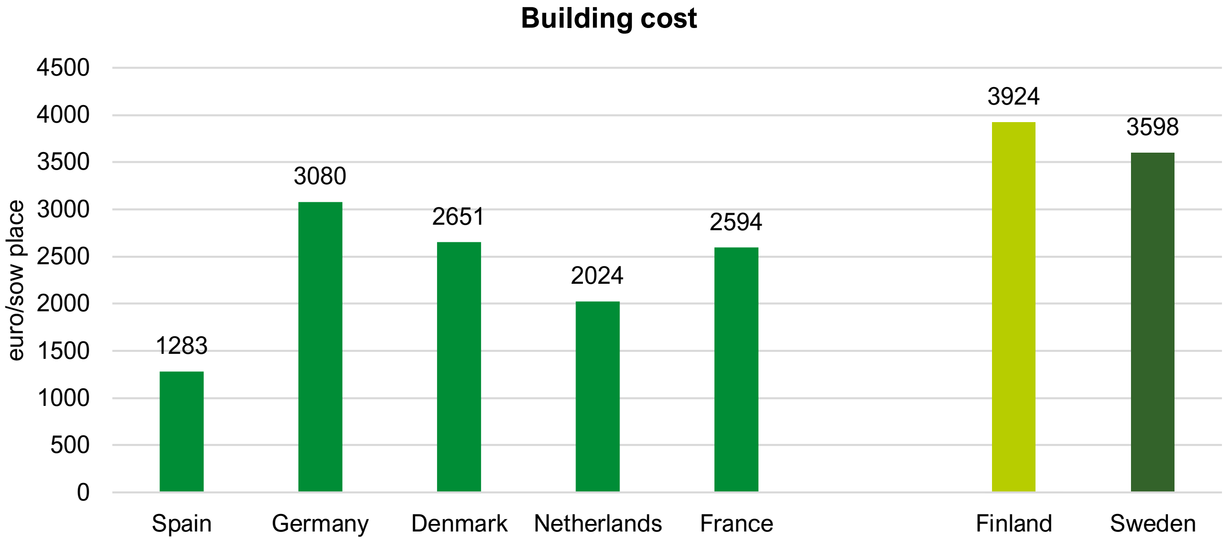
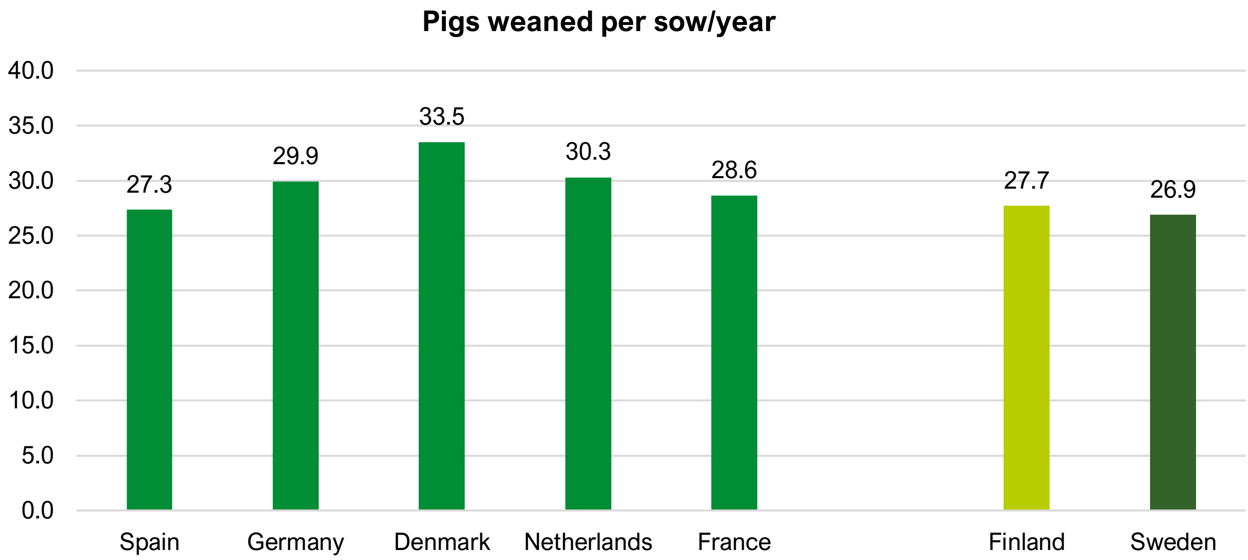
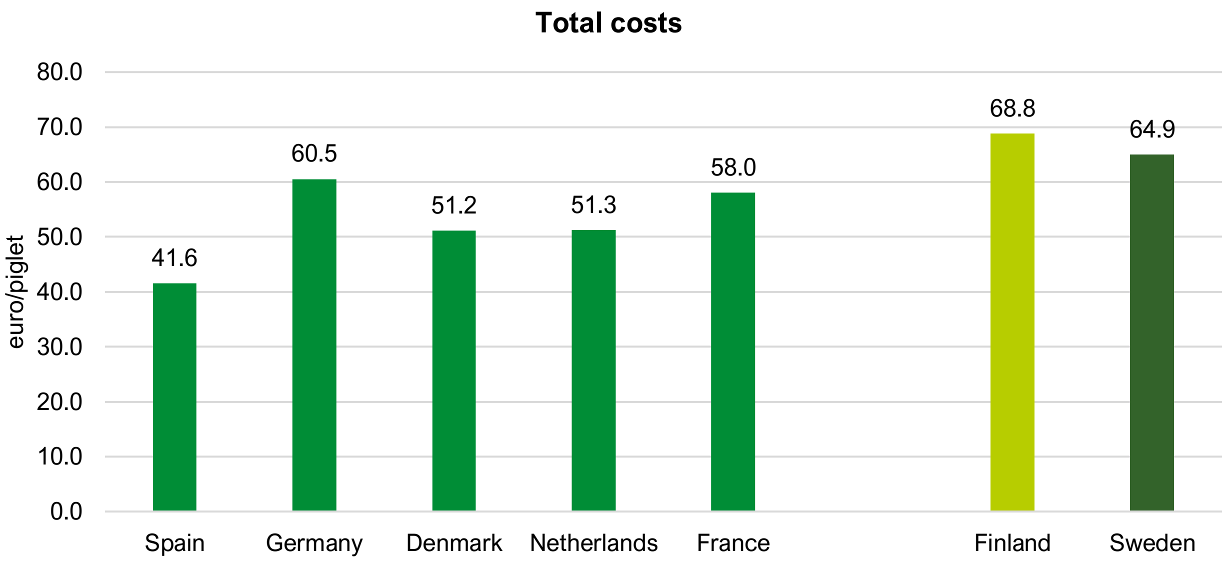
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
22.2
29.5
19.8
27.0
36.8
34.0
28.2
Spain
Germany
Denmark
Netherlands
France
Finland
Sweden







Source: based on InterPIG data

1.1.11. State of legislation and transition in the EU

EU-level legislation

The European Commission has confirmed its plan to ban the use of confinement farrowing crates in the near future, but currently the 2008/120/EC Council Directive is in effect, and the Member States of the EU must comply with the minimum pig welfare standards set out in the Directive. The regulations of the Directive especially related to farrowing (i.e., gilt/sow, litter welfare, space and material requirements for the time of farrowing, etc.) are the following:

- Article 3./3. "Member States shall ensure that sows and gilts are kept in groups during a period starting from four weeks after the service to one week before the expected time of farrowing. The pen where the group is kept must have sides greater than 2,8 m in length. When fewer than six individuals are kept in a group the pen where the group is kept must have sides greater than 2,4 m in length."
- Annex 1. Chapter II. Specific Provisions for Various Categories of Pigs

Sows and gilts

1. Measures shall be taken to minimise aggression in groups.
2. Pregnant sows and gilts must, if necessary, be treated against external and internal parasites. If they are placed in farrowing crates, pregnant sows and gilts must be thoroughly cleaned.
3. In the week before the expected farrowing time sows and gilts must be given suitable nesting material in sufficient quantity unless it is not technically feasible for the slurry system used in the establishment.
4. An unobstructed area behind the sow or gilt must be available for the ease of natural or assisted farrowing.
5. Farrowing pens where sows are kept loose must have some means of protecting the piglets, such as farrowing rails.

Piglets

6. A part of the total floor, sufficient to allow the animals to rest together at the same time, must be solid or covered with a mat, or be littered with straw or any other suitable material.
7. Where a farrowing crate is used, the piglets must have sufficient space to be able to be suckled without difficulty.
8. No piglets shall be weaned from the sow at less than 28 days of age unless the welfare or health of the dam or the piglet would otherwise be adversely affected. However, piglets may be weaned up to seven days earlier if they are moved into specialised housings which are emptied and thoroughly cleaned and disinfected before the introduction of a new group and which are separated from housings where sows are kept, in order to minimise the transmission of diseases to the piglets."

Member States

In terms of legislation, besides a few exceptional cases, where regulation at the national level precedes EU regulations, it is typical for most Member States to wait for EU legislation to follow. Among the largest producers, Spain, France, Poland, the Netherlands and Italy are in a wait-and-see position.

Sweden

Although Sweden is not considered to be a large producer, it should be mentioned, since Sweden is the first and until now the only Member State where using confinement crates is completely prohibited. Sweden banned confinement crates in two steps. First, in the Animal Welfare Act (Nr. 539/1988) they banned the use of farrowing crates but left the option of confinement after birth for up to one week, in the second step in 1994, they completely banned confinement with the exceptional case, if the sow is so aggressive that endangers even the life of the piglets, or if she put at risk her own life or safety. The minimum pen area in Sweden is 6 m^2.

Germany

Germany was the biggest big meat producer in the EU in 2020, with 5,1 million tonnes of pig meat (EUROSTAT, 2020). Regarding farrowing, the Bundesrat issued amendments to the Animal Welfare Act in 2019 (Nr. 587/2019) and 2020 (Nr.302/2020). The Decrees shorten the former 35 days of confinement period (from one week before farrowing until weaning) to a maximum 5 days period and order a minimum 6.5 m^2 area per farrowing pen. Except the confinement period, sows and piglets has to be kept in groups. In 15 years, the use of farrowing crates should be completely eliminated on every pig farm. Furthermore, the Bundesrat announced a EUR 300 million funding for transition purposes in the scheme of the COVID-19 stimulus program (Driver, 2020).

Denmark

Denmark produces 14% of the pig meat output of the EU (EUROSTAT, 2020). Denmark set a goal in 2014 to reach 10% of the sows to farrow in a loose-housed system until 2020. Danish swine production did not achieve this goal, however, banning confinement farrowing systems is an ongoing debate in Denmark (Danish Crown, 2021). The current 4-5% is still far from the targeted 10%, therefore, in 2022 Denmark will triple the available investment support. From October 2022 a DKK 25 million funding will open for farmers who install free farrowing-lactating systems with at least 6 m^2 area per pen. The subsidy will cover around 40% of the farmers' expenditures, DKK 4000 per square meter (Hansen, 2022). In 2017 the Ministry of Environment and Food of Denmark introduced the new government animal welfare label system, which means 3-level labelling of animal products, and in which the highest, third level requires free outdoor farrowing for sows (Ministry of Environment and Food of Denmark, 2017).

Austria

Austria produces only 3% of the EU's pig meat, however, it is considered to be one of the flagships of the national legislation on reduced confinement farrowing. The 2012 amendment (Nr.61/2012) of the 2004 Animal Welfare Act (Nr. 485/2004) ordered a minimum area of 4 m^2 per sow with piglets under 10 kg and 5 m^2 per sow with piglets above 10 kg from 2013 and set the goal for 2033 to provide at least 5.5 m^2 are per sow. The design of the farrowing pens must allow free moving for sows and free suckling for piglets. The 2033 goals restrict the time of confinement but still leave a quite long and undefined time period for it. „Until the end of the critical life phase of the suckling piglets, the sow can be confined to protect the suckling piglets from being crushed" (Nr. 61/2012 3.3.2.). The 2022 amendment (Nr. 296/2022) shortened and specified the confinement goal of 2033 as a maximum of 1 day before and 5 days after farrowing. Before and after the confinement period sows and piglets has to be kept in groups.

Free Farrowing Workshop 2021 provided information from experts about the situation in the Member States where the legislation procedure has not started yet, still there are signs of transition:

The Netherlands

In the Netherlands new buildings usually have free farrowing-lactating pens. Many farmers are enthusiastic to try a few pens, but the failures that happen in some cases discourage the farmers from making the complete transition. In the Netherlands, the intended minimum area is 7.5 m^2.

1.2. Literature review on the efficiency of cage-free housing systems for laying hens

Based on the Council Directive 1999/74/EC, European farmers were obliged to change their egg production method starting from 1rst of January 2012 if they used the conventional cage system. As stated in the legislation, a minimum of 750 cm^2 per cage is required to ensure extended space for laying hens in the enriched cage housing system. The 'End the Cage Age' Initiative (CIWF, 2020; Kollenda *et al.*, 2020) highlights the advantages of the non-cage housing systems (barn, aviary, free-range and organic) – especially regarding animal welfare – and bans enriched cage farming methods from 2027. Therefore, it is necessary to give an insight into the transition process from enriched cages (also known as furnished cages) to cage-free housing systems. The latter consists of alternative (barn and aviary) and other non-cage (free-range and organic) farming methods. Therefore, in retail, the following egg labels (codes) can be differentiated: free-range eggs (1); alternative eggs: barn or aviary (2), caged eggs (3), and organic eggs (0).

1.2.1. Housing systems and welfare of laying hens

The literature describing the influence of various hen-rearing systems on various aspects of welfare is very rich, – the issues of hen welfare have been the subject of numerous studies since the 1960s. Moreover, many studies show contradictory results, which makes the assessment of many welfare problems ambiguous. Hartcher and Jones (2017) note that knowledge related to hens' welfare in non-cage systems is currently highly inconsistent, although the general principles of welfare are rather not controversial. Among others, extensive reviews (based on dozens of studies) on hen welfare can be found in the works of authors such authors as: Blokhuis *et al.*, 2007, Sosnówka-Czajka *et al.*, 2010; Lay *et al.*, 2011; De Jong and Blokhuis, 2014; Dikmen *et al.*, 2016; Hartcher and Jones, 2017; Molnár and Szőllősi, 2020; Kollenda *et al.*, 2020). Nevertheless, the general opinion formulated by the researchers participating in the LayWel project (Blokhuis *et al.*, 2007) is that with the exception of conventional cages, all systems have the potential to provide satisfactory welfare for laying hens. However, this potential is not always realized in practice. Among the numerous explanations are management, climate, design, different responses by different genotypes and interacting effects. For example, there was a different use of nest boxes in enriched cages by different genotypes. The design of small, enriched cages also had a significant impact on dust-bath use.'

To summarise, the current state of knowledge indicates that specified systems of hens housing generate a different level of risk for different aspects of welfare (Table 20).

Table 20: **Assessment of potential threats to hens' welfare and environment in different housing systems**

Indicator	Conventional cage	Enriched cage			Non-cage		
		small	medium	Large	single level	multi level	Outdoor
Mortality rate	medium	medium	high	high	high	high	high
Mortality due to feather pecking or cannibalism	low	medium	medium	medium	medium	medium	medium
Red mite	medium	medium	medium	medium	medium	medium	medium
Bumble foot	low	medium	medium	medium	high	high	high
Feather loss	medium	medium	medium	medium	medium	medium	medium
Use of nest boxes (nesting)	high	low	low	low	low	low	
Use of perches (perching)	high	medium	medium	medium	medium	medium	medium
Foraging behaviour	high	medium	medium	medium	low	low	low
Dustbathing behaviour	high	medium	medium	medium	medium	medium	medium
Air quality	low	medium	medium	medium	high	high	low
Water intake	low	low	low	low	low	low	medium
Movement (PS)	high	medium	medium	medium	low	low	low
Disease (PS)	low	low	low	low	high	high	high
Skeletal heath (PS)	high	medium	medium	medium	medium	medium	low

Legend – threats level: high medium (or variable) low (positive)

Source: Lay *et al.*, (2011);, own assessments for last 3 items (marked PS)

Despite wide criticism of the enriched cages system, many authors underline that it is difficult to demonstrate its superiority over conventional cages (Guesdon and Faure, 2004; RSCPA, 2005; Savory, 2004). However, various studies indicate improved hens' welfare due to reduced stress, less aggression and feather eating, and better bone mineralisation (Sosnówka-Czajka, 2010). Nevertheless, enriched cages are also subject to criticism for limiting natural and essential animal behaviours such as exercising, flying, and dustbathing (Kollenda *et al.*, 2020). In summary, regarding animal welfare, each system has its own strengths and weaknesses.

The comparison in Table 24 shows, among other things, that conventional cages reduce the risk of cannibalism and feather pinching and thus reduce the level of mortality. In general, feather pecking and cannibalism are one of the most important problems in the non-cage system, which in practice is reduced by beak trimming, which can hardly be considered a treatment improving hens welfare (Appleby, 2003). Generally, mortality is lower in enriched cages than in conventional cages. Mortality in non-cage systems is higher than in any cage system (Lay *et al.*, 2011). The mortality level seems to be particularly high in aviary housing,mainly due to hypocalcaemia, ventilation, cloacal prolapse, foot disease, and cold or other diseases (Molnár and Szőllősi, 2020; Nernberg, 2018). Compared to other systems, cages perform well, for example, in terms of air quality, which is the worst in the case of barn and aviary systems (it is related to the movement of hens and the generation of dust). Higher mobility of birds in alternative systems also generates an increased risk of bone fractures, feather pinching and cannibalism (e.g. Molnár and Szőllősi, 2020; Rodeburg, 2008; Tauson, 2005; Fulton, 2019, and many others). On the other hand, the lack of ability to exercise can also lead to problems such as bone weakness or poor status of plumage, which relates not only to hens in conventional but also in enriched cages (Kollenda *et al.*, 2020; Augère-Granier, 2019; Castellini *et al.*, 2006). In the case of enriched cages, these problems are mitigated by access to perches, scratch areas, a dust-bathing area and a nesting box which allows for the expression of several natural behaviours (Blatchford *et al.*, 2016; Kollenda *et al.*, 2020). However, scratching and dust-bathing opportunities may be restricted as litter inside the cages can be quickly depleted. This leads to increased stress in the case of hens which are excluded from dust-bathing by more dominant animals (Kollenda *et al.*, 2020). Hens in any cage system have less bumblefoot and footpad dermatitis than hens in more extensively housed hens (Lay *et al.*, 2011). Many of the before mentioned authors note that diseases caused by parasites may occur more frequently in non-cage solutions (Lay *et al.*, 2011). Also, the risk of contamination of Escherichia coli and Salmonella in non-cage systems seems to be higher (Hoorebeke *et al.*, 2011; Vlckova *et al.*, 2018; De Reue, 2008).

Air quality is also an important parameter from the welfare point of view – when litter is used, higher dust concentration (PM) and higher ammonia emissions are observed (which is the result of bird activity and the presence of litter) (David *et al.*, 2015; Kollenda *et al.*, 2020).

1.2.2. Production systems

A key success factor of the cage housing system has been productivity maximisation and increased profits due to a greater density of laying hens per unit area (Sosnówka-Czajka *et al.*, 2010) and lowering production costs. The system allowed for better feed conversion, lower labour inputs and a considerable decrease in the mortality rate as a consequence of a higher hygiene status in the hen houses as well as cleaner and less contaminated eggs (Windhorst, 2017). Due to the high efficiency of the cage system, vertically integrated agribusiness companies keeping sometimes several million laying hens were created in Europe, North America, Japan and Australia, and the cage system solutions were also transferred in the 1980s to developing countries such as China, India, Mexico and South America (Windhorst, 2017).

Introduction of enriched cages attempted to solve the fundamental problems related to animal welfare in conventional cages. It provides additional equipment to facilitate foraging and dustbathing behaviour (Mench *et al.*, 2011). In comparison to conventional battery cages, the group size is enlarged. According to Directive 99/74/EC, the enriched cage gives each hen 750 cm^2 surface area, increased height, a perch, a nest box and litter. Additional equipment (as appropriate perches, suitable nest boxes and friable litter) intends to enable hens to provide some of their behavioural properties (LayWel, 2006). The main advantages and disadvantages of solutions based on enriched cages are presented in Table 21.

Table 21: **Main advantages and disadvantages of enriched cage systems**

Advantages	Disadvantages
• better hygiene than in alternative, free-range and organic systems (comparatively low risk of infections with parasites or infectious agents, lower use of preventive drugs) • generally low mortality (it can reach high values in non-beak-trimmed genotypes) • ability to exercise results in stronger bones compared to conventional cages • more laying hens can be kept on one square meter • the investment cost can be reduced on laying hen space • processes can be operated automatically • more favourable microclimate for the animals • the flock is overviewed better • the caged eggs are uncontaminated • more efficient feed use • the heating costs can be reduced during winter • the lowest production cost	• it is still a cage system – it does not allow the natural behaviour (needs of animals) to be met (limited space per hen, reduced ability of hens to fly, flap their wings and exercise etc.) • increasing mortality in brown genotypes with increasing group size if the birds are not beak-trimmed • use of perches during the day for substantial amounts of time may result in keel bone damage • the layout of the scratching area and the offered substrate usually do not meet the needs of the hens

Source: Windhorst (2017) Janczak and Riber (2015), Decina *et al.* (2019), and based on Sütő (2020) cited by Molnár and Pákozd (2022)

A modification of the cage system is the 'colony nest' (small or large), developed in Germany at the beginning of the current century as a reaction of the egg industry and equipment companies to the regulations introduced by the EU Directive 1999/74 (Windhorst, 2017). In these solutions, laying hens have more space (800 to 900 cm^2 per hen), and the cages are higher and have perches placed at different levels. Colony nest systems come in varieties for different sizes of hen groups – from 30 to 80 birds.

Non-cage systems include three basic categories of solutions: floor systems (single-level systems, barn), aviaries (multi-tier systems) and 'outdoor systems' (Mench and Sumner, 2011; Windhorst, 2017). The barn/aviary system is based on the floor accommodation, whereby via levels, the hens can also use the vertical space in the house. Each hen has 1,100 cm^2 of usable area, part of the surface area of the house is covered with litter, and in the house, there is one nest box per 7 laying hens and perches for the hens (Kollenda *et al.*, 2020). In single-level barns, hens are housed on the floor of the building instead in cages (buildings are usually equipped with nest boxes configured to allow for automatic egg collection). In the case of aviaries, some multi-tiered platforms use the height of the building. The ground level is covered with litter material, and upper-level platforms are arranged so that manure does not fall on the hens (Mench and Sumner, 2011). In non-cage systems, the outdoor area could be a veranda or winter garden or access to free-range. The main advantages and disadvantages of non-cage systems are presented in Table 22.

Table 22: **Main (general) advantages and disadvantages of non-cage systems**

Advantages	Disadvantages
• greater opportunities for the laying hens to express the full behavioural repertoire (flying, scratching, foraging). • the high use of nest boxes • availability of space enables submissive hens to avoid contacts	• highly variable risks of feather pecking and cannibalism (leading to high mortality rates) • high percentage of bone fractures (results from collisions with perches, nest boxes and other structures) • subordinate laying hens may have restricted access to water and feed due to bullying of aggressive fellows and move to the upstairs • increased risk of disease in litter-based systems due to internal parasites and contact with wild birds (in free-range system) • a higher risk of predation • likely higher air pollution in litter-based systems (can lead to higher loads of infective agents and depress the immune system of the laying hens) • higher production cost • higher use of antibiotics and medicine • disinfectants can cause higher environmental degradation • higher emission of greenhouse gas • requires more arable land for egg production • higher water use

Source: Windhorst (2017) and based on Sütő (2020) cited by Molnár and Pákozd (2022)

Considering the advantages and disadvantages of different systems of housing laying hens, it is worth noting that there are many conflicting reports in the literature. While it is unquestionable that non-cage systems provide hens with more freedom of movement, the impact of keeping hens in non-cages solutions on their health, yield (productivity), and product quality often remain an area of contention. According to Rakonjac *et al.* (2014), the frequently observed differences in research results are likely due to the effect of a variety of factors that could modify the impact of the housing systems, such as genotype, age, nutrition, and different components of the environment. For example, many studies indicated that egg production was higher in conventional cage systems than in alternative rearing systems (Yakubu *et al.*, 2007; Mugnai *et al.,* 2009; Anderson, 2010), although some have reported that egg production of hens showed no difference (Neijat *et al.*, 2011; Ahammed *et al.*, 2014). Opinions on egg quality are also ambiguous. Some investigators (Rossi, 2007; Hidalgo *et al.*, 2008) observed higher Haugh units values (a measure of egg protein quality based on the height of its egg white (albumen)) of eggs from hens that were housed in cages, whereas others (Minelli *et al.*, 2007; Dukic-Stojcic *et al.*, 2009) reported higher Haugh units from hens under organic or free-range systems (Dong *et al.*, 2017).

The current situation regarding the importance of the specified hens' housing systems in EU and non-EU countries is synthesised in Tables 23 and 24. Generally, the EU can be considered the leader in disseminating the non-cage system, although there are huge differences between member countries.

Table 23: **Laying hens according to housing systems (%) in EU countries**

Country groups according to the share of laying hens in cage systems	Countries	Number of layers (millions)	Share in the EU number (%)	Laying hens according to breeding systems (%)			
				Enriched frames	Voliera / Bedding	Free-range	Organic
0%	AT, LU	7.2	1.9	0.0	68.3	13.3	18.5
5-15%	SE, DE, DK, NL,	103.9	27.9	12.6	60.1	13.8	13.5
16-50%	BE, IT, FI, SL	56.3	15.1	43.2	44.0	6.8	6.0
51-75%	IE, FR, RO, HR, CZ, BG, HU, CY, LV	86.9	23.3	64.7	22.5	10.5	2.2
over 75%	SK, EL, ES, PL, EE, LT, PT, MT	118.1	31.8	82.9	12.1	3.3	1.7
TOTAL		372.4	100.0	48.0	33.9	11.9	6.2

Source: own elaboration based on Eurostat (2021)

Table 24: **Laying hens according to housing systems (%) in non-EU countries**

Country	Laying hens (million)	Cages	Voliera / Barn	Free-range	Organic
		% of laying hens			
India	402,976	100.0	0.0	0.0	0.0
Ukraine	91,200	100.0	0.0	0.0	0.0
Russia	196,906	99.9	0.1	0.0	0.0
Mexico	212,387	99.5	0.5	0.0	0.0
China	1,250,000	97.0	0.0	3.0	0.0
Brazil	166,528	95.0	2.5	2.5	0.0
Japan	139,036	94.6	4.5	0.9	0.0
Turkey	141,276	88.0	3.0	8.0	1.0
USA	404,190	76.4	17.8	0.0	5.8
Great Britain	41,000	44.2	1.4	51.9	2.5
Norway	4,300	9.2	82	1.5	7.5
Switzerland	3,024	0.0	22.2	60.5	17.3

Source: own elaboration based on https://www.hen-welfare.org/map.html

1.2.3. Legal context

Adopted on 15 June 1999, Council Directive 1999/74 / EC regulates minimum standards for the welfare and protection of laying hens, and nowadays is the key regulation of the EU egg sector. The Directive 1999/74/EC has a sectoral character and is in line with the general Council Directive 98/58/EC (1998) on the protection of animals bred and kept for farming purposes. The general Directive provides that the freedom of movement of animals must not be restricted in such a way as to cause them unnecessary suffering or injury. In addition, it requires that where an animal is continuously or regularly tethered or confined, it must be given appropriate space in line with its physiological and ethological needs. Keeping animals in cages is thus allowed, but subject to certain conditions.

From 1 January 2002, enriched cages must provide:

- 750 cm^2 area per bird (550 cm^2 until 2003), of which at least 600 cm^2 is at least 45 cm high
- a minimum total cage area of 2,000 cm^2
- a nest
- litter that allows pecking and scratching are possible
- 15 cm perch per hen
- 12 cm of food trough per hen
- a claw shortener

In addition to the ban on using conventional cages since 2012, Council Directive 1999/74/EC (July 1999) also regulates minimum standards for the protection of laying hens (European Parliament 2019).

The standard for 'alternative systems' (non-cage), included (from 1 January 2002) the following:

- a maximum of 9 hens per m^2 of usable area
- litter occupying at least one-third of the floor
- 15 cm perch per hen

Growing welfare awareness is making EU egg consumers increasingly supportive of the idea of moving away from cage systems altogether (Schjøll, 2012; Eurobarometer, 2020). In 2018, the 'End the Cage Age' campaign was initiated, under which 1.4 million signatures were collected in support of the initiative to ban the cage system in the EU. After the plenary discussion on the initiative 'End the Cage Age', the European Parliament called on the Commission 'to propose a revision of Council Directive 98/58/EC, which aims to phase out the use of cages on EU farms, possibly with a view to complete phasing out by 2027; this phasing out should be based on a scientifically supported impact assessment and provide for a sufficient transition period.' In accordance with the procedure, the Commission issued a Communication (EC, 2021) in which it stated that the expectations of the 'End the Cage Age' initiative are consistent with the assumptions of the European Green Deal or Farm to Fork Strategy.

The EC (2021) underlined that 'the request to phase out cages is in line with current developments, as several Member States have already implemented total or partial bans on cages indicating that enriched cages for laying hens are' or will be

- banned in Austria and Luxembourg,
- banned in France for new or refurnished farms,
- banned in Germany from 2025,
- banned in the Czech Republic from 2027,
- banned in Wallonia (Belgium) from 2028,
- banned in Slovakia from 2030.

1.2.4. Economic aspects

Costs of production

The current debate on a total ban on cages in EU hen housing is taking place in the shadow of relatively recent changes related to the replacement of conventional cages with enriched cages. The transition from conventional to enriched cages has involved significant costs; hence many producers are now concerned about incurring further capital expenditures. Before the ban on traditional cages, it was estimated that the cost to EU egg producers would be around EUR 354 million annually[2]. Changes in running costs relate to expenditures on energy, feed, veterinary expenses, land management, certification costs for organic producers, etc. Where buildings need to be altered, new structures created, and perhaps additional land acquired or rented, there are likely to be capital requirements that will increase costs. Any sort of transition usually requires an initial investment,

[2] https://www.thepoultrysite.com/articles/abolition-of-battery-cages-in-eu25-cost-estimated-at-euro354-million

increasing overall production costs, with consequences for profitability (although the consequences may be short-term) (IEEP, 2020).

The problem of the cost-effectiveness and profitability of egg production has been one of the key issues in discussions on the egg sector since its fast development in the 20th century. Undoubtedly, the development of intensive production in the cage system, which began in the first half of the 20th century, was connected with the relatively high profitability of this approach to farm organization compared to other solutions (Elson *et. al*., 2011; Sosnówka-Czajka *et al.*, 2010; Appleby, 2011). Research and discussion on egg production costs increased in intensity alongside a parallel discussion on the need to take into account the welfare of hens (which already gained importance in the 1980s). Table 25 presents the results of Elson's research from 1985, which indicated a relative level of production costs in various technological solutions in relation to a cage based on a minimum area of 450 cm^2 / bird (production cost in such cage = 100%). These studies indicated that the most expensive system at that time was the free-range system, where production costs were about 50% higher than in conventional cages – the area allocated to one hen was of key importance.

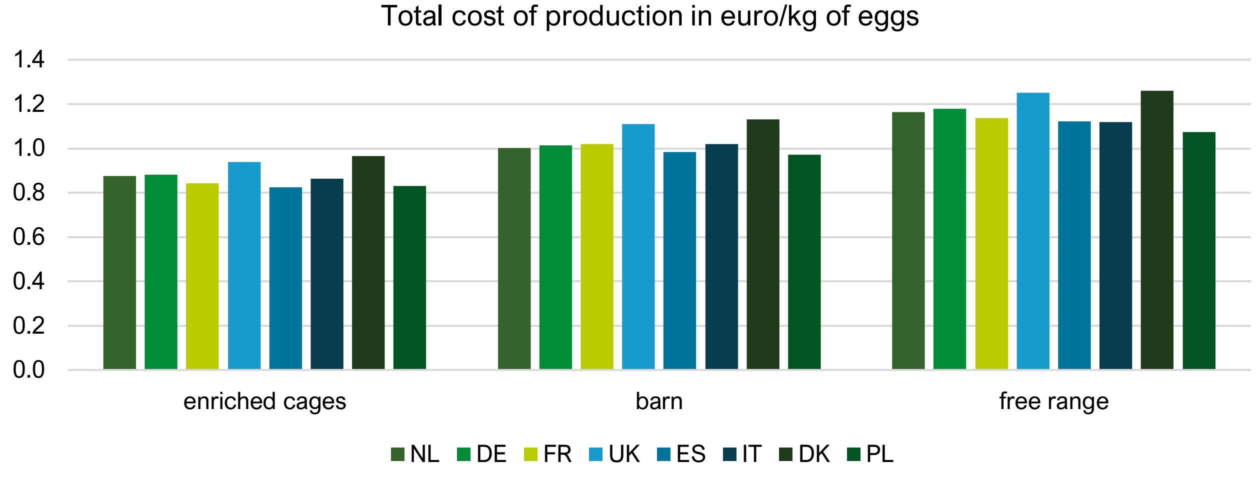
Table 25: **Relative cost of egg production in different variants of housing systems**

System	Space	Relative cost (%)
Laying cage	450cm^2 / bird	100
Laying cage	560cm^2/ bird	105
Laying cage	750cm^2/ bird	115
Laying cage	450 cm^2/bird + nest	102
Shallow laying cage	450 cm^2/bird	102
Get-away cage	10 to 12 birds/m^2	115
Two-tier aviary	10 to 12 birds/m^2	115
Multitier housing	20 birds/m^2	105-108
Deep litter	7 to 10 birds/m^2	118
Straw yard	3 birds/m^2	130
Semi-intensive	1000 birds/hectare	135 (140 including land rental)
Free-range	400 birds/hectare	150 (170 including land rental)

Source: Elson (1985) cited in Appleby (2003)

More recent analyses (using 2017 prices) based on field data from laying hen farms conducted by van Horne (2019) confirmed Elson's observations from years ago that the key factor influencing the costs of egg production is the area available for one hen. According to the cited data, the difference in the cost of egg production between the enriched cage systems and barn/aviary systems is 17%. More detailed data on the level of production costs of one kg of eggs (according to van Horne (2019)) are presented in Figure 7, while Table 26 presents data reflecting costs' components for the studied countries, and Table 27 contains detailed data on the level of specified categories of costs by country and production (housing) system.

Figure 7: **Total cost of egg production (euro/kg of egg) in selected EU countries in 2017**



Source: van Horne (2019a)

Table 26: **Level of specified costs categories (average for all analysed countries NL, DE, FR, UK, ES, IT, DK, PL) in different housing methods**

Cost category	Cost (absolute values)			Relative approach	
	enriched cages	barn	free-range	barn	free-range
	eurocent per 1 kg of egg			enriched cages = 100%	
Hen cost at 20 weeks	18.7	22.5	23.7	120%	127%
Feed	50.4	54.5	58.3	108%	116%
Other	5.7	7.4	7.9	131%	140%
Labour	4.0	6.5	10.8	165%	272%
Housing	9.0	11.7	14.3	130%	159%
General	0.9	1.5	2.4	172%	280%
Manure disposal	0.3	0.4	0.3	107%	100%
Revenue spent hen	–1.2	–1.3	–1.4	113%	120%
Total	87.7	103.2	116.3	118%	133%

Source: van Horne (2019)

Results presented in Table 26 are consistent with the conclusions of the IEEP Policy Report (Kollenda *et al.*, 2020), pointing out that the most important for costs level are changes in labour requirements (more time required for supervising and maintaining larger indoors and outdoors areas), running costs (expenditure on energy, feed, veterinary expenses, land management, certification costs for organic producers, etc.). Substantial investments in buildings and land (reconstruction of buildings, creation of new structures, sometimes additional land) are also required.

Reported results are also consistent with the conclusions presented in the works of Leinonen *et al.*, (2012) or in Leenstra *et al.*, (2014), which indicate that production costs are comparatively high in non-caged systems. In any case, many researchers underline (Tauson, 2005; Englmaierová *et al.*, 2014; Sumner *et al.*, 2010; Dikmen *et al.*, 2016; Philippe *et al.*, 2020) that the increase in total costs is also connected with higher feed costs due to the worsening of feed conversion. Some authors also note the costs associated with mislaid eggs in litter in non-cages systems (Tauson, 2005).

Table 27: **Costs of egg production (by categories; system of housing and countries)**

Category of costs	Housing system	NL	DE	FR	UK	ES	IT	DK	PL
		EUR per 1 kg of egg							
Hen cost at 20 weeks	enriched cages	17.7	17.7	19.3	21.7	16.2	17.1	21.4	18.6
	barn	20.9	21.2	21.5	25.1	21.7	21.2	25.6	22.8
	free-range	23.3	23.7	23.8	23.8	23.8	21	26.7	23.3
Feed	enriched cages	49.0	50.2	48.5	51.6	50.1	52.5	49.6	51.3
	barn	52.7	54	53.1	56.8	53.3	55.9	54.9	55
	free-range	56.3	58.1	55.5	60.5	58.2	59.6	58.6	59.9
Other	enriched cages	5.7	5.7	4.8	6.5	5.8	5.6	6.6	4.6
	barn	6.8	6.9	7.8	8.1	7.2	7.4	8.0	7.1
	free-range	8.0	8.2	8.6	7.5	7.7	7.3	8.8	7.1
Labour	enriched cages	4.5	4.5	4.1	3.1	3.6	2.9	6.5	2.5
	barn	7.6	7.7	8.8	5.7	5.6	4.9	10.0	2
	free-range	12.7	12.9	13.3	11.1	9.1	8.1	13.6	5.4
Housing	enriched cages	9.9	10.1	8.1	10.7	7.2	7.2	11.0	7.8
	barn	14.0	13.9	12.3	20.0	13.0	12.9	15.7	12.4
	free-range	9.0	11.7	14.3	1.3	1.6	0.0	0.0	0.0
General	enriched cages	1.0	1.0	0.8	0.9	0.8	0.8	0.9	0.7
	barn	1.6	1.6	1.4	1.7	1.4	1.3	1.7	1.2
	free-range	2.7	2.7	2.3	2.7	2.2	2.2	2.6	1.9
Manure disposal	enriched cages	1.4	0.7	0.0	–0.6	–0.3	1.4	0.4	–0.3
	barn	1.5	0.7	0.0	–0.6	–0.3	1.5	0.4	–0.3
	free-range	1.5	0.8	0.0	–0.6	–0.3	1.6	0.0	–0.3
Revenue spent hen	enriched cages	–1.8	–1.8	–1.4	0.0	–1.0	–1.1	0.0	–2.3
	barn	–2.0	–2.3	–1.9	0.0	–1.4	–0.7	–0.1	–2.2
	free-range	–2.1	–2.5	–2.1	0.0	–1.6	–0.7	–0.1	–2.2
Total	enriched cages	87.4	88.1	84.2	93.9	82.4	86.4	96.4	82.9
	barn	100.2	101.3	102.0	111.1	98.3	102.1	113.2	97.0
	free-range	116.4	117.8	113.7	125	112.1	112	125.9	107.5

Source: van Horne (2019)

It is also worth noting van Horne's (2019) analyses conducted for the North-Western Europe countries (i.e. those with the greatest experience in transformation), showing that the average cost increase per hen is much higher when transforming from the enriched cages system to alternative systems, than the cost of 2012 transformation from conventional to extended cages (Table 28).

Table 28: **Differences in costs production between enriched cages and barn/aviary system in the North-Western Europe countries (in prices from 2017)**

Category of costs	SYSTEM		
	enriched cage	barn/aviary	enriched cage=100%
	euro per laying hen		
Hen (pullet at 17 weeks)	3.90	4.40	113%
Feed	12.85	13.95	109%
Other variable costs	1.51	1.39	92%
Housing	3.05	3.65	120%
Labour	1.04	1.88	181%
General costs	0.28	0.46	164%
Revenue spent hen	–0.30	–0.29	97%
Total costs per hen	22.33	25.44	114%
Total costs per egg (eurocent/egg)	5.59	6.52	117%
Total costs per kg (euro/kg)	0.9	1.05	117%

Source: based on van Horne (2019a)

Results presented in Table 28 show that the costs increase in percentages is slightly higher per egg (117%) than per hen (114%) due to the lower yield of eggs per hen (on average) in alternative systems.

Previous studies indicate that from an economic point of view, the cage system is the cheapest solution. The comparison prepared by Molnár and Szőllősi (2020) based on studies conducted by various authors shows that organic production is the most expensive option – in this case, the costs of producing eggs may represent over 200% of the costs incurred in the cage system. In the case of barn/aviary, the costs turned out to be 15-40% higher, and in the case of free-range 15-30% higher. However, this compilation is based on various methodologies and concerns different regions, so direct comparisons are not quite legitimate. It can be assumed, however, that all the results indicate changes going in the same direction (Table 29) – costs of production in all non-cage systems are higher.

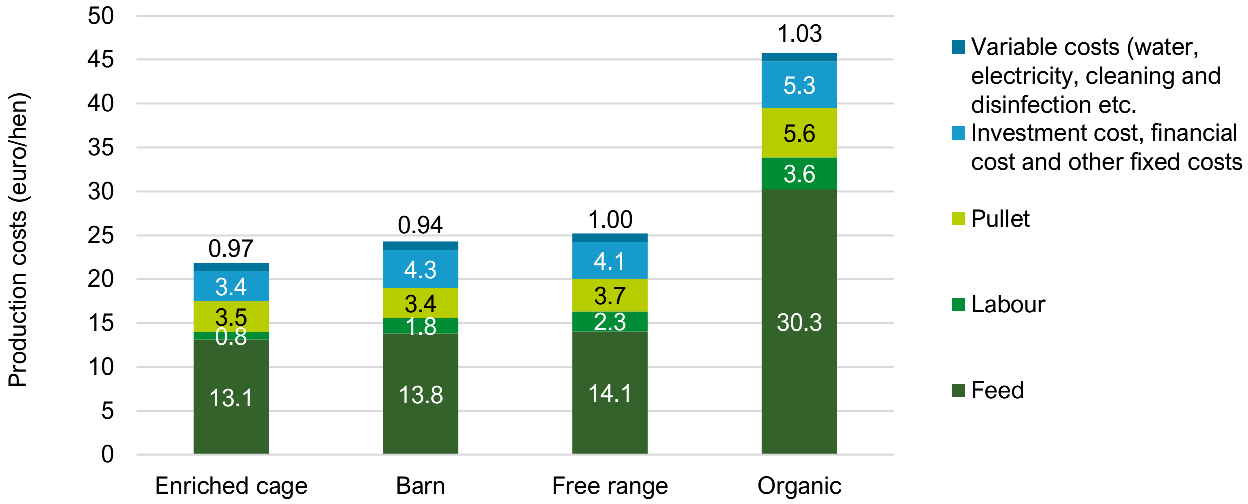
Table 29: **Comparison of the relative cost of egg production based on selected studies**

Housing methods	Costs of egg production in different studies					
	country of study					
	Netherlands (2007-2008)[1]	USA (2011a)[2]	USA (2011b)[3]	France (2012)[4]	Hungary (2012-2015)[5]	EU (2015,2017)[6,7]
	% of costsin conventional cages					
Conventional cage	100	100	100	100	n.d.	100
Enriched cage	n.d.	n.d.	113	n.d.	100	106
Barn / aviary	112-115	140	136	113	139	123
Free-range	115-117	n.d.	n.d.	128	n.d.	n.d.
Organic	185	n.d.	n.d.	213	n.d.	n.d.

Source: Molnár and Szőllősi (2020) based on [1]Dekker *et al.* (2011), [2]Sumner *et al.* (2011), [3]Matthews and Summer (2015), [4]Chenut (2013), [5]Szőllősi *et al.*, (2019), [6]van Horne (2017), [7]van Horne (2019a)

Similar to van Horne (2019a), the components of the total cost are also higher in the French housing systems. The highest cost was the cost of production of organic eggs, more than two times higher compared to eggs from the enriched cage housing system. Furthermore, feed cost was more than doubled in the organic housing system. Barn and free-range costs were 11 and 15 percent higher compared to the furnished cage farming system (Figure 8).

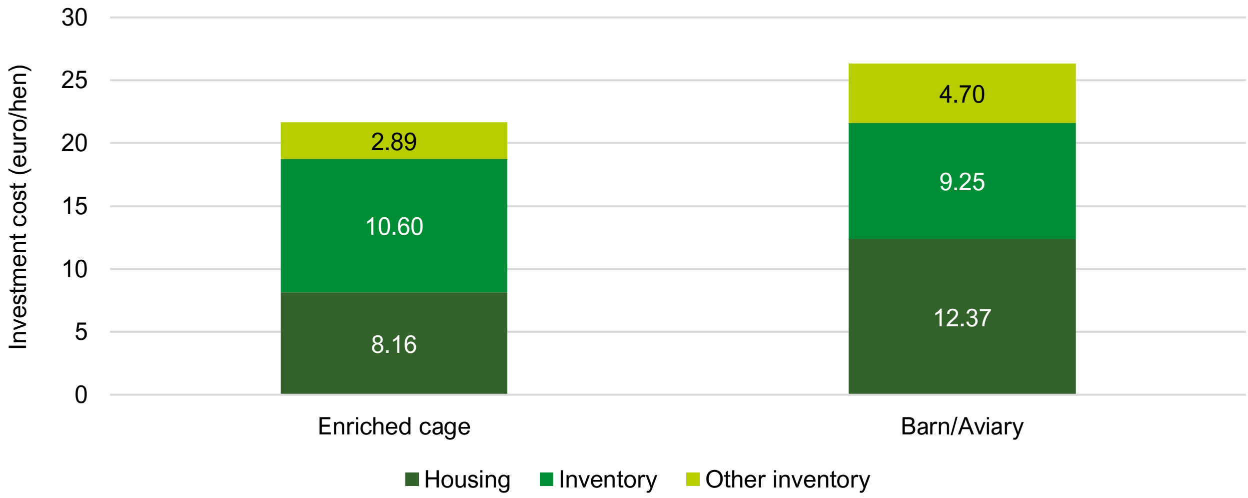
Figure 8: **Comparison of the factors of the production cost in different farming systems in France (2019)***



* Labour, investment cost, financial cost and other fixed costs, variable costs based on 2018 data
Source: own elaboration based on Bouzidi (2021)

Transition to alternative housing systems will generate significant investment costs. According to van Horne (2019a), the investment costs of alternative housing methods (barn and aviary) were EUR 26.32 per hen in some observed European countries in 2017 (Figure 9). This was 22 percent higher compared to the enriched cages.

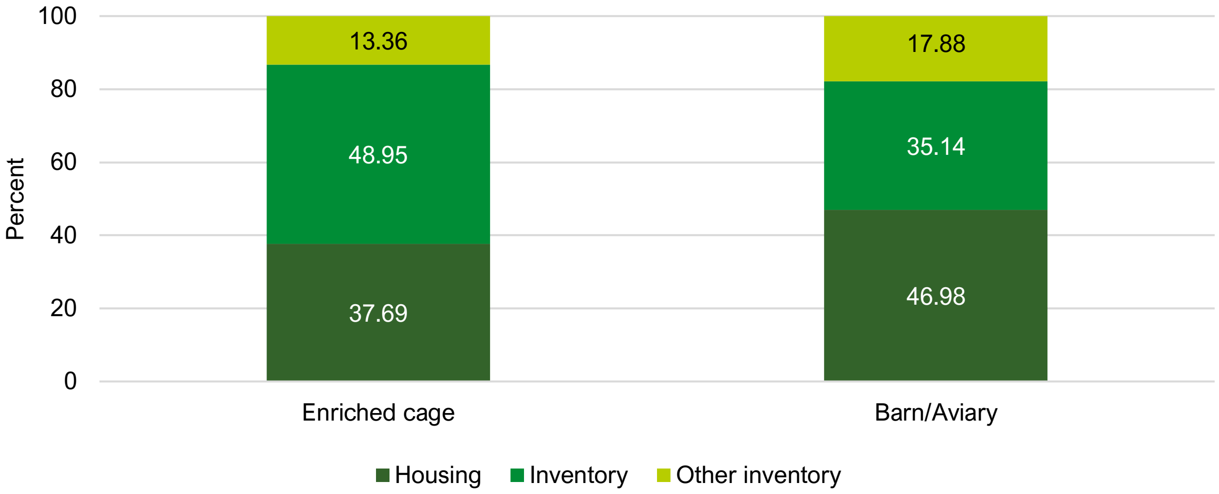
Figure 9: **The average investment costs of the enriched cage and the alternative (barn and aviary) farming systems in some European countries* (2017)**



* The Netherlands, Germany, France, the United Kingdom, Spain, Italy, Denmark, Poland
Source: own elaboration based on van Horne (2019a)

Replacing enriched cages with barn/aviary systems results in increased costs of housing. The comparison of the systems in the UK in 2018 shows a similar pattern of changes (Figure 10). Housing costs have increased by 9 percentage points, but the inventory cost was lower by almost 14 percentage points in barn/aviary systems. Overall, the investment costs were higher by 22 percent in the alternative farming systems, similar to the average of the analysed EU countries.

Figure 10: **Structure of investment costs in different housing systems in the UK (2018)**



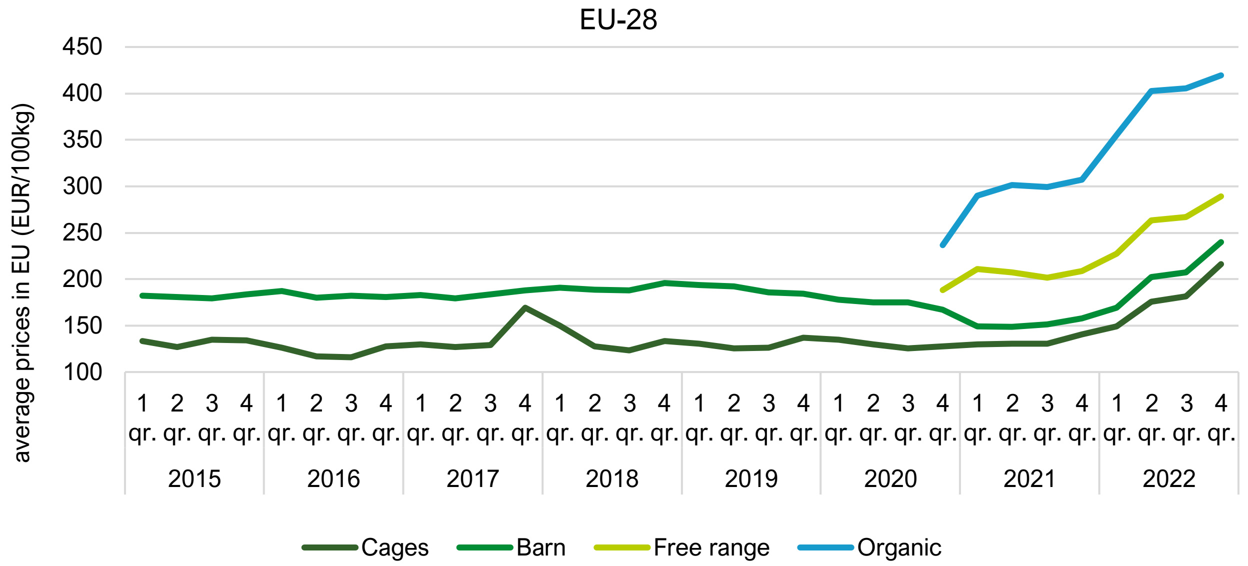
Source: own elaboration based on van Horne (2019b)

Profitability and market connected issues

All the above-discussed costs impact profitability, although ultimately, in the long term, the economic consequences will depend on consumers' willingness to pay higher prices. The balance between premiums and additional costs is critical for profitability. Market prices vary greatly and can be sensitive to local market conditions but generally are highest for organic and outdoor systems. Consumers' willingness to pay higher prices varies between regions and countries (Kollenda *et al.*, 2020). For example, research conducted in Poland (Żakowska-Biemans and Tekień, 2017) showed that the price of eggs is of primary importance for Polish consumers, but information on farming systems substantially differentiates consumers' preferences. According to the study, Polish consumers preferred free-range eggs over organic ones – as a result, free-range claims generate more market prospects than organic ones (barn eggs are also less preferred). Also, preference studies conducted in Canada and the USA indicate that the market is heterogeneous, and the price factor still plays a key role (Bejaei *et al.*, 2015, Chang *et al.*, 2010, Lusk, 2018). In Western Europe, a continuous increase in the demand for non-caged eggs has been observed recently (Kollenda *et al.*, 2020). Research conducted nu Yeh *et al.*, 2020 indicated that the price is the most sensitive factor for Hungarian and Italian consumers, followed by nutrition and health attributes. Norwegian research (Gerini *et al.*, 2016) showed that there is a segment of consumers who are willing to pay a substantial premium for organic eggs, but this segment is of small size.

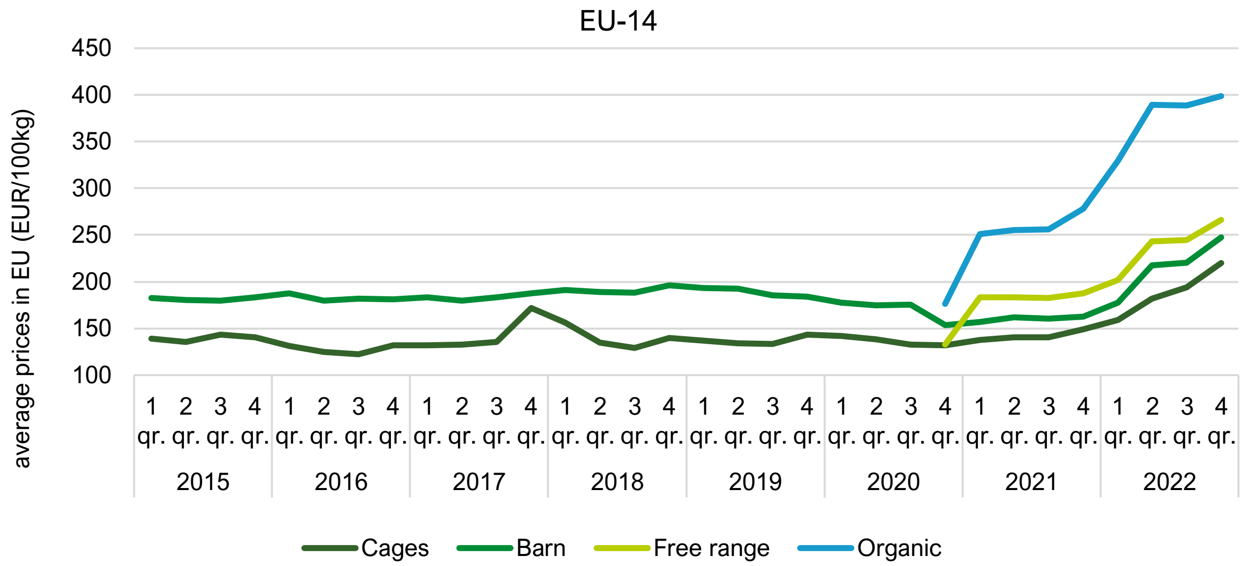
A comparison of average farm-gate prices by production system in the EU, based on the Eurostat data, provides a more comprehensive insight into price relations (Figures 11-13). It is also worth noting that in all categories, average prices in the EU-14 are slightly higher than in EU-13.

Figure 11: **Average farm-gate eggs' prices in EU-28 by housing system (quarterly data)**



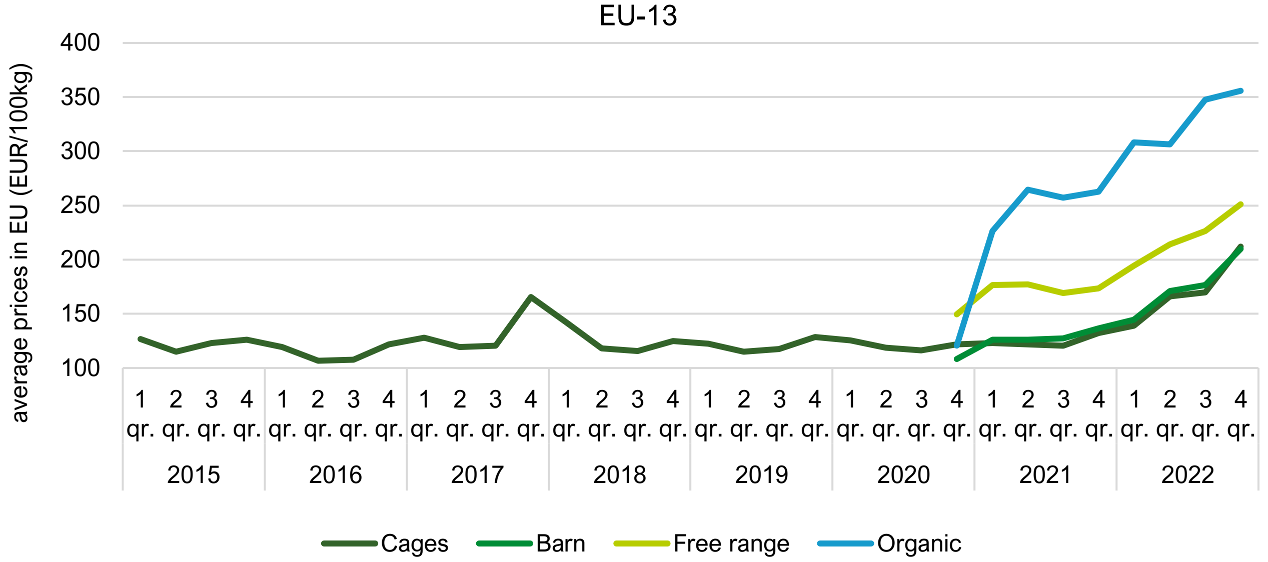
Source: own elaboration based on EC (2022)

Figure 12: **Average farm-gate eggs' prices in EU-14 by housing system (quarterly data)**



Source: own elaboration based on EC (2022)

Figure 13: **Average farm-gate eggs' prices in EU-13 by housing system (quarterly data)**



Source: own elaboration based on EC (2022)

1.2.5. Productivity, efficiency, management, and product quality

Table 30 and Table 31 show that moving from enriched cages to non-cage-keeping systems results in deteriorating physical efficiency in some EU Member States (the Netherlands, Germany, France, the United Kingdom, Spain, Italy, Denmark, Poland).

Table 30: **Physical efficiency indicators related to enriched cage and alternative housing systems (2017)**

Indicators	Enriched cage	Alternative (barn, aviary)	Difference (alternative compared to enriched cage) (percent)
Labour efficiency (hens/worker)	70,000	40,000	–43.0
Stocking density (hens/m^2)	27	18	–33.0
Mortality (%)	8	9	+1.0*
Length of production period (days)	450	450	–
Number of eggs per hen housed	400	390	–2.5
Egg production (kg/hen housed)	24.8	24.2	–2.4
Feed consumption (g/hen/day)	110	120	+9.0

* Percentage points
Source: own elaboration based on Van Horne (2019a)

Table 31: **Physical efficiency indicators in France (2019)**

Indicators	Enriched cage	Barn	Free range	Organic
Length of production period (days)	437	417	383	369
Empty period (days)	28	65	32	41
Mortality rate (%)	5.0	11.2	7.0	8.4
Egg production (eggs/hen)	350	320	300	290
Egg production (kg/hen housed)	22.5	20.9	20.5	20.0
FCR (kg/kg)	2.27	2.51	2.58	2.60

Source: own elaboration based on Bouzidi (2021)

Numerous studies indicate the difficulty of detailed evaluation of production results. Dikmen *et al.* (2016) underline that many parameters do not differ significantly between the conventional and enriched cage system, while the comparison of the cage system with the free-range indicates that some parameters are better in cage systems (better feather and bone traits in free-range, but higher dirty egg ratio, feed consumption, and foot lesions).

Yields of eggs per hen vary significantly across housing systems. Generally, yields are usually lower if animals have more space and freedom to move around, as in the case of outdoor and grass-based production systems (Kollenda *et al.*, 2020). In outdoor and grass-based production systems feed consumption may increase as a consequence of extra physical activity and thermoregulation at lower temperatures – due to the birds having outdoor access, and the lower density of hens in the house in organic systems (Leenstra *et al.*, 2014, Kollenda *et al.*, 2020). The literature also suggests that the number of birds and feed required to produce 1 kg of eggs is highest in the organic and lowest in the cage system (Leinonen *et al.*, 2012).

Some authors point out a reduced efficiency of labour when moving from the cage to non-cage system (Stadig *et al.*, 2016).

As a result of the transition to alternative housing systems, changes can be expected in both, the quantity and quality of the eggs produced. However, it is difficult to establish the full significance of this with so many different options and variability shown in results.

Some literature reported that caged hens deliver a higher yield of eggs, but their qualitative aspects (Haugh index and yolk colour) were not optimal (Castellini *et al.*, 2006). The egg quality in enriched cages was found to be largely dependent on cage design – for example, when nest-boxes or perches are not functional, quality can be negatively affected (EFSA, 2005, Kollenda *et al.*, 2020). On the other hand, Kraus *et al.* (2019) reported that most of the values of the main quality parameters of eggs were higher in eggs from enriched cages. Also, the significant effect of the enriched housing system on the yolk index was confirmed by Englmaierová *et al.* (2014) and Zita *et al.* (2018). On the contrary, Dikmen *et al.* (2017) did not find an interaction between housing systems in the yolk index. The nutritional properties of eggs and the quality preferred may differ due to the feed composition, e.g. widening the diet through grazing (Castellini *et al.,* 2006; Rakonjac *et al.,* 2014; Kollenda *et al.*, 2020). Matt *et al.* (2009) state that no significant difference between organic and conventional housing systems was found in the content of fatty acids, protein, sodium or dry matter in eggs. Organic eggs had considerably lower contents of calcium (2.8 times) compared with eggs from conventional farming. Similar results indicating a lower quality parameters of eggs from the organic system were presented by Küçükyılmaz *et al.* (2012).

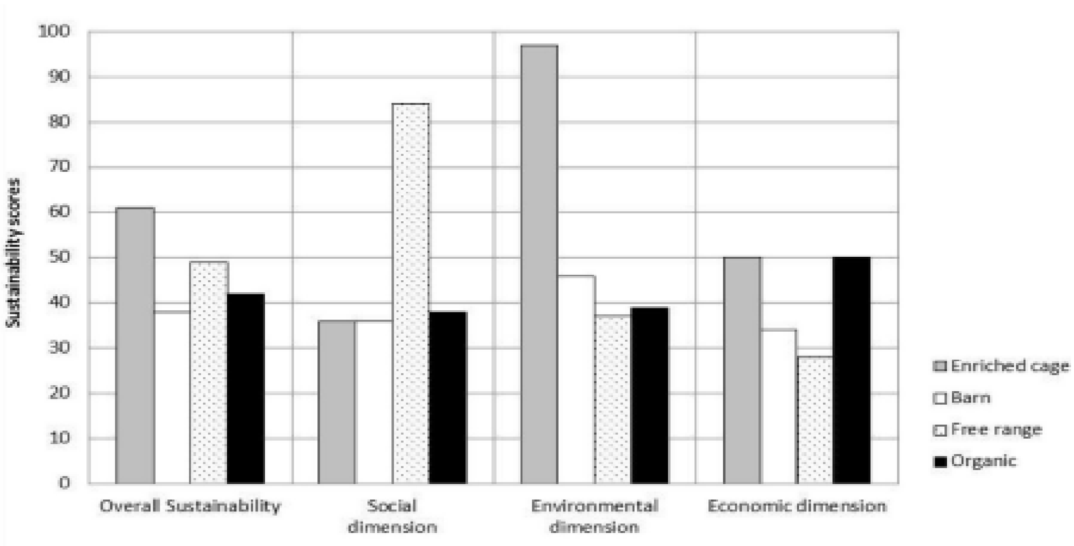
Another important issue is the risk of disease transmission and hygiene problems. While in indoor systems, the risk of disease transmission within the farm is higher, outdoor access may provide additional sources of infection (Kollenda *et al.*, 2020). Outdoor animals face additional threats. Laying hens, for example, are exposed to wild bird diseases (Bhanja *et al.*, 2018). Farmers must additionally be careful about diseases originating from contact with faeces in outdoor production more than in other systems (Kollenda *et al.*, 2020).

1.2.6. Environmental impacts

Egg production like other agricultural activities has a negative impact on the environment through the emission of greenhouse gases and the pollution of soil and water. The livestock and manure management practices of different hen housing systems can generate different emission levels and minimize the impact on the environment. In terms of environmental impacts, cage systems are preferable as high-yielding herds in concentrated housing systems provide the most efficient and least environmentally harmful solutions (eco-efficiency). Some authors emphasize that intensive agriculture means the most efficient use of agricultural land and water resources (sustainable intensification). It can be concluded that the use of resources (water, forage area, energy) and polluting emissions (ammonia, methane, carbon dioxide) are also changing negatively as a result of the transition from caged to non-caged housing.

Figure 14 shows the equal weights sustainability scores for examined farming methods assessed for the Netherlands. Considering economic, social and environmental sustainability aspects overall score is the highest for the enriched cage system, resulting mainly from the highly valued low environmental impacts. This statement is proved also by Molnár and Szőllősi (2020), as when the full sustainability aspects (economic, social and environmental) are taken into accounbt, alternative, free-range and organic farming methods have more unfavourable values than enriched cage housing systems. In the social dimension enriched cages have the lowest score, although probably here the level of consumer prices was not taken into account when assessing social acceptability. It is very likely that consumers from lower income societies could demonstrate a higher level of acceptance of cages (Żakowska-Biemans and Tekień, 2017; nu Yeh *et al.*, 2020).

Figure 14: **Comparing the sustainability scores of different housing systems in the Netherlands**



Source: van Asselt *et al.* (2015)

The breeding sector

According to the data of European Poultry Breeders (EPB), half of the world's poultry breeding stock is produced in Europe. The scope of the European breeding programme includes research and innovation in a way that fosters both the improvement of the environmental standards of animals and the sustainability of breeding itself. The action programme will be implemented under the Code EFABAR[3].

According to the EPB and EFFAB (European Forum of Farm Animal Breeders) the proportion of pure-line poultry kept in group cages was 0.048%, and the proportion of poultry kept in separate cages was 0.013% of the global poultry stock in the European countries. In developing countries, where animal welfare is of marginal importance, the laying hen population kept in cages has reached 3.9 billion. However, these countries are probably not willing to phase out the use of cages in the foreseeable future.

The key reasons for the use of cages in breeding are the following:

- it enables the individual measurement of data such as egg yield, features of egg quality, bird identification, sperm quality, feed utilisation or bowel function
- copulation programme can be carried out (if several males and females are kept in the same cage, fertilisation can not be assigned)
- health of workers is ensured during their worktime (reviewing of poultry stock is more efficient in cages, furthermore, working conditions of workers can be more secured)
- bad behavioural traits of laying hens can be suppressed (feather pecking and mortality decrease, if hens are kept in groups in cages – for the very same reason, selection can also be more efficient).
- birds' health status is considerably better (remaining biological security issues are much easier to handle than in the non-cage systems because of the manure management problems)

The breeding process focused on collecting 20-30 parameters, of which only about one-third can be implemented in cage-free systems. The remaining features (such as good standards of behaviour, FCR) cannot be determined in the cage-free systems. If birds could not be isolated in the breeding process, the selective genetic breeding program would seriously be affected by the following consequences: reduction in sustainability (the 1.5% better feed conversion ratio of caged animals contributes to a reduction of 931 thousand hectares of arable land used for feed production); increased aggression; more frequent occurrence of inbreeding (especially biological security and breeding development could be deteriorated).

If a prohibition of the caged housing system is adopted, the breeding programmes of quails and other smaller species could be endangered as the non-cage system is not suitable for them.

Transforming to non-cage housing systems will bring about a reduction in human labour efficiency. Automation and robotisation can be a good solution for this problem, but this has limited scope within the breeding programme and also needs a high level of investment. Completely banning the cages would lead to more costly breeding (ultimately increasing the price of day-old chicks), slower genetic improvement, and therefore a decreased competitiveness of the most important breeding companies. For this reason, the increased investment needs cannot be fully offset by subsidies. As a result, the main breeding companies will leave the European Union and the smaller ones will cease their production. Taking into account the current uncertainty of the supply chain, which was triggered by the coronavirus pandemic and the Russian-Ukrainian war, it is imperative to avoid any breeding dependency on third countries, and national-level breeding programmes should be uphold. Given the fact that the European breeding programmes face nowadays so many challenges (e.g. animal

[3] Code-EFABAR is a voluntary European code of good practice for responsible livestock production, which ensures the best animal health and welfare, food safety and public health, resource efficiency, reduced environmental impact, and product quality. (The Commitment to responsible breeding, URL: http://www.responsiblebreeding.eu/).

welfare and climate objectives), these things will definitely have negative repercussions on the whole production chain (Bábolna TETRA EPB and EFFAB).

1.2.7. General observations

The process of switching to a non-cage system which is largely demand-driven and pushed by animal welfare movements is progressing around the globe. Farmers from several European Union countries are already advanced in replacing cages with alternative housing systems responding to national regulations introducing a ban on cages and/or growing market demand for eggs produced in the barn or free-range systems. Although the price factor is important in purchasing consumers' decisions even in richer societies enlargement of the premium-priced eggs segment can be observed. However, the lowest price related to caged eggs, which is one of the most important influencing factors for many consumers – e.g. in Italy, Poland, Hungary (Żakowska-Biemans and Tekień, 2017; nu Yeh *et al.*, 2020).

The results from the most recent studies which were made available to the public show, that moving from cage to alternative housing system several factors (hygiene aspects, nearly doubled mortality rates, physical efficiency indicators, production costs, environmental impact) are increasingly unfavourable. In some studies, the authors also point out that the area available for one hen belongs to the key factors influencing the costs of egg production.

Alternative housing systems create conditions that allow freedom of movement and natural behaviours (e.g. perching, ground pecking, scratching and dustbathing). The ability to perform those behaviours offers a better laying hen welfare. Some researchers indicate, however, also disadvantages of alternative systems (i.e. bone fractures, feather pecking, cannibalism) are more common in alternative systems as compared to enriched cages, such as slightly greater losses (all systems) or exposure to rodents and predators in a natural barn or free-range systems. On the other hand, an enriched cage housing system provides more uncontaminated eggs, automatic processes, easy flock overviewing, healthier working place for workers (less dust and ammonia), less mortality, less infection, less use of medicine and antibiotics.

In terms of environmental impacts cage systems are considered less harmful solutions (eco-efficiency). Some authors emphasise that switching to a non-cage system does increase the use of resources (water, forage area, energy) as well as polluting emissions (ammonia, methane, carbon dioxide). According to Molnár and Szőllősi (2020), "non-caged production is not the best solution for environmentally, socially and economically sustainable egg production".

Related to the breeding sector, if the enriched cage housing system is banned, genetic improvement, efficiency and competitiveness would be in danger. This situation would cause a significant reduction in laying hen breeding.

2. Methodology

2.1. Farm-level assessments

2.1.1. Methodology of the farm-level assessments for sows

A basis for the assessments was the results of the farm survey, supported with additional data and information collected from the following sources:

- literature review on the efficiency of farrowing systems in pig farming,
- farm survey,
- contributions from farmers' organisations in the EU Member States,
- contributions from experts:
  - Robert Hoste, Herman Veermeer, Anita Hoofs from Wageningen University,
  - InterPIG global network,
  - Marcin Sońta, Anna Rekiel from Warsaw University of Life Sciences,
  - pig production companies' experiences in transition.

In the first stage of assessments, several indicators were calculated from the farm survey data to feed the CAPRI model. In the next stage, the assessment of impacts has been made for four basic scenarios (S1-S4) of changes in the sector – more details are provided in the methodological chapter. Farm-level assessments have been made for the surveyed sample of farms. Results from the second stage of the assessment served as a basis for scaling up the whole EU sector of pig production with a specific aggregation procedure. At the final stage, the CAPRI simulations also provided input for the recalculation of the EU sector results in the fifth scenario (S5).

The following housing systems were considered in the assessments:

- reference system – farrowing in crates at current size (at the farm)
- alternative systems:
  - free farrowing pen with confinement (temporary up to 5 days) – 5.5 m^2
  - free farrowing pen with no confinement – 7 m^2
- options for farmers were to declare resignation from pig production (Exit) or shift into pig fattening.

The key outcomes of the farm-level assessments are:

- selected parameters generated on the basis of the farm survey for the CAPRI model,
- farm-level impacts of the crates-ban up-scaled to the EU level under defined scenarios,
- key results of the assessment are as follows: additional variable costs, additional costs of investments + additional costs due to the depreciation of current buildings, likely structure of farrowing systems, foreseen exits from the sector (percentage of farms, percentage decrease in the number of sows and piglets weaned), the estimated number of pens to be replaced, the estimated number of sows, piglets weaned, and investments needs after the introduction of the ban on the use of crates,
- qualitative analysis of farmers' opinions about the intended ban (final report),
- qualitative analysis of farmers' opinions on the transition period (final report).

The main data source for the assessments of phasing out the use of farrowing crates in EU pig production was the farm survey conducted using the questionnaire constructed especially for this purpose.

The questionnaire contained the following categories of information regarding pig production:

- General farm characteristics – e.g. number of sows, farm capacity (number of places for sows, fattening pigs), size of farrowing pens and farrowing area,
- Technical parameters of production – e.g. sales of sows, piglets, fatteners, number of litters per sow, number of piglets born alive/dead, mortality of piglets, culling rates, piglets weaned per litter,
- Inputs – e.g. amount of feed for sows in the lactation period, labour input in the farrowing, vet-med costs,
- Prices of inputs (labour, feed for sows, gilts),
- Questions related to farmers' decisions on the future of farms when the ban on crates is introduced.

Several approaches have been applied in running the survey – online or paper questionnaires filled in by farmers or, less frequently, face-to-face or telephone interviews.

The key objective of the survey was to collect data allowing assessment of the impacts of the ban on the production and additional costs of pig farms. A specific objective was to learn preferences and plans regarding alternative farrowing systems choices. The possibility of declaring 'exit' (resignation from continuing production) and switching to pig-fattening also has been included.

Initially, it was planned to conduct the survey in all EU-27 countries. However, after analysis of the EU statistics for the sector, it was decided to eliminate from the set of countries those with negligible, below 0.3% share in the EU sow herd (Cyprus, Luxembourg, Malta, Slovenia, Estonia and Slovakia), and countries which completely transited to alternative systems (Sweden).

In the countries selected for the survey, the questionnaire has been distributed through organisations associated with COPA-COGECA.

In addition to parameters calculated from the farm survey sample, there were several assumptions made, based mainly on contributions from pig production experts and literature as well as data on alternative systems provided by pig companies experienced in transition. These assumptions concerned changes in productivity and inputs after the transition from crates to free farrowing systems. Farm-level averages were also sourced from Farm Organisations, especially for countries where the farm survey did not provide sufficient data). Separate survey for Farm Organisations was developed and distributed. Some parameters (average prices, labour costs, veterinary costs per sow, investment value per pig place) were also sourced from the InterPIG database.

Measuring costs of transition

Additional variable and investment costs of transition into free farrowing systems were the categories used to assess the financial impacts of the ban on farrowing crates.

The size of the pen differentiated alternative systems (with and without confinement):

- 5.5 m^2 for the free farrowing pen with the possibility of temporary confinement (up to 5 days);
- 7 m^2 for the free farrowing pen without the possibility of confinement.

Respectively, all specific parameters were adjusted as estimated by experts. Scenarios S1 and S2 were calculated as if all farms in the sample stayed in production. At this stage number of sows is reduced in alternative systems due to lower density, reflecting the difference between the current and alternative pen sizes (5.5 m^2 or 7 m^2) .

Key parameters used in Farm Assessments were (values for farrowing crates = 100%)

- mortality of piglets: +15% (in free farrowing with temporary confinement), and +20% (in free farrowing with no confinement),
- litters per sow/year: –1.9%,
- feed (concentrates) consumption in the lactation period (28 days): +7.3%,
- mortality of sows: +5%,
- culling-out percentage: +15%,

- labour input: +1 minute/sow per day during lactation, +2 minutes/sow per day during the lactation period,
- Vet-med costs: +7.5%,
- average cost of new farrowing pen is EUR 1700, with a depreciation period of 15 years,
- depreciation of the existing buildings in 25 years,
- depreciation cost was increased by 10% due to the cost of reconstruction of the existing buildings to install new pens.

Selected additional costs considered in alternative systems are:

- variable costs: increased feed costs during the lactation period for sow, increased cost of sow replacement, additional labour cost, increased vet-med costs,
- investment cost in the new farrowing pen
- depreciation of the existing building + cost of its rebuilding to install new pens (floor, etc.).

Transition scenarios at farm and EU sector levels

Five alternatives to farrowing crates scenarios were considered in farm-level aggregation of results. The **baseline scenario** represents production with the use of farrowing crates. In all scenarios, all financial calculations are made in fixed prices of 2021. Technical assessment parameters were estimated from the farm survey or assumed based on literature and experts' contributions, as well as from producer organisations. All 5 scenarios represent a hypothetical situation after the transition into alternative systems due to the EU policy impact. Other market parameters stayed unchanged as of 2021.

Baseline: CRATES: represents piglet production with the use of farrowing crates made at fixed prices and production parameters as of 2021.

Scenario S1$_{conf}$: "All farms move into the free farrowing system with temporary confinement" This scenario assumes that all farms in the sample will stay in production and all will move into the free farrowing system with temporary confinement [pen size 5.5m^2].

Scenario S2$_{no\text{-}conf}$ "All farmers will move to free farrowing system with NO confinement" This scenario assumes that all farms in the sample will stay in production and all will move into the free farrowing system with no confinement [pen size min. 7m^2].

Scenario S3$_{exit}$ "All farm declarations to alternative systems included" This scenario reflects a situation where all declarations regarding farmers' decisions will be taken into account. Considered options were: 1) switch to free farrowing system with temporary confinement; 2) switch to the free farrowing system with no confinement; 3) switch to production of fatteners only; 4) resigning from pig production. A respective number of sows was removed from the sample.

Scenario S4$_{modified}$ "Farm declarations to alternative systems were MODIFIED" It is very likely that some farmers declaring exit expressed such opinions because of frustration caused by the proposed regulations. Thus, in this scenario, we 'modified' initial declarations from scenario S3, assuming that, in reality, the decisions will be more rational and the number of 'exits' will be less than declared in the survey. Declarations of switching to free farrowing or pig-fattening remained unchanged comparing scenario S3. Only farm exits were rationalised. The modification procedure is described below.

It seems that the very high percentage of exits declared by farmers is to some extent a demonstration of discouragement and even frustration resulting from the disapproval of the ban. Such a conclusion is supported by the more detailed analysis of the group of farmers making such declarations (see Table 32). Among these farmers, there were farmers relatively young and/or having successors, as well as farmers owing large herds of sows. We assume these farmers are less likely to exit, as opposed to farmers from small farms, older and without successors.

Since we take into account that each farm in the sample represents a certain number of farms with similar characteristics, the valid conclusion is that only a part of the farmers declaring exit will quit in reality. Thus, we estimated the number of farmers who will stay in production despite 'exit' declarations in the survey. The linear interpolation was applied to take simultaneously into account three criteria to estimate probabilities of the exit:

- number of sows: if less than 50 – the probability is 100%, if more than 500 – it is 0%;
- age of farmer: if younger than 45 years old – 0%, if older than 60 years old – it is100;,
- likely successor in the family is expressed as a percentage of likelihood – if no successor at all – the probability of exit is 100%, if succession is certain – it is 0%.

Only in the case all three criteria jointly indicated a 100% probability of accession, such farms, including sows, were eliminated from the sample. In the case of farms with probabilities of exit within the range of 0-100% respective number of sows was removed from the sample. For farms which stayed in production, the choice of the system was assumed as S1 (free farrowing system with temporary confinement).

For companies in the sample, the only criterion used was the size of the herd, assuming that irrespective of age, farm managers can always be replaced.

Table 32 presents the structure of farmer decisions in scenarios S3 and S4, expressed in the percentage of sows affected by these decisions. It is to note that the share of farm declarations to exit was much higher than the related share of sows, which are affected by these decisions. It is due to the fact that those farmers who declared exits came mostly from small farms.

Following this procedure, the final number of sows in alternative systems after the transition in scenarios S3 and S4 was estimated.

Table 32: **Farmer declarations assumed for the scenarios C and D [expressed in percentage of sows in the sample*]**

$S3_{exit}$ "All farm declarations to alternative systems included"	**Swich to free farrowing with confinement 5.5m²**	**Swich to free farrowing system with NO confinement 7m²**	**Switch to Pig Fattening**	**Resignation from production**
TOTAL	60.2%	4.3%	5.1%	30.4%
west	54.2%	3.2%	7.0%	35.7%
east	67.3%	5.7%	2.8%	24.1%
$S4_{modified}$ "Farm declarations to alternative systems were MODIFIED"	**Swich to free farrowing with confinement 5.5m²**	**Swich to free farrowing system with NO confinement 7m²**	**Switch to Pig Fattening**	**Resignation from production**
TOTAL	94.5%	4.3%	0.3%	0.8%
west	95.7%	3.2%	0.4%	0.8%
east	93.2%	5.7%	0.3%	0.8%

* It is to note that the share of farm declarations to exit was much higher than the related share of sows, which are affected by these decisions. It is due to the fact that those farmers who declared exits came mostly from small farms.
Source: own elaboration based on the farm survey

Scenario $S5_{capri}$ "Farm exits and number of sows based on the CAPRI A scenario results" represents the assumption that all farmers are forced to transition by (1 January) 2025 due to the policy change.

Aggregation (scaling-up) procedure

As the last step, the results of the sample assessments were aggregated to the EU sector level. Results were weighted according to the sow-herd structure and share of sows kept in cages as of 2021 (Table 33).

Table 33: **Number of sows and the structure of sow herd in the EU Member States, 2021**

	Number of SOWS [2021, thousand heads]	Share in the Total EU	% Sows in crates
Spain	2,684.9	24.7%	99%
Germany	1,583.0	14.6%	99%
Denmark	1,235.0	11.4%	95%
France	928.0	8.5%	96%
Netherlands	910.0	8.4%	98%
Italy	551.0	5.1%	99%
Belgium	386.3	3.6%	95%
Portugal	229.6	2.1%	99%
Austria	224.1	2.1%	95%
Ireland	144.8	1.3%	99%
Sweden	120.7	1.1%	0%
Greece	100.0	0.9%	99%
Finland	93.0	0.9%	60%
Cyprus	31.0	0.3%	95%
Malta	3.7	0.0%	99%
Luxembourg	3.1	0.0%	99%
Poland	654.1	6.0%	95%
Romania	298.9	2.7%	99%
Hungary	240.7	2.2%	99%
Czechia	126.4	1.2%	95%
Croatia	104.0	1.0%	95%
Bulgaria	65.8	0.6%	99%
Lithuania	44.3	0.4%	95%
Latvia	39.7	0.4%	95%
Slovakia	37.2	0.3%	99%
Estonia	25.7	0.2%	95%
Slovenia	14.2	0.1%	95%
TOTAL EU	10,879.1	100.0%	96.2%
WEST	9,228.2	84.8%	96.1%
EAST	1,650.9	15.2%	96.6%
7 biggest producing countries (SP, DE, DK, FR, NL, IT, PL)	8,546.0	78.6%	97.7%

Source: own elaboration based on EUROSTAT data.

Despite some differences between countries regarding farm parameters and farmer decisions, the average proportion for the whole sample was applied with a division into groups of countries classified as 'East' (new member states from central and eastern Europe) and 'West' – all of those remaining representing 'old' member states. A group consisting of the seven biggest producing countries was also distinguished (Spain, Denmark, Germany, The Netherlands, France, Italy, and Poland) according to the number of sows in the country. This was a necessary simplification because of the uneven representation of farms from different countries in the sample. Also, not all EU countries participated in the farm survey for a variety of reasons. It did not allow us to aggregate results for individual countries, but scaling up to the EU-level should not cause a significant bias in the final assessments.

2.1.2. Methodology of the farm-level assessments for hens

Sources of data and information:

A basis for the assessments was the results of the Farm Survey, supported with additional data and information collected from the following sources:

- Literature Review,
- EU statistics on the number of laying hens in the year 2021 and the structure of housing systems,
- Contributions from farmers' organisations in the EU countries,
- Contributions from experts: Bernhard Hoerning (Eberswalde University for Sustainable Development, Germany), Jan Niemiec (Warsaw University of Life Sciences, Poland), Aneta Gębczyk (Academy of Applied Sciences, Nowy Sącz, Poland).

In the first stage of assessments, several indicators were calculated from the Farm Survey data to feed the CAPRI model. In the next stage, the assessment of impacts has been made for three basic scenarios of changes in the sector – more details are provided in the methodological chapter. An additional scenario was constructed using critical parameters from the CAPRI model – the equilibrium price of eggs and the shift in egg production volume.

All stage I and II assessments have been made for the surveyed sample of farms – the results served as a basis for scaling up to the whole EU sector of egg production using a specific aggregation procedure.

The housing systems considered in the assessments were as follows:

- Reference system – Enriched Cages
- Alternative systems – Voliera (Barn), Free-Range, Organic

The key outcomes of the farm-level assessments are as follows:

- Selected parameters generated for the CAPRI model based on Farm Survey;
- Farm-level impacts of the ban up-scaled to the EU-level under defined scenarios. Key results of the assessment are as follows: Gross Margins from egg production, likely structures of housing systems, foreseen exits from the sector (number of farms), the estimated number of laying hens and eggs production, and value of investments.
- Qualitative analysis of farmers' opinions about the intended ban.

The assessment's main data source was the Farm Survey conducted using the questionnaire constructed for this purpose.

The questionnaire contained the following categories of information regarding eggs production:

- General characteristics – e.g. number of hens, size of hen houses, the value of the historic investment;
- Production – yields and sales of eggs, mortality, culling rates, sizes and prices of eggs for consumption, sales for industrial use;
- Inputs – feed, labour, litter, pullets, and similar;
- Prices of products and inputs.

Several approaches have been applied in running the survey – online or paper questionnaires filled in by farmers or, less frequently, face-to-face or telephone interviews.

The key objective of the survey was to collect data allowing assessment of the impacts of the ban on the production and financial performance of egg farms. A specific objective was to learn farmers' preferences and plans regarding choices of alternative hens housing system choices. The possibility of declaring 'exit' (resignation from continuing production) also has been included.

Initially, it was planned to conduct the survey in all EU-27 countries. However, after analysis of the EU statistics for the sector, it was decided to eliminate from the set of countries those with a negligible, below 0.2% share of the EU eggs production (Cyprus, Luxembourg, Malta), and countries which have almost completely transitioned to alternative systems (Austria, Denmark, Germany, Sweden, The Netherlands).

In the countries selected for the survey, the questionnaire has been distributed through organisations associated with Copa-Cogeca.

Measuring Financial Performance

Gross Margin from egg production is a category used to assess the financial impacts of the ban on enriched cages. The general formula to calculate Gross Margin (GM) is as follows:

GM = Value of Production minus Direct Costs.

Value of production is the sum of revenues from sales of eggs and end-of-lay hens for slaughter.

In the category of **Direct Costs**, only those costs were included, which differentiate housing systems.

Financial results have been calculated in fixed 2021 prices, what allows to demonstrate only the impact of changes in production systems because of the ban on enriched cages, irrespective of long-term trends. 2021 is the reference year.

Transition scenarios

The key assumption for the entire analysis was that each surveyed farm represents a certain number of farms with similar characteristics, although the sample cannot be called "representative". So the approach we have taken is more type of a case study, which does not allow for formal statistical analysis and econometric modelling, but provides a valid basis for concluding on likely reactions of farmers to the ban and future trends in the egg production sector.

Starting with the primary Farm Survey data (number of hens per farm, eggs yield per hen) for the reference year (2021), the structure of laying hens kept in alternative housing systems after the complete transition from enriched cages was estimated. Hens' movement from cages was planned, considering farmers' declarations indicating their preferred systems. Because of a large number of declarations of ‘exit’, in reality unlikely, in our opinion, we developed differentiated variants of exits. It resulted in the construction of the following transition scenarios:
H1 2035 – ‘Extreme Exits’
H2 2035 – ‘No Exits’
H3 2035 – ‘Modified Exits’
H4 2035 – ‘Capri Market Equilibrium’

In all scenarios, **2021 is the base year**, and all financial calculations are made in fixed prices of 2021. Technical assessment parameters were estimated from the Farm Survey or assumed based on literature and experts' contributions. It is assumed that all enriched cages will be eliminated at the end of the foreseen transition period (2035). Laying hens kept in enriched cages as presented in the EU statistics will be moved to alternative systems in proportions resulting from the declarations of farmers in the Farm Survey after eliminating from production a certain number of hens due to exits declared by some farmers and reductions forced by EU regulations imposing lower density in alternative housing systems. In scenarios $H1_{exits}$, $H2_{no\text{-}exits}$ and $H3_{modified}$ 2035, the assumption was made that there are no investments in new houses for hens that would increase the production capacities of the sector. Such investments are planned in the $H4_{capri\ eq}$ 2035 scenario.

In all scenarios, investments in new equipment replacing enriched cages were planned.

Brief description of scenarios

$H1_{exits}$ 2035 – ‘Extreme Exits’
According to the Farm Survey, some farmers may resign from continuing egg production. This scenario reflects an extreme situation, assuming all farmers who declared exit would quit, and hens from their farms would be moved out of production.

$H2_{no\text{-}exits}$ 2035 – 'No Exits'

This is another extreme – all farmers continue production, and all hens from the base year 2021 are moved into alternative systems after deducting reductions in the number of hens due to lower densities in alternative systems.

$H3_{modified}$ 2035 – 'Modified Exits'

Some farmers declare exit likely because of frustration caused by the proposed regulations, which egg producers do not widely accept. That is why we 'modified' initial declarations assuming that, in reality, the decisions will be more rational and the number of 'exits' will be less than declared in the survey.

The modification procedure is described in detail in the following subchapter.

The "Modified Exits" in terms of the number of the hens can be placed between $H1_{exits}$ and $H2_{no\text{-}exits}$ 2035 scenarios.

$H4_{capri\ eq}$ 2035 – 'Capri Market Equilibrium'

This scenario is a variant of the $H3_{modified}$ 2035 with introduced equilibrium production and equilibrium price estimated in the CAPRI model: Accordingly, the average price increase set initially for farm-level assessments at 14% was reduced to 7%. Similarly, after the CAPRI solution, the volume of egg production was reduced by 3,6% compared to the 2021 situation. With 'exits' at the level as in the Modified scenario, it was assumed that there would be new entries to the sector or additional investments in buildings and equipment on farms staying in the system would be required.

Estimating the number of hens and eggs produced after the transition to alternative systems

The number of hens moved to alternative scenarios from enriched cages is estimated based on the assumed likelihood of exits and reduced density in alternative systems and existing buildings.

Simple assumptions have been made for two extreme scenarios: $H1_{exits}$ – 100% of declared exits, and $H2_{no\text{-}exits}$ – no exits at all.

For the $H3_{modified}$ and $H4_{capri\ eq}$ scenarios, the estimation procedure has been developed, based on the assumption, that the likelihood of exits decreases in line with the lower age of farmers' high probability of having a successor, also in the case of farmers owing larger herds of hens. In the case of older farmers, without successors and running small-scale family farms, resignations from continuing production will probably be more likely. It was also assumed that for companies, the human factor is not decisive (managers can be replaced), and only the small scale of operations may be a factor leading to the exit.

In order to estimate the probability of exits, the linear interpolation was made for all farms in the sample, taking simultaneously into account three criteria:

- Number of hens: if less than 25 thousand – the probability of exit is 100%, if more than 120 thousand – it is 0%;
- Age of farmer: if younger than 45 years old – the probability of exit is 0%, if older than 60 – it is 100%;
- Likely successor in the family is expressed as a percentage of likelihood: if no successor at all – the probability of exit is 100%, if succession is certain – it is 0%.

Only in the case of all three criteria jointly indicating a 100% probability of the exit such farms, including hens, were eliminated from production. The probability of exit within the 0-99% range determines a proportion of farms and hens moving out of production.

Example to clarify the procedure:

- Number of hens: 50000 – the probability of exit is about 73%,
- Age of farmer: less than 45 – the probability is 0%;
- Likely successor in the family: the probability is 50%.

The likelihood of exit for this example is (73% + 0% + 50%)/3 = 41%.

Such a coefficient has been calculated for each farm in the sample. In the next step, the existing number of hens was multiplied by the coefficient.

Following this procedure and the indication of the selected housing system, the final structure of farms and hens in alternative systems after the transition was estimated. The final number of hens staying in production after assumed exits were adjusted to lower densities in alternative systems compared to enriched cages.

Key parameters used in Farm Assessment models (values for Enriched Cages = 100)

In addition to parameters calculated from the Farm Survey sample, there were several assumptions made (Table 34), based mainly on contributions from experts, concerning change in productivity and inputs after the transition from cages to alternative housing systems.

Table 34: **Assumptions for the farm-level assessments: ratio for enriched cages system = 100**

Parameters	Justification for the change	Housing System		
		Barn (Voliera)	Free-range	Organic
Feed consumption per hen	More movement (lower density, outdoor run)	102.2	104.3	108.7
Price of feed	Certified feed in organic production	100	100	135
Average weight of eggs	–	100	95	95
Yield of eggs (number/hen/year)	–	97	85	85
Mortality increase	movement, threat of diseases (FR, organic)	102	103.9	103,9
Veterinary costs per hen	As above	100	111	111
Energy costs per hen	Lower density (less hens)	117.6	142.8	142.8
Labour costs per hen	Additional input of labour, worse working conditions	122.1	127.6	133.2
Price of pullet	Adaptation to the housing system	100	110	125
Price of eggs	Market relations*	109	135	170
Central and East European Countries		16 (11)	17 (12)	17 (12)
Other EU countries		20 (15)	22 (16)	22 (16)
Duration of exploitation (number of years) to calculate depreciation of: new equipment – 20, new buildings – 40				

* Derived from average prices calculated for the set of EU countries noted in https://agridata.ec.europa.eu/extensions/DashboardEggs/EggsPrice.html#
** Average values based on information provided by farmers organizations in a number of countries
Source: own elaboration

Aggregation (scaling-up) procedure

In the base year 2021, about 45% of laying hens in the Member States were housed in enriched cages (Table 35). All hens from the cages (about 169 million heads), considering farmers' declarations regarding the choice of the hens' housing systems, were distributed after deducting reductions due to exits and lower densities among the alternative systems in proportions as calculated from the Farm Survey sample.

Despite some differences between countries regarding farmers' choice of systems, the average proportion for the whole sample was applied. This was a necessary simplification because of the uneven representation of farms from different countries in the sample. Also, for different reasons, not all EU countries participated in the Farm Survey. It did not allow us to aggregate results for individual countries, but scaling up to the EU-level should not cause a significant bias in the final assessments.

Results of assessments have been aggregated to the level of the entire EU egg sector, as well as at the scale of groups of countries classified as 'East' (new member states from central and eastern Europe) and 'West' (all remaining, representing 'old' member states).

Table 35: **Number of laying hens by farming method (maximum capacity) according to notifications under Commission Implementing Regulation (EU) 2017/1185, Art. 12(b) – Annex III.9**

			Hens in housing systems – share [%]					Hens in housing systems – [million hens]			
Member State (MS)	Total number of laying hens	Share of MS in the EU	Enriched cages	Barn	Free-range	Organic	Total	Enriched cages	Barn	Free-range	Organic
DE	58,064,747	15.40	5.50	58.80	22.10	13.60	100	3.19	34.14	12.83	7.90
PL	51,241,025	13.60	76.20	17.80	5.00	1.00	100	39.05	9.12	2.56	0.51
FR*	48,255,709	12.80	54.10	11.70	23.00	11.20	100	26.11	5.65	11.10	5.40
ES	47,069,236	12.50	73.20	16.10	9.10	1.60	100	34.45	7.58	4.28	0.75
IT	40,519,407	10.80	35.60	54.60	4.90	4.90	100	14.42	22.12	1.99	1.99
NL	31,483,393	8.40	7.80	60.80	22.80	8.60	100	2.46	19.14	7.18	2.71
BE	10,814,337	2.90	36.20	42.90	13.50	7.40	100	3.91	4.64	1.46	0.80
PT	10,228,212	2.70	75.00	19.50	4.70	0.80	100	7.67	1.99	0.48	0.08
RO	8,954,319	2.40	57.20	36.80	3.30	2.70	100	5.12	3.30	0.30	0.24
SE	8,655,197	2.30	3.70	77.10	4.90	14.30	100	0.32	6.67	0.42	1.24
HU	7,548,745	2.00	71.20	27.20	1.30	0.30	100	5.37	2.05	0.10	0.02
AT	7,406,040	2.00	0.00	58.70	28.40	12.90	100	0.00	4.35	2.10	0.96
CZ	7,471,545	2.00	62.20	36.20	1.20	0.40	100	4.65	2.70	0.09	0.03
BG	5,090,680	1.40	70.20	27.50	2.30	0.00	100	3.57	1.40	0.12	0.00
FI	5,071,922	1.30	45.50	43.90	3.50	7.10	100	2.31	2.23	0.18	0.36
EL**	4,649,598	1.20	76.50	12.40	5.50	5.60	100	3.56	0.58	0.26	0.26
DK	4,331,408	1.20	9.90	49.00	8.10	33.00	100	0.43	2.12	0.35	1.43
IE	3,880,164	1.00	48.50	1.40	46.40	3.70	100	1.88	0.05	1.80	0.14
LV	3,533,598	0.90	69.30	27.50	3.00	0.20	100	2.45	0.97	0.11	0.01
SK	3,126,067	0.80	75.30	22.30	2.20	0.20	100	2.35	0.70	0.07	0.01
LT	2,926,891	0.80	79.70	18.50	1.20	0.60	100	2.33	0.54	0.04	0.02
HR	2,369,476	0.60	62.10	33.50	3.90	0.50	100	1.47	0.79	0.09	0.01
SI	1,449,060	0.40	17.20	61.30	18.90	2.60	100	0.25	0.89	0.27	0.04
EE	843,487	0.20	87.70	8.30	2.60	1.40	100	0.74	0.07	0.02	0.01
CY	516,461	0.10	67.80	15.90	13.10	3.20	100	0.35	0.08	0.07	0.02
MT	360,585	0.10	99.40	0.60	0.00	0.00	100	0.36	0.00	0.00	0.00
LU	134,497	0.00	0.00	66.60	10.70	22.70	100	0.00	0.09	0.01	0.03
TOTAL	375,995,806K	100.00	44.90	35.60	12.80	6.60	100	168.82	133.85	48.13	24.82

* 2019 data ** 2020 data
Source: https://agriculture.ec.europa.eu/farming/animal-products/eggs_en

Characteristics of the sample

Parameters characterising the sample of surveyed farms and further assessments results are presented for clusters distinguished based on two criteria:

a. Geographic location:
   - 'East' (PL, HU, CZ, SK, LV, HR, EE, BG)
   - 'West' (IE, ES, EL, PT, FR, IT)

b. Size of the flock of laying hens:
   - Small – below 30 000 hens;
   - Medium – between 30 000 – 100 000 hens;
   - Large – above 100 000 hens.

The basic characteristics of the sample are presented in Table 36.

Table 36: **Basic characteristics of the sample of surveyed farms**

Farm cluster	Number of farms	Number of laying hens ('000)	Number of hens/ farm	Mean age of hen-house [years]	Mean age of enriched cages [years]	Egg yield/ hen	Fully employed per farm*	Fully employed per '000 hens	Average price of eggs – class A [EUR/egg]	Revenues [EUR/ hen]
Sample and groups of countries according to geographical location										
East	108	11,525	106,711	19.1	8.7	303	11.7	0.110	0.073	21.71
West	63	13,893	220,516	23.8	9.2	306	16.5	0.075	0.081	24.48
Sample	171	25,417	148,639	20.8	8.8	304	13.4	0.090	0.077	23.22
Clusters according to the flock size (number of hens/farm)										
Small (<30k)	57	659	11,558	25.7	9.1	308	2	0.192	0.081	27.88
Medium (30-100 k)	48	2,979	62,052	18.0	8.8	301	6	0.090	0.079	28.16
Large (>100k)	66	21,780	330,000	18.8	8.6	305	29	0.087	0.077	22.41

* Number of fully employed was calculated as follows: [number of permanent staff + (number of part-time workers * averages number of days worked)] / 1800 hours/year.
Source: own elaboration

There are no significant differences in the value of parameters characterizing different farm clusters in the sample, although mean values presented in Table 36 hide a relatively wide range of values of indicators calculated for single farms.

The most significant difference is in the indicators for employment. The number of fully employed per '000 hens is noticeably greater in the eastern countries and in the cluster of 'small' farms. This influences the efficiency of labour and financial results, considering egg yields and prices are comparable across different clusters in the sample.

In total, 45,03% of 'cage' farmers declared they would switch to Voliera (Barn), as presented in Table 37.

Table 37: **Farmers' declarations regarding transition after the ban on enriched cages (switch to alternative systems or exit)**

HENS	Voliera (Barn)	Free-range	Orga-nic	Exit	Total	HENS	Voliera (Barn)	Free-range	Orga-nic	Exit	Total
Sample and groups of countries according to geographical location											
Number of farms						**Structure %**					
Sample	77	19	3	72	171	Sample	45.03	11.11	1.75	42.11	100.00
EAST	49	12	2	45	108	EAST	45.37	11.11	1.85	41.67	100.00
WEST	28	7	1	27	63	WEST	44.44	11.11	1.59	42.86	100.00
Clusters according to the flock size											
Small	14	3	2	38	57	Small	24.56	5.26	3.51	66.67	100.0
Medium	27	7	0	14	48	Medium	56.25	14.58	0.00	29.17	100.0
Large	36	9	1	20	66	Large	54.55	13.64	1.52	30.30	100.0

Source: own elaboration

Discontinuing egg production was the second choice (42.1% in the whole sample) – this was a dominating option in the cluster of small farms (66.7%). Because the average age of farmers in all clusters was similar (between 42-54 years), a valid hypothesis is that the scale of operations was a decisive factor in the choice.

Shifts of hens from cages resulting from farmers' declarations are in similar proportions (Table 38).

Table 38: **Transformations declared by farmers after the ban on enriched cages**

HENS	Voliera (Barn)	Free-range	Orga-nic	Exit	Total	HENS	Voliera (Barn)	Free-range	Orga-nic	Exit	Total
Sample and groups of countries according to geographical location											
Number of hens ('000)						**Structure %**					
Sample	14,924	3,476	186	6,832	25,417	Sample	58.72	13.68	0.73	26.88	100.0
EAST	5,707	1,682	175	3,961	11,525	EAST	49.52	14.59	1.51	34.37	100.0
WEST	9,217	1,794	11	2,871	13,893	WEST	66.34	12.91	0.08	20.67	100.0
Clusters according to the flock size											
Small	193	37	26	404	659	Small	29.25	5.58	3.87	61.30	100.0
Medium	1,639	497	0	843	2,979	Medium	55.02	16.69	0.00	28.29	100.0
Large	13,093	2,942	160	5,585	21,780	Large	60.11	13.51	0.73	25.64	100.0

Source: own elaboration

If the decisions of farmers match in reality declarations, and there are no new investments, 26.88% of hens from the sample would go out of production.

The number of hens staying in production would be even less considering reductions due to imposed lower densities. A combined effect of exits, assuming an extreme situation of the number of exits equal declarations and lowering density, is shown in Table 39.

The majority of hens would be moved to the Barn eggs system (81.2%), which is also a preferred option for the largest farms (81.0%). Noticeably, six times higher than in the sample is the share of hens moved to organic production (6.2%) in declarations of small farmers. This option might be considered reasonable for small-scale producers, especially considering the excessive labour resources in this cluster of farms.

Table 39: **Estimated number of hens in the sample after exits and reduction of density**

HENS	Voliera (Barn)	Free-range	Orga-nic	Exit	Total	HENS	Voliera (Barn)	Free-range	Orga-nic	Exit	Total
Sample and groups of countries according to geographical location											
Number of hens ('000)						Structure %					
Sample	12,454	2,748	146	–	15,347	Sample	81.15	17.90	0.95	–	100.0
EAST	6,050	1,686	139	–	7,875	EAST	76.82	21.41	1.77	–	100.0
WEST	6,404	1,061	6	–	7,472	WEST	85.71	14.20	0.08	–	100.0
Clusters according to the flock size											
Small	236	47	19		302	Small	78.17	15.63	6.20	–	100.0
Medium	1,618	472	3		2,092	Medium	77.31	22.56	0.13	–	100.0
Large	13,257	2,971	137		16,365	Large	81.01	18.15	0.84	–	100.0

Source: own elaboration

The structure of alternative systems in the sample after transformation, based on farmers' declarations, faithfully reflects the existing situation in the EU laying hens sector. In reality, the number of farmers switching to Free-range would probably be less than declared, and slightly more hens will be moved to organic production.

It seems, however, that a very high percentage of exits declared by farmers is, to some extent, a demonstration of discouragement and even frustration resulting from the disapproval of the ban. In reality, the number of extreme exit decisions will likely be less, assuming egg production in alternative systems will still be profitable, and farmers will have sufficient financial resources to cover necessary investments.

Variable costs for the sample of farms (enriched cages), which form a basis for further estimates, are presented in Table 40.

Table 40: **Variable costs – sample, enriched cages (EUR/hen)**

Cluster	Pullet	Vet	Energy	Feed	Labour	Other	Total
Sample and groups of countries according to geographical location							
Costs EUR/hen							
Sample	4.38	0.19	0.41	13.33	2.04	0.40	20.75
East	4.52	0.25	0.44	12.10	1.52	0.62	19.45
West	4.26	0.14	0.38	14.34	2.48	0.22	21.83
Structure %							
Sample	21.12	0.92	1.97	64.23	9.85	1.92	100.00
East	23.25	1.28	2.26	62.22	7.81	3.17	100.00
West	19.54	0.65	1.76	65.71	11.35	1.00	100.00
Clusters according to the flock size							
Costs EUR/hen							
Small	4.48	0.33	0.59	13.67	2.43	0.54	22.03
Medium	4.59	0.36	0.42	12.46	1.47	0.48	19.77
Large	4.35	0.16	0.40	13.43	2.11	0.38	20.84
Structure %							
Small	20.32	1.48	2.67	62.07	11.01	2.45	100.00
Medium	23.20	1.84	2.12	62.99	7.42	2.44	100.00
Large	20.87	0.78	1.93	64.45	10.13	1.84	100.00

Source: own elaboration

The cost of feed is dominating in the structure (64.2%) on average, followed by the cost of pullets and labour. The cost of own labour in individual, family farms was calculated at the price of one hour of hired labour provided by respondents.

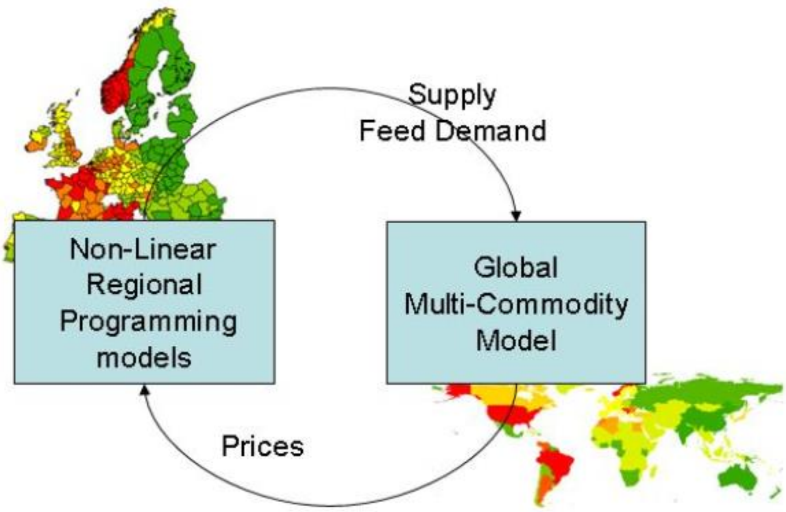
2.2. CAPRI model

2.2.1. A brief overview of the CAPRI model

General model structure

The Common Agricultural Policy Regional Impact (CAPRI) model is a global economic partial comparative static equilibrium model for the agricultural sector, with a focus on the European Union. It was designed for the *ex-ante* impact assessment of agricultural, environmental and trade policies. The model is composed of two main parts which are interlinked: a set of supply models for the European agricultural sector and a market module covering global agri-food markets. The supply part calculates and passes on the profit maximising (optimal) EU agricultural supply to the market model. On the other hand, the market model calculates the adjustment in global agri-food trade and provides price feedback to the CAPRI supply models (Figure 15).

Figure 15: **The two main parts of CAPRI, the supply models and the global market model, and their interlinkages**



Source: CAPRI model documentation

European agricultural supply in CAPRI

The supply module consists of independent aggregate non-linear programming models, representing activities of farmers at regional (NUTS-2) or farm type level captured by the Economic Accounts for Agriculture (EAA). The optimal supply is determined under a number of constraints, including land availability, policy restrictions and feeding restrictions based on requirement functions. The underlying methodology assumes the following adjustment possibilities for farmers:

- producers determine optimal variable input coefficients per hectare of land or per head of livestock (e.g. nutrient needs for crops and animals, seed, plant protection, energy or pharmaceutical inputs),
- producers also determine the optimal mix of crop and animal activities simultaneously with the cost minimising feed and fertiliser mix.

The optimal (profit maximizing) decision of farmers in the CAPRI supply model is subject to a set of restrictions, formulated mathematically either as balance equations or direct constraints:

- availability of different land types (e.g. grass and arable land),
- nutrient requirements of crops and animals enter the supply models as constraints,
- animal nutrient requirements (e.g. gross energy and crude protein) are covered by a cost minimised feeding combination,
- fertiliser needs of crops have to be met by the use of either organic or synthetic fertilisers,
- policy restrictions directly affecting agricultural production (e.g. limits on nutrient load or greening requirements), formulated as direct constraints.

Profit maximization builds on the concept of gross value added, and optimises agricultural land use, livestock production and other input use under fixed output prices. It is the market model which calculates the price feedback from agricultural markets, factoring in also the demand for food commodities.

Cost allocation

CAPRI uses data from the Farm Accountancy Data Network[4] (FADN) to estimate input use and input costs for the production activities comprised in the model. The FADN database has an EU-wide geographical coverage based on standardised questionnaires targeting farm accounts. Nevertheless, production costs are not broken down to the level of agricultural activities, therefore, adequate input/cost allocation models need to be developed to estimate the input use and costs of the activities.

There are different approaches for input allocation in CAPRI:

1. For the nutrients nitrate, phosphate, and potash (NPK), nutrient balances are constructed. Nutrient content of crops and manure as well as observed fertiliser use are taken into account, combined also with gaseous losses. The nutrient balances determine the input coefficients and regional availability of manure, and they also define potential overfertilisation rates.
2. For feed, the input calculation is based on engineering knowledge (requirement functions for animal activities, nutrient content of feeding stuff, recommendations on feed mix), observed feed use (total national feed use, national feed costs). These information sources are combined and made consistent in a Highest Posterior Density (HPD) estimation framework[5].
3. For other inputs, estimation results from a FADN sample are combined with current aggregate national input demand reported in the Economic Accounts for Agriculture (EAA) and standard gross margin estimations, again using a HPD estimation framework.

For the third type of inputs[6] above, the CAPRI cost estimation model follows a Bayesian estimation approach: the HPD estimator is maximised, relative to a set of prior information and structural equations/consistency constraints. The set of prior information includes:

- FADN-based estimates already at activity level,
- unit value statistics from EAA,
- standard gross margins calculated from EUROSTAT data.

[4] The FADN monitors farms' income and business activities. It is also an important informative source for understanding the impact of the measures taken under the common agricultural policy. FADN is the only source of microeconomic data based on harmonised bookkeeping principles. It is based on national surveys and only covers EU agricultural holdings which, due to their size, can be considered commercial. The methodology applied aims to provide representative data according to three categories: region, economic size, and type of farming.

[5] The Highest Posterior Density (HPD) estimation framework is a Bayesian statistical technique, where the uncertainty in model parameters is described by probability distributions. The prior distribution is updated with the prior information (data input for the HPD estimator) to get a posterior probability distribution, which finally describes the model parameters.

[6] Such production inputs typically include fuel and energy costs, maintenance, pesticides, seeds, services, and veterinary costs.

The role of the consistency constraints is to establish logical links between the priors. For example, gross margin is defined as the difference between the revenue and the sum over all inputs used for an activity. Thus, the gross margins coming from the third set of priors are combined with the revenues calculated based on the second set of priors and with the input coefficients of the first set of priors.

The advantage of the CAPRI cost allocation model is, therefore, that it builds on FADN cost estimates but combines it with other information sources. As a result

- compatibility with EAA figures is achieved at the level of agricultural activities,
- the differences in how cost categories are defined in FADN versus CAPRI are addressed,
- estimating input coefficients that would violate simple consistency constraints or economic considerations (automated quality control for estimated coefficients) are avoided.

The estimated variable costs assume input-saving technological progress and take also into account macroeconomic projections on the inflation rate. These can be further adjusted by the CAPRI during the simulation exercise because CAPRI has the flexibility to fine-tune the intensity of animal production activities, with a direct impact on the average costs. The intensity of production in the livestock sectors are adjusted to maximise profits.

Global trade in agricultural and food products

The market module covers the globe by 40 countries and country groups (80 countries in total), each featuring equation systems of agricultural supply, and demand for feed and processing. The market model is parameterised to be consistent with basic economic properties: regularity is ensured through the choice of the functional form, while further restrictions are imposed during calibration (e.g. homogeneity of degree zero in prices, symmetry and correct curvature). The market module allows for welfare analysis: welfare changes for consumers, processing industry and public sector can be estimated. Trade policy instruments are also covered by the market module, including *ad-valorem* and specific tariffs (custom duties), tariff rate quotas, public intervention, and subsidised exports.

The market module follows the Armington approach for simulating bilateral trade flows (each export and import flow between each country pair is simulated). Imports from various sources of origin are differentiated by their prices, i.e. price differences between imports from different countries are covered. This setup allows the model to reflect existing trade preferences for certain regions.

The data sources used for modelling international trade in CAPRI includes FAOSTAT data (production statistics, food balances and trade matrices, statistics related to land and other input use), the MacMap and TradeMap databases[7] from the International Trade Centre, as well as data and projections from the GLOBIOM and PRIMES models.

EU trade in young animals

The trade of young animals is also implemented in the CAPRI market module, but in a simplified manner. Modelling the trade of young animals follows a net trade approach: the sum of excess supply or import demand among the EU countries is balanced out for the two EU macro-regions (EU-14 and EU-13) in the market model. This is not a simple accounting equation but rather a market clearing condition. This equation allows for defining the price feedback to any change in the young animal supply and demand, as arising from the supply models.

[7] https://intracen.org/research-and-data

Environmental impacts

CAPRI includes a GHG accounting scheme, which endogenously calculates EU agricultural GHG emissions for nitrous oxide and methane. The calculation is directly linked to the inputs and outputs of agricultural production activities. Following the IPCC guidelines (IPCC, 2006), a Tier 2 approach is used for the calculation of activity-based emission factors, but where the respective information is missing a Tier 1 (less detailed) approach is applied. Based on the GHG accounting scheme, CAPRI calculates non-CO_2 GHG emissions from EU agriculture, also converted into their global warming potential[8] (GWP) for direct comparison.

The calculation of agricultural emissions in CAPRI is different for the EU and the rest of the world. While EU agricultural emissions are calculated directly from the input use and outputs of agricultural activities in the CAPRI supply model, GHG emissions for the rest of the world are estimated on a commodity basis (i.e. per kg of product) and are calculated in the market model of CAPRI. Even though the GHG accounting in CAPRI is less detailed for non-EU countries, it is essential to cover emissions on a global scale. First, it allows us to assess the impact on global warming. Second, it also allows for an estimation of the emission leakage impacts, which are usually significant, if countries implement GHG reduction policies unilaterally and not in a coordinated manner with the other countries to avoid emission leakage (Himics *et al.*, 2018).

2.2.2. CAPRI database adjustments

The CAPRI database reconciles various data sources in a consistent manner, aimed at producing a complete database for the simulation exercise. The CAPRI database is composed of several parts, which are constructed in a sequence:

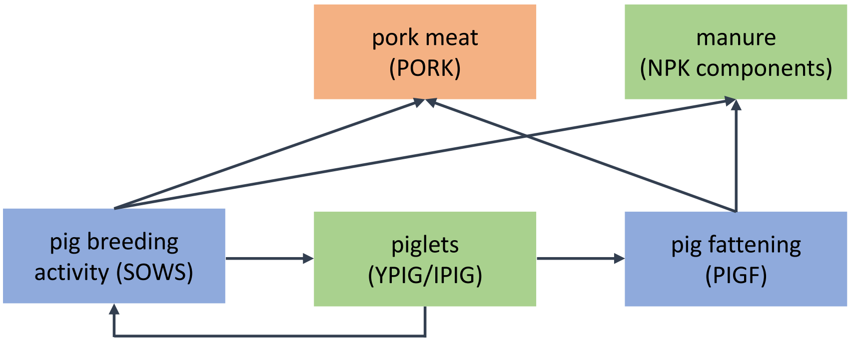
- starting from the Complete and Consistent (COCO) database for the European countries,
- the regionalised database for European NUTS-2 regions (CAPREG), which is the regionalised version of the COCO database, including additional (regional level) domains from Eurostat, and data from the Farm Structure Surveys (FSS) and the Farm Accountancy Data Network (FADN),
- the FAOSTAT global database for international agri-food markets, which is the key data source for the market module of CAPRI,
- additionally, further databases are also compiled, e.g. a database on EU agricultural policies, including financial subsidies under the EU Common Agricultural Policy (CAP), including both direct payments and rural development support, and a database including several domains from Eurostat in a consistent form (CAPRI-FAO database).

Adjustments based on InterPIG data

Pig breeding and pig fattening are two separate but interlinked activities in CAPRI. The pig breeding activity produces piglets for fattening, but also meat (from sows after their productive life cycle is over). The pig fattening activity uses piglets as production inputs and produces pork meat as primary output. Manure is produced in both activities (depicted in CAPRI with their NPK-nutrients content), and it is treated as a partly marketable intermediate product (with high transport cost). In most regions it has value for covering the nutrient need of crops (fertiliser source). The relevant production inputs and outputs of the two pig activities are depicted by Figure 16.

[8] GWP allows for the comparison of the global warming impacts of different gases. It is a measure of how much energy the emissions of 1 tonne of a gas will absorb over a given period of time, relative to the emissions of 1 tonne of CO_2 with a GWP value of 1.

Figure 16: **Input-output flows of pig activities in the CAPRI model**



Source: own elaboration

Assigning herd size, process length, activity levels, yields, and other production-related data to the countries and sectors often requires significant re-aggregation from the slaughtering statistics. Furthermore, technical coefficients are also consolidated in the respective data consolidation models of the COCO database. The consolidation models aim at completing the often-incomplete time-series/input data and they also make different data sources consistent with the CAPRI model structure.

Physical performance parameters from InterPIG

Data from the InterPIG database for 2021 were collected (see Annex 1) to refine certain physical efficiency parameters and to improve recent cost estimations for the pig breeding activity. The InterPIG dataset includes country averages in the main pig producing Member States and a few of the Eastern Member States of the EU[9].

The standard CAPRI approach derives the sow replacement rates from the annual livestock inventories, assuming that sows are on average first mated at the age of 240 days. For this study, country-specific replacement rates were taken from the InterPIG database. Technically, the new replacement rates directly change the input coefficients for the pig breeding activity.

The adjusted physical efficiency parameters were implemented in the COCO database generation part of CAPRI. The baseline process takes up these new values from there and adjusts also the projected physical efficiency parameters in the baseline for the years selected as possible deadlines for full transition.

Adjusted cost allocation using InterPIG data

CAPRI uses FADN data to estimate input use and input costs for the production activities comprised in the model. The FADN database has an EU-wide geographical coverage based on standardised questionnaires targeting farm accounts. Nevertheless, production costs are not broken down to the level of agricultural activities. Therefore, adequate input/cost allocation models had to be developed to estimate the input use and costs of the activities.

The term input allocation (or cost allocation) describes how aggregate input demand is allocated to production activities. The resulting activity-specific input coefficients are measured in value (e.g. EUR/ha) or in physical terms (e.g. kg/ha). For the allocation of inputs other than nutrients and feed, estimation results from an FADN sample were combined with current aggregate national input demand reported in the Economic Accounts for Agriculture (EAA) and standard gross margin estimations, using a Highest Posterior Density (HPD) estimation framework.

[9] InterPIG EU countries include Austria, Belgium, Czech, Denmark, Finland, France, Germany, Ireland, Hungary, Italy, Netherlands, and Spain. Of the non-InterPIG EU countries, for Poland its own survey data, for Portugal and Greece the French InterPIG data, for Bulgaria, Croatia, Romania and Slovakia the Hungarian InterPIG data, for Lithuania the Polish survey data were used. The sow herds in Cyprus, Latvia, Estonia, Slovenia, Luxembourg, and Malta are too small to be taken into consideration for any adjustments.

The CAPRI cost estimation model follows a Bayesian estimation approach: the HPD estimator is maximised, relative to a set of prior information and structural equations/consistency constraints. The set of prior information includes:

- FADN-based estimates already at activity level,
- unit value statistics from EAA,
- standard gross margins calculated from Eurostat data.

Input coefficients and costs were estimated for historical years and for the base year in the CAPREG part of CAPRI. Base year estimates were then projected for the simulation years previously agreed on, assuming an input-saving technological progress, and taking macroeconomic projections on the inflation rate into account as well.

The above cost estimation model was extended for the pig breeding activity with additional prior information from the InterPIG database for 2021 (see Annex 1). The prior information covered feed, veterinary costs, costs related to the maintenance of buildings and equipment, energy, and miscellaneous costs (Table 41).

Table 41: **InterPIG prior information in the CAPREG cost allocation model**

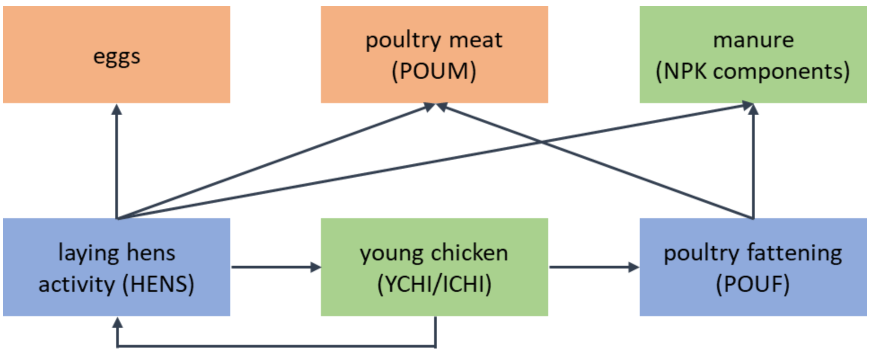
CAPRI cost item	InterPIG data
Feed cost (FEED), including own produced (fedg) and purchased feed (fedp)	Feed cost per sow/year (EUR)
Pharmaceutical inputs (IPHA)	Vet-Med & breeding cost per sow/year (EUR)
Maintenance and buildings related costs (REPM, REPB)	Building & equipment maintenance per sow place/year (EUR)
Electricity and heating costs (ELEC, EGAS)	Energy cost per sow/year (EUR)
Other costs (INPO)	Miscellaneous costs per sow/year (EUR)

Source: own elaboration

Adjustments based on the farm-level survey data

The poultry and egg industries are represented by two production activities in CAPRI, with overlap between the breeding and laying hens farm operations. The laying hens activity in CAPRI includes the production of both breeding and laying eggs. Total egg production in statistics typically includes both fertile eggs (from breeding flocks) and those for human consumption. As output of the laying hens activity, only marketed eggs for human consumption are considered, while hatching eggs do not appear as an explicit production output or input in CAPRI (but are considered implicitly in the price of young chickens for laying).

Figure 17: **Input-output flows of poultry activities in the CAPRI model**



Source: own elaboration

The eggs sector is so much vertically integrated that the costs of fertile egg production, hatcheries and laying hen rearing are difficult to separate, often being intermediates of a long supply chain, which produces eggs. Due to this vertical integration and the resulting data availability issues, breeding is included in the laying hens activity in CAPRI, i.e. the breeding industry is not represented by a separate production activity. As a recent Wageningen report assesses the eggs sector (van Horne, 2019):

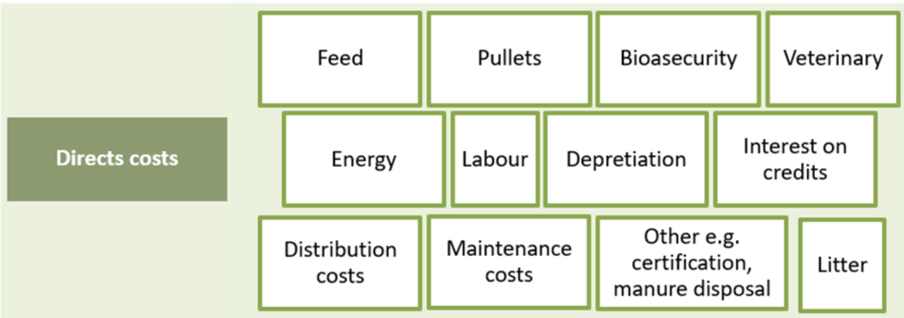
In the supply chain, different companies are involved in supplies and packing/processing of eggs. Examples are farms with parent stock supplying hatching eggs to hatcheries, hatcheries supplying day-old chicks and feed mills supplying feed to the farmers. The EU does not collect information on the number of companies in the supply chain. There is only very fragmented information of some member states. This information is too limited to give an estimate of the number of farms with parent stock, number of hatcheries, slaughterhouses for layers, packing stations, egg-processing companies or feed mills.'

The broiler industry is covered in CAPRI by the poultry fattening production activity. CAPRI considers broilers, turkeys, geese, and ducks in its poultry fattening aggregate activity, but in the CAPRI database, distinction of the four species is kept to some extent. The relevant production inputs and outputs of the two poultry activities are depicted on Figure 17. Some production outputs are simultaneously also production inputs for other activities (green boxes), e.g. young chicken are produced by the laying hens activity, while they are also inputs for poultry fattening.

Adjusted cost allocation in the layer sector

The cost allocation calculation for the CAPRI database was updated with the collected and adaptable data for 2021 from the farm-level surveys carried out in the layer sector (Figure 18). This update was part of the fine-tuning of the CAPRI baseline by including latest economic information from laying hen farms in the EU. In the CAPRI cost allocation calculation, the data from the farm-level surveys were included as additional information to the standard datasets from FADN and Eurostat, paying careful attention to avoiding any possible bias by the adaptation of these.

Figure 18: **Survey data on the cost structure of alternative layer housing systems**



Source: Farm Survey technical document

2.2.3. CAPRI baseline

To enable modelling alternative transition periods, the CAPRI baseline was simulated for 2025, 2035 and 2045, using the same calibrated model.

The CAPRI baseline includes those agricultural, environmental and trade policies which have already been approved, including measures of the 2014-2020 CAP, implemented at EU Member State or regional level. The future development of agricultural markets is calibrated to the European Commission's medium-term outlook for agricultural markets and income (European Commission, 2020). The outlook provides commodity market projections within a consistent modelling framework, using also external sources for the assumptions on macroeconomic developments (GDP growth, exchange rates, crude oil prices, inflation, and population growth).

Himics *et al.* (2014) provide more details and an in-depth discussion of the CAPRI calibration process. As two of the projection years of our analysis go beyond the time horizon of the EU Agricultural Outlook, we extrapolated and supplemented the European Commission's projections with other information (e.g. projections from the GLOBIOM and PRIMES models) to arrive at the CAPRI reference scenario for the years 2035 and 2045.

First, trend projections were prepared from the historical period up to the final simulation year (2045). While the base year of the CAPRI version used for this study is 2017 (the three-year average of 2016-2018), the CAPRI database includes data up to 2019. After this ex-post period, projections for the agricultural markets and agricultural production were established.

To validate the CAPRI baseline, the key baseline results were compared to historical data/statistics and projections from other studies, modelling exercises. The key validated baseline results included the market developments in the sectors of interest, covering EU agricultural production and demand, prices, and international trade. Data sources for the comparison included Eurostat, FAOSTAT, national statistics on agricultural production and prices, and preliminary AGMEMOD baseline results.

2.2.4. Scenario assumptions

The scenario exercise is a comparative static analysis in which the simulated state of the economy assuming the policy change (i.e. the full implementation of the ban on the use of cages in EU livestock production as part of the revamped EU animal welfare legislation) is compared to the baseline.

In the CAPRI simulations, switching to alternative housing systems include:

- in the pig sector: the use of temporary crating or non-confinement in farrowing, or specialising in fattening,
- in the egg sector: the use of aviary and barn systems.

The CAPRI simulations cover the two livestock sectors through the following set of scenarios:

- **Main scenarios**: 'End the Cage Age' scenarios assuming, as previously agreed, three different transition periods, i.e. (A) an immediate one (phase-out by 2025); (B) a 10-year long (phase-out by 2035); and (C) a 20-year long (phase-out by 2045). The main scenarios allowing for a longer transition period are broken down into sub-scenarios, assuming different speeds of non-EU-policy-driven transition to cage-free production systems.

1) **Scenario A (immediate transition, full EU policy impact)**: The assumption is that all farmers are forced to transition by (1 January) 2025.
2) **Scenario B1 (transition by 2035, full EU policy impact)**: The assumption is that farmers refrain from any further advancement in transitioning before the transition deadline. Scenario B1 represents an extreme situation.
3) **Scenario B2 (transition by 2035, partial EU policy impact)**: The assumption is that transition continues as observed in the years preceding 2021, driven by national legislation (draft or already in force), financial support incentives (planned or already existing), the need for investing into modernisation, and/or the increasing pressure by society, the retail sector, integrators, etc., and thus the obligation to be introduced by EU law will force only the rest of farmers to transition. We assume this group of farmers to make the transition by the transition deadline (1 January 2035). Farmers, who transitioned *before* the deadline, are assumed to maintain their level of production and incomes, otherwise they would have not transitioned[10].
4) **Scenario C1 (transition by 2045, full EU policy impact)**: The assumption is that farmers refrain from any further advancement in transitioning before the transition deadline. Scenario C1, like scenario B1, represents an extreme situation.
5) **Scenario C2 (transition by 2045, partial EU policy impact)**: The assumption is that transition continues as observed in the years preceding 2021, driven by national legislation (draft or already in force), financial support incentives (planned or already existing), the

[10] Transition itself is already in an advanced stage in some Western EU Member States. Even though this could be a harbinger of things to come for the rest of the EU, this expense is clearly an opportunity cost not taken into account by CAPRI.

need for investing into modernisation, and/or the increasing pressure by society, the retail sector, integrators, etc., and thus the obligation to be introduced by EU law will force only the rest of farmers to transition. We assume this group of farmers to make the transition by the transition deadline (1 January 2045). Farmers, who transitioned *before* the deadline, are assumed to maintain their level of production and incomes, otherwise they would have not transitioned.

- **Sensitivity analyses on discount rates**: The above scenarios are calculated with a 5% nominal social discount factor as recommended by the Commission (European Commission, 2021b). However, as the annualised investment costs in the main scenarios are sensitive to the modelling assumptions on the discount rates, sensitivity analyses with higher (10%) and lower (2.5%) discount rates were also conducted for Scenarios B1-2 and C1-2. The results of these simulations are not discussed in this Report but are provided in the form of tables in the Annexes.
- **Sensitivity analyses on trade**: Sensitivity analyses on a possible ban on products from non-cage-free systems (i.e. pork and eggs) imported from third countries were originally envisaged; however, these were abandoned for multiple reasons:
  1) The 'End the Cage Age' Communication by the Commission identified three options (i.e. enhancing cooperation with trading partners, imposing rules on imports, and introducing an animal welfare labelling system which would also apply to imports) to promote policy coherence between domestic and imported products. Most of these trade-related policy action would be of non-tariff nature, and as long as the concrete policy measures are not communicated by the Commission, estimating reliable tariff equivalents is not possible.
  2) The main suppliers of pork meat and eggs to the EU (see Annex 2) are either complying with the stricter animal welfare requirements already (e.g. the UK for both pork and eggs), or explicitly committed themselves to comply with those in the future (e.g. Ukraine for eggs, in case of which Article 64 of the EU-Ukraine DCFTA includes a commitment for Ukraine to align its animal welfare legislation with the EU's). The main suppliers of pork meat and eggs to the EU will or are most likely to be able to satisfy the increasing import demand for these products from the EU without difficulties, this is what the CAPRI results (see Chapter 3.2.) show for Scenarios B1-2 and C1-2.

2.2.5. Modelling the transition

General approach to the scenario design

The CAPRI simulation scenarios were designed to cover the key elements of transition to cage-free livestock housing systems in the EU. These include both the adjusted technical parameters for alternative livestock production systems and the additional compliance costs related to the new policy requirements EU farmers would face when transitioning.

The CAPRI scenarios are parameterised based on the previously submitted literature reviews, expert inputs, and the results of the farm-level surveys and of expert questionnaires. The general approach to modelling the transition is to compare technical and economic indicators for the different livestock housing systems. For example, physical performance data and production cost estimates were compared among caged and cage-free systems. The relative differences in the housing system indicators were introduced as changes in the CAPRI model parameters, driving the scenario results and describing the EU-wide transition of the pig and layer sectors to cage-free production.

More specifically, the scenario assumptions for modelling the transition include the following elements:

1. physical performance,
2. compliance cost estimations,
3. market premium for cage-free products,
4. assumptions on the rate of transition to cage-free housing systems without the EU policy drive.

Physical performance

The differences between livestock housing systems were grasped through technological parameters, based on the literature reviews, expert consultations, other databases, and the farm-level surveys.

When setting up the scenarios, the following technical parameters were taken into account by converting them to changes in the input/output efficiency of the CAPRI production activities:

- in piglet production (except for Sweden, where free farrowing systems have been compulsory since 1993, and for Finland, for which comparable values were provided by the Atria company, the largest pork integrator in the country)
  - sow replacement rate: +22.0% (but not exceeding the corresponding value for Sweden from the 2021 InterPIG database)
  - litters per sow/year: –1.9%
  - pre-weaning mortality: +17.0%[11] (but not exceeding the corresponding value for Sweden from the 2021 InterPIG database)
- in egg production, based on the results of the farm-level surveys
  - duration of production cycle (days): –1.0%
  - number of eggs per hen/year: –5.7%
  - average weight of eggs (kg): –0.9%
  - mortality: +2.6%

Other technical parameters were considered in the CAPRI analysis only through their impacts on costs: e.g. changes in the stocking density or the need for additional space imply investment needs, which were lumped together in the investment cost assumptions; or labour intensity indicators were taken into account through their impact on labour costs.

Feed costs are impacted by the transition to cage-free livestock housing systems. Although direct feed cost estimations are available for the various systems, we opted for modelling the changes in feeds through modifying the related technical parameters in CAPRI. This is due to the cost-minimising modelling approach for feed in CAPRI, which derives feed costs from feed use/feed mix and the related feed prices. The feed-related technical parameters include those which define feeding efficiency and/or feed requirements for sows and laying hens. When adjusting the feed efficiency related parameters in CAPRI because of the transition to cage-free housing systems, feed costs also adjust. The feed efficiency related indicators in the CAPRI analysis included:

- for sows kept in temporal and non-confinement stalls, based on AHDB (2020)
  - kg feed per sow/year: +7.3%
- for layers kept in barns and aviaries, based on the results of the farm-level surveys
  - g feed per hen/day: +2.3%
  - kg feed per 100 kg eggs: +3.1%

Compliance cost estimations

The transition to cage-free livestock housing systems assumes additional costs for the EU agricultural sector, i.e.

- cost of investment in new buildings and equipment,
- costs related to decreasing physical efficiency,
- costs related to increasing labour intensity.

[11] In the farm-level analyses, the assumed increase in pre-weaning mortality is 15% for farrowing systems with temporal confinement and 20% for farrowing systems with no confinement. The 17% average used in the CAPRI impact assessment is based on the assumption that more and in particular larger farms will prefer investing into farrowing systems with temporal confinement.

The compliance cost estimations were derived from a systematic comparison between cage-free compliant and non-compliant housing systems. The comparison was based on the economic and technological indicators below, collected in the literature review phase of the project, and from experts:

- estimated changes in specific production cost elements for sows kept in temporal and non-confinement stalls
  - Vet-Med and breeding cost per sow/year: +7.5%
  - energy cost per sow/year: +1.0%
  - building & equipment maintenance per sow/place: +63.9%
  - miscellaneous costs per sow/year: +1.0%
  - average cost of labour per sow: +22%
- estimated changes in specific production cost elements for layers kept in barns and aviaries
  - Vet-Med cost per hen/year: –0.04%
  - cost of cleaning, disinfection & biosecurity per hen/year: +3.0%
  - total cost of energy: –1.8%
  - total cost of services: –0.3%
  - insurance and other costs: –2.7%
  - average cost of labour per hour: +12.7%
  - average cost of labour per hen: +26.0%

Investment cost estimates for sows

In the case of sows, an increase of 30% in the average cost of sow places with temporal and non-confinement was estimated at the country-level based on expert consultations and extensive literature review, and on InterPIG country-specific data. This magnitude of cost increase is underpinned by the increased space and circumference of the individual pens, the creeping area, and the special equipment for temporal confinement (AHDB, 2020; Baxter *et al.*, 2011; Seddon *et al.*, 2013). The average cost of sow places with temporal and non-confinement represents the average investment need in alternative housing systems in old and new buildings.

Investment cost estimates for laying hens

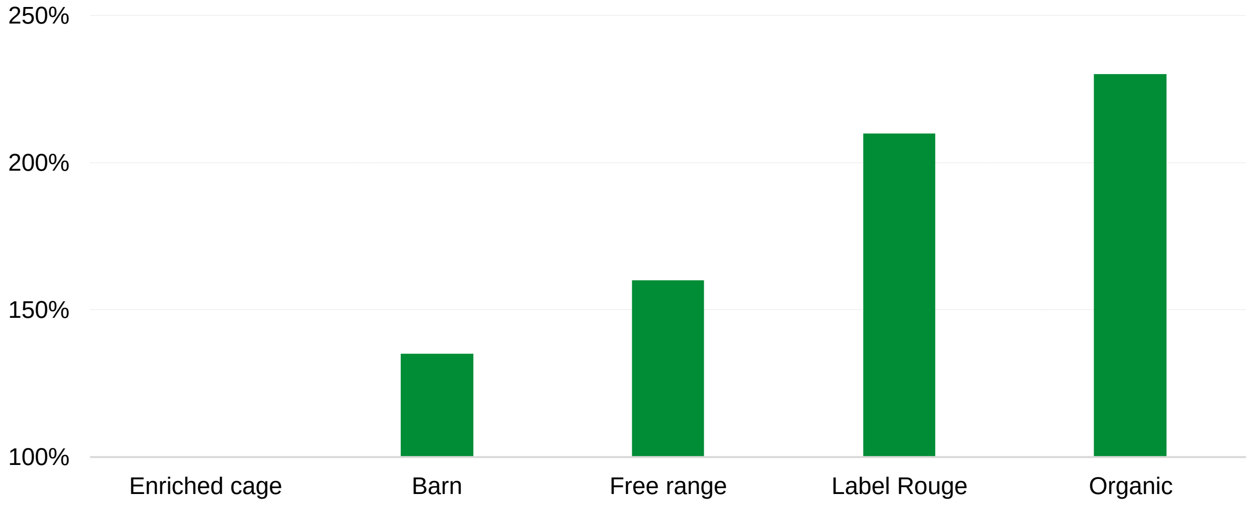
The farm-level surveys and the expert consultations provided estimates on the average investment need in the layer sector for transitioning to aviary and barn systems. Based on these, an average investment cost of EUR 21.65 per hen was used in the scenario assumptions for the EU-14 Member States, and EUR 16.0 per hen for the EU-13 Member States.

The economic burden of investing in alternative housing systems depends on the possible investment periods (e.g. the conditions for credits, flexibility for dealing with currently running investment costs). In the CAPRI simulations, this aspect was dealt with by calculating annualised investment costs due to the necessary investments. A longer transition period decreases these annualised costs, making the transition economically less burdensome.

Market premium for cage-free products

Animal products from cage-free livestock housing systems might be perceived by a considerable group of consumers as of higher quality, leading to a price premium for such products (i.e. there is willingness to pay a higher price for products labelled 'cage-free'). Indeed, e.g. cage-free eggs can be sold at significantly higher prices than eggs from enriched cages (Figure 19).

Figure 19: **A comparison of retail prices of eggs from different housing systems in France**



Source: based on ITAVI survey and Kantar Worldpanel *in*: ITAVI (2019)

Although there is empirical evidence that a market premium for cage-free products currently exists, this is not considered in the CAPRI analysis because of the assumption of the price premium eroding

- as a whole sector transitions to cage-free housing systems, and
- as all (including price-sensitive) consumers shift to consuming cage-free products (in particular, as the EU is set to demand compliance of imported goods with EU animal welfare rules, products from conventional systems will simply not be available on the EU market).

Nevertheless, the CAPRI simulations yield new producer and consumer equilibrium prices for the relevant products, which represent the average for pork and for eggs from the different cage-free housing systems. In the partial equilibrium framework of CAPRI, the consumer price increase is triggered by the increase in average production costs, which faces relatively inelastic demand for food items in the EU[12].

Rate of transition to cage-free housing systems without the EU policy drive

Cage-free livestock housing systems which already comply with future EU animal welfare legislation have already been applied in the EU. Information on the composition of the current livestock housing systems (Table 2) and, in the case of layers, the trend in uptake of cage-free production since 2012 based on Eurostat data were taken into account, and assumptions on the rate and speed of natural transition triggered by national legislation or financial support incentives, the need for modernisation, the increasing pressure by society, etc. were made at the Member State level for scenarios B2 and C2.

The following relevant and effective national policy measures were considered:

- in piglet production
  - existing ban in Sweden
  - future ban in Austria (2033), and Germany (2035)
  - financial support for transitioning to non-confinement stalls in Finland and Denmark
- in egg production
  - existing ban in Austria and Luxembourg
  - existing ban in new and refurbished buildings in France
  - future ban in Germany (2025), Czech Republic (2027), Wallonia in Belgium (2028), and Slovakia (2030)

[12] This also implies that compliance costs are largely passed on to consumers in our analysis by design.

Table 42: **Assumed percentages of sow herds and laying hen flocks in natural transition to cage-free housing systems at EU Member State level in the different CAPRI scenarios**

			Scenario A		Scenario B1		Scenario B2		Scenario C1		Scenario C2	
			Percentage transitioned not because of obligations from EU regulation									
	#	MS	Sows	Hens	Sows	Hens	Sows	Hens	Sows	Hens	Sows	Hens
			before 2025		before 2035				before 2045			
	1	AT*	5%	100%	5%	100%	100%	100%	5%	100%	100%	100%
	2	BE*	5%	64%	5%	64%	50%	100%	5%	64%	100%	100%
	3	DE*	1%	95%	1%	95%	100%	100%	1%	95%	100%	100%
	4	DK*	5%	90%	5%	90%	50%	100%	5%	90%	100%	100%
	5	EL	1%	24%	1%	24%	30%	63%	1%	24%	60%	88%
	6	ES*	1%	27%	1%	27%	50%	55%	1%	27%	100%	77%
EU-14	7	FI*	40%	55%	40%	55%	100%	90%	40%	55%	100%	100%
	8	FR*	4%	46%	4%	46%	40%	100%	4%	46%	90%	100%
	9	IE*	1%	52%	1%	52%	35%	67%	1%	52%	70%	79%
	10	IT*	1%	64%	1%	64%	30%	100%	1%	64%	60%	100%
	11	LU	–	100%	–	100%	–	100%	–	100%	–	100%
	12	NL*	2%	92%	2%	92%	50%	100%	2%	92%	100%	100%
	13	PT	1%	25%	1%	25%	50%	38%	1%	25%	100%	53%
	14	SE*	100%	96%	100%	96%	100%	100%	100%	96%	100%	100%
	15	BG	1%	30%	1%	30%	25%	43%	1%	30%	50%	52%
	16	CY	–	32%	–	32%	–	84%	–	32%	–	100%
	17	CZ*	5%	38%	5%	38%	30%	100%	5%	38%	60%	100%
	18	EE	5%	12%	5%	12%	30%	25%	5%	12%	60%	31%
	19	HR	5%	38%	5%	38%	30%	74%	5%	38%	60%	99%
	20	HU*	1%	16%	1%	16%	25%	19%	1%	16%	50%	21%
EU-13	21	LT	5%	20%	5%	20%	30%	40%	5%	20%	60%	57%
	22	LV	5%	31%	5%	31%	30%	40%	5%	31%	60%	53%
	23	MT	–	–	–	–	–	–	–	–	–	–
	24	PL	5%	24%	5%	24%	30%	39%	5%	24%	60%	53%
	25	RO	1%	43%	1%	43%	25%	52%	1%	43%	60%	100%
	26	SK	1%	25%	1%	25%	25%	100%	1%	25%	50%	100%
	27	SI	5%	83%	5%	83%	30%	100%	5%	83%	60%	100%

* EU member countries of InterPIG. For InterPIG countries, estimates for the current share of free farrowing sows in commercial pig farms were provided by experts due to the lack of official EU statistics. For non-InterPIG EU Member States, the estimates for the current share of free farrowing sows were based on consultations and on similarities in the pig sector between countries.
Source: compilation by AKI

3. Results

3.1. Results of the farm-level assessments

3.1.1. Results of the farm-level assessments for sows

Results for the sample of farms

Characteristics of the sample

Parameters characterising the sample of surveyed farms and further the results of the assessment are presented for the whole sample and clusters, distinguished based on two criteria:

a. Geographic location:
   - Eastern Europe (PL, HU, RO, LV, HR, BG)
   - Central and Western Europe (AT, BE, IE, SP, EL, PT, FR, IT, NL, DE)

b. Number of SOWS on the farm:
   - <=70 sows
   - 71-200 sows
   - 201-500 sows
   - 501-1000 sows
   - >1000 sows

The basic characteristics of the sample are presented in Table 43.

Table 43: **SOWS: Basic characteristics of the sample of surveyed farms**

Clusters	Number of farms in sample	Average Number of sows per farm	Number of sows in the sample	Size farrowing pen m^2	Mortality of piglets	Number of litters/ sow/year	Piglets weaned per sow per year	Mortality of sows	Replacement ratio (%)	Amount of feed for sows in the lactation period (28 days) kg/sow/day	Transition period (Years)
SAMPLE	225	897.9	202,038	4.7	10.7%	2.3	28.4	6.0%	42%	6.4	15.4
WEST	121	906.6	109,700	4.7	11.4%	2.3	29.9	5.9%	44%	6.4	18.2
EAST	104	887.9	92,338	4.8	9.9%	2.2	26.7	6.2%	39%	6.3	12.3
Number of sows at the farm											
<=70	43	43.1	1,853	4.9	9.7%	2.2	25.3	5.2%	39%	6.2	14.4
71-200	47	143.1	6,725	5.2	11.5%	2.2	26.4	6.0%	39%	6.6	17.4
201-500	39	360.7	14,066	4.6	10.2%	2.3	29.7	5.4%	41%	6.5	16.2
501-1000	40	747.3	29,890	4.3	11.4%	2.3	29.5	6.4%	44%	6.3	16.7
>1000	56	2,669.7	149,504	4.5	10.7%	2.3	30.9	6.8%	46%	6.2	13.2

Source: own elaboration based on the farm survey

There are no significant differences in the value of parameters characterising different clusters of farms in the sample, although mean values presented in Table 43 hide a relatively wide range of values of indicators calculated for single farms.

It can be observed that the performance parameters (e.g., piglets weaned per sow per year) are generally weaker in eastern countries and farms with smaller herd sizes. It is also interesting that in the Eastern countries, the expected transition period is shorter than in the West (12 versus 18 years). This may be due to the less modernised production in Eastern Europe, which is currently under investment process. Regardless of the system, planned investment activities must be carried out in a shorter time to maintain production.

Table 44 shows several indicators calculated for 3 farrowing systems based on the sample of farms.

Farrowing systems are crates and two alternative systems (with and without confinement), which are differentiated by the size of the pen – 5.5 m^2 for the free farrowing pen with the possibility of confinement and 7 m^2 for the free farrowing pen without the possibility of confinement, respectively and other specific parameters as estimated by experts. Calculations were made as if all farms in the sample stayed in production. At this stage number of sows is reduced in alternative systems due to lower density (due to the difference between the current size of the farrowing pen at the farm and the alternative size of 5.5 or 7 m^2).

Table 44: **Several indicators calculated for three farrowing systems for the sample of farms**

	CRATES	Free farrowing with confinement - 5.5m² [EUR]	Free farrowing NO confinement – 7m² [EUR]	Free farrowing with confinement [% change]	Free farrowing no confinement [% change]
Number of sows per farm [mean]				**(% change vs. crates)**	
SAMPLE	897.9	719.4	570.8	–19.9%	–36.4%
WEST	906.6	724.5	575.1	–20.1%	–36.6%
EAST	887.9	713.5	565.9	–19.6%	–36.3%
According to herd size clusters					
<=70	43.1	36.3	29.3	–15.8%	–32.0%
71-200	143.1	124.8	105.9	–12.8%	–26.0%
201-500	360.7	295.6	234.4	–18.0%	–35.0%
501-1000	747.3	578.2	458.1	–22.6%	–38.7%
>1000	2,669.7	2,138.9	1,691.7	–19.9%	–36.6%
Mortality of piglets [%]				**(% change vs. crates)**	
SAMPLE	10.7	12.3	12.9	+15%	+20%
WEST	11.4	13.1	13.7	+15%	+20%
EAST	9.9	11.4	11.9	+15%	+20%
According to herd size clusters					
<=70	9.7	11.2	11.6	+15%	+20%
71-200	11.5	13.2	13.8	+15%	+20%
201-500	10.2	11.7	12.2	+15%	+20%
501-1000	11.4	13.1	13.7	+15%	+20%
>1000	10.7	12.4	12.9	+15%	+20%
Total PIGLETS weaned per SOW (n.litters * n.weaned per litter)				**(% change vs. crates)**	
SAMPLE	28.4	27.4	27.2	–3.7%	–4.3%
WEST	29.9	28.7	28.6	–3.8%	–4.4%
EAST	26.7	25.8	25.6	–3.6%	–4.1%
According to herd size clusters					
<=70	25.3	24.4	24.3	–3.5%	–4.1%
71-200	26.4	25.3	25.2	–3.9%	–4.5%
201-500	29.7	28.7	28.5	–3.6%	–4.1%
501-1000	29.5	28.4	28.2	–3.8%	–4.5%
>1000	30.9	29.7	29.6	–3.7%	–4.3%

	CRATES	Free farrowing with confinement - 5.5m² [EUR]	Free farrowing NO confinement – 7m² [EUR]	Free farrowing with confinement [% change]	Free farrowing no confinement [% change]
Feed cost during lactation per piglet weaned [EUR]				**(% change vs. crates)**	
SAMPLE	4.6	5.1	5.1	+11.4%	+12.1%
WEST	4.5	5.0	5.0	+11.6%	+12.3%
EAST	4.7	5.2	5.2	+11.2%	+11.9%
According to herd size clusters					
<=70	4.9	5.4	5.4	11.2%	11.8%
71-200	4.9	5.5	5.6	11.6%	12.4%
201-500	4.5	5.0	5.0	11.3%	11.9%
501-1000	4.4	4.9	4.9	11.6%	12.3%
>1000	4.1	4.6	4.7	11.4%	12.1%
Cost of sow replacement per piglet weaned [EUR]				**(% change vs. crates)**	
SAMPLE	4.4	5.2	5.2	+17.9%	+18.7%
WEST	4.3	5.1	5.1	+18.3%	+19.1%
EAST	4.6	5.4	5.4	+17.6%	+18.3%
According to herd size clusters					
<=70	4.3	5.1	5.1	17.8%	18.4%
71-200	4.6	5.4	5.4	18.0%	18.8%
201-500	4.1	4.9	4.9	17.9%	18.6%
501-1000	4.6	5.4	5.4	18.1%	19.0%
>1000	4.4	5.2	5.3	17.9%	18.6%
Additional labour cost per piglet [EUR]					
SAMPLE	0.0	0.6	1.1		
WEST	0.0	0.5	1.1		
EAST	0.0	0.6	1.2		
According to herd size clusters					
<=70	0.0	0.7	1.3		
71-200	0.0	0.6	1.3		
201-500	0.0	0.5	1.0		
501-1000	0.0	0.5	1.0		
>1000	0.0	0.5	1.0		

	CRATES	Free farrowing with confinement - 5.5m² [EUR]	Free farrowing NO confinement – 7m² [EUR]	Free farrowing with confinement [% change]	Free farrowing no confinement [% change]
Average VET-MED costs per piglet weaned [EUR]				**(% change vs. crates)**	
SAMPLE	1.3	1.5	1.5	11.6%	12.4%
WEST	1.4	1.6	1.6	11.8%	12.5%
EAST	1.2	1.3	1.3	11.5%	12.1%
According to herd size clusters					
<=70	1.5	1.7	1.7	11.4%	12.1%
71-200	1.4	1.6	1.6	11.9%	12.6%
201-500	1.3	1.4	1.4	11.5%	12.2%
501-1000	1.2	1.4	1.4	11.8%	12.6%
>1000	1.2	1.3	1.3	11.6%	12.3%
Total Selected Variable costs per piglet weaned [EUR]				**(% change vs. crates)**	
SAMPLE	8.0	9.2	9.8	14.5%	22.2%
WEST	7.9	9.1	9.7	14.7%	22.1%
EAST	8.2	9.3	10.0	14.2%	22.4%
According to herd size clusters					
<=70	8.3	9.6	10.2	15.3%	23.5%
71-200	8.6	9.9	10.6	14.6%	22.8%
201-500	7.8	9.0	9.5	14.8%	22.1%
501-1000	7.9	9.0	9.7	14.0%	21.6%
>1000	7.6	8.6	9.2	13.8%	21.2%
Cost of investment in new pen per piglet weaned [EUR/piglet weaned]					
SAMPLE		1.3	1.3		
WEST		1.1	1.1		
EAST		1.5	1.5		
According to herd size clusters					
<=70		1.9	1.9		
71-200		1.4	1.4		
201-500		1.1	1.1		
501-1000		1.1	1.1		
>1000		1.0	1.0		

	CRATES	Free farrowing with confinement - 5.5m² [EUR]	Free farrowing NO confinement – 7m² [EUR]	Free farrowing with confinement [% change]	Free farrowing no confinement [% change]
Depreciation (existing building + equipment) EUR per piglet weaned					
SAMPLE	5.2	7.3	9.2	40.9%	77.2%
WEST	4.0	5.6	7.1	40.2%	77.0%
EAST	6.6	9.3	11.7	41.4%	77.4%
According to herd size clusters					
<=70	6.4	8.7	11.0	35.4%	70.2%
71-200	6.0	8.1	9.9	35.0%	64.6%
201-500	4.4	6.3	8.1	43.2%	82.5%
501-1000	4.7	6.9	8.8	48.0%	88.1%
>1000	4.5	6.7	8.5	46.7%	87.3%
Depreciation of existing buildings and equipment + depreciation of new investments in pens per piglet weaned					
SAMPLE	5.2	8.6	10.5	65.4%	101.8%
WEST	4.0	6.7	8.2	67.4%	104.3%
EAST	6.6	10.8	13.2	63.9%	100.0%
According to herd size clusters					
<=70	6.4	10.6	12.8	64.4%	99.1%
71-200	6.0	9.5	11.3	58.5%	88.2%
201-500	4.4	7.4	9.1	67.0%	106.4%
501-1000	4.7	8.0	9.8	70.9%	111.2%
>1000	4.5	7.7	9.5	68.9%	109.7%
TOTAL costs of transition (selected variable costs + depreciation of existing buildings + depreciation of new investment) per piglet weaned [EUR]				**(% change vs. crates)**	
SAMPLE	13.2	17.8	20.3	34.5%	53.5%
WEST	11.9	15.8	17.9	32.4%	49.7%
EAST	14.8	20.1	23.2	36.4%	57.1%
According to herd size clusters					
<=70	14.7	20.2	23.1	36.8%	56.5%
71-200	14.6	19.4	21.9	32.6%	49.6%
201-500	12.2	16.3	18.7	33.7%	52.6%
501-1000	12.6	17.0	19.5	35.0%	54.7%
>1000	12.1	16.3	18.7	34.4%	54.3%

Source: own elaboration based on the farm survey

Aggregated results for the sample of farms according to 4 scenarios

Based on the farm survey data and farmers' decisions declared in the questionnaire, the aggregated impact of the ban on farrowing crates has been estimated. All sows kept in crates in 2021 were moved in line with assumptions made for each of the 4 scenarios described in the methodology section (S1-S4) and reduced due to lower density in respective farrowing systems (due to difference between the current size of the farrowing pen at the farm and the alternative size of 5.5 or 7 m^2). The main results of aggregation for the sample of farms are presented in Table 45.

Table 45: **Results of Aggregation for Sample of farms in 4 scenarios**

	Crates [value]	All farms in Free farrowing with confinement – 5.5m² [% change] $S1_{conf}$	All farms in Free farrowing with NO confinement – 7m² [% change] $S2_{no-conf}$	All farm declarations to alternative systems included [% change] $S3_{exit}$	Farm declarations to alternative systems MODIFIED [% change] $S4_{modified}$
Number of sows					
SAMPLE	202,038	–19.9%	–36.4%	–48.0%	–21.2%
WEST	109,700	–20.1%	–36.6%	–52.7%	–21.2%
EAST	92,338	–19.6%	–36.3%	–42.4%	–21.2%
According to herd size clusters					
<=70	1,853	–15.8%	–32.0%	–41.9%	–27.3%
71-200	6,725	–12.8%	–26.0%	–44.0%	–18.8%
201-500	14,066	–18.0%	–35.0%	–46.5%	–22.6%
501-1000	29,890	–22.6%	–38.7%	–51.7%	–23.9%
>1000	149,504	–19.9%	–36.6%	–47.6%	–20.6%
Number of farrowing pens					
SAMPLE	50,257	–19.5%	–36.1%	–47.9%	–21.1%
WEST	26,241	–19.7%	–36.3%	–50.6%	–20.9%
EAST	24,016	–19.4%	–35.9%	–45.0%	–21.3%
According to herd size clusters					
<=70	672	–17.6%	–33.9%	–42.7%	–30.1%
71-200	2,016	–12.1%	–25.3%	–45.2%	–18.4%
201-500	3,629	–18.6%	–35.4%	–48.4%	–23.3%
501-1000	7,848	–22.4%	–38.4%	–52.8%	–23.9%
>1000	36,092	–19.4%	–36.3%	–47.0%	–20.2%
Total PIGLETS weaned					
SAMPLE	6,210,020	–23.0%	–39.3%	–51.2%	–24.2%
WEST	3,530,755	–23.3%	–39.5%	–55.9%	–24.4%
EAST	2,679,265	–22.5%	–39.0%	–45.0%	–23.9%
According to herd size clusters					
<=70	48,492	–19.0%	–35.2%	–43.6%	–29.9%
71-200	176,900	–16.3%	–29.7%	–45.9%	–22.1%
201-500	420,054	–20.7%	–37.5%	–47.1%	–24.8%
501-1000	880,900	–25.8%	–41.6%	–53.9%	–26.8%
>1000	4,683,674	–23.0%	–39.5%	–51.3%	–23.6%
Selected Variable costs per piglet weaned [EUR, % change vs. crates]					
SAMPLE	7.45	13.8%	21.2%	16.2%	13.8%
WEST	7.43	14.2%	21.3%	20.0%	14.2%
EAST	7.49	13.3%	21.1%	12.2%	13.4%

	Crates [value]	All farms in Free farrowing with confinement – 5.5m^2 [% change] S1$_{conf}$	All farms in Free farrowing with NO confinement – 7m^2 [% change] S2$_{no\text{-}conf}$	All farm declarations to alternative systems included [% change] S3$_{exit}$	Farm declarations to alternative systems MODIFIED [% change] S4$_{modified}$
Selected Variable costs per sow [EUR, % change vs. crates]					
SAMPLE	229.0	9.4%	15.7%	9.1%	9.5%
WEST	239.0	9.6%	15.7%	12.0%	9.6%
EAST	217.2	9.2%	15.9%	7.1%	9.4%
Number of pens to be replaced					
SAMPLE		40,447	32,106	26,181	39,675.7
WEST		21,079	16,723	12,973	20,763.8
EAST		19,368	15,383	13,208	18,911.9
According to herd size clusters					
<=70		554	444	385	469.8
71-200		1,772	1,506	1,105	1,644.5
201-500		2,955	2,345	1,871	2,783.0
501-1000		6,092	4,831	3,703	5,971.4
>1000		29,074	22,980	19,117	28,807.0
Total cost of investment [EUR]					
SAMPLE		68,759,900	54,580,200	44,507,700	67,448,605
WEST		35,834,300	28,429,100	22,054,100	35,298,460
EAST		32,925,600	26,151,100	22,453,600	32,150,145
N. of sows at the farm					
<=70		941,800	754,800	654,500	798,660
71-200		3,012,400	2,560,200	1,878,500	2,795,650
201-500		5,023,500	3,986,500	3,180,700	4,731,100
501-1000		10,356,400	8,212,700	6,295,100	10,151,295
>1000		49,425,800	39,066,000	32,498,900	48,971,900
TOTAL costs of transition (selected variable costs + depreciation of existing buildings + depreciation of new investment) per PIGLET weaned [EUR, % change vs. crates]					
SAMPLE	11.9	32.7%	51.8%	32.9%	33.1%
WEST	10.8	31.5%	48.5%	29.8%	31.8%
EAST	13.3	33.8%	55.1%	32.7%	34.4%
TOTAL costs of transition (selected variable costs + depreciation of existing buildings + depreciation of new investment) per SOW [EUR, % change vs. crates]					
SAMPLE	365.5	27.6%	44.9%	24.8%	28.1%
WEST	347.6	26.2%	41.5%	21.2%	26.4%
EAST	386.7	29.0%	48.4%	26.7%	29.8%

Source: own elaboration based on the farm survey

Aggregated results for the EU-27 Pig Sector

As the last step, the results of the sample assessments presented in subchapter 4 were aggregated to the EU-27 pig sector level. Results were weighted according to the sow-herd structure and share of sows kept in cages as of 2021 (compare with Table 42). At the final stage, the CAPRI simulations also provided input for the EU sector results recalculation, and the fifth scenario (S5) was added.

The Scenario $S5_{capri}$ “Farm exits and number of sows based on the CAPRI A scenario results”, represents the assumption that all farmers are forced to transition by 2025 due to the policy change. In this scenario, we used estimates by the CAPRI model, as described in the technical paper related to CAPRI modelling. In this scenario, the production of pork in the EU-27 was projected to decrease by 23.6% (including in the EU-West reduction of 21.2% and the EU-East reduction of 37.2%). Results of aggregation are presented in Table 46 and Figures 20-29.

Table 46: **Results of aggregation for the EU sector according to 4 scenarios**

	In Crates	All farms in Free farrowing with confinement – 5.5m^2 [% change] $S1_{conf}$	All farms in Free farrowing NO confinement – 7m^2 [% change] $S2_{no\text{-}conf}$	Farm declar. to alternative systems included [% change] $S3_{exit}$	Farm declar. to alternative systems MODIFIED [% change] $S4_{modified}$	Based on CAPRI A scenario results [% change] $S5_{capri}$
Number of sows ['000 heads]						
Total EU	10,462.2	8,367.7	6,641.0	5,109.2	8,209.1	7,989.2
WEST	8,868.2	7,086.7	5,625.0	4,190.4	6,956.8	6,988.1
EAST	1,594.0	1,281.0	1,015.9	918.8	1,252.3	1,001.1
7 biggest producers (SP, DE, DK, FR, NL, IT, PL)	8,348.0	6,673.8	5,297.0	4,009.1	6,549.5	6,478.8
Total EU [% change vs. crates]		–20.0%	–36.5%	–51.2%	–21.5%	–23.6%
WEST [% change vs. crates]		–20.1%	–36.6%	–52.7%	–21.6%	–21.2%
EAST [% change vs. crates]		–19.6%	–36.3%	–42.4%	–21.4%	–37.2%
7 biggest (SP, DE, DK, FR, NL, IT, PL) [% change vs. crates]		–20.1%	–36.5%	–52.0%	–21.5%	–22.4%
Total PIGLETS weaned ['000 heads]						
Total EU	331,680	254,696	200,755	151,321	250,148	253,963
WEST	285,427	218,867	172,550	125,872	215,045	224,917
EAST	46,252	35,829	28,205	25,449	35,102	29,046
7 biggest producers (SP, DE, DK, FR, NL, IT, PL)	266,717	204,660	161,334	119,590	201,048	207,288
Total EU [% change vs. crates]		–23.2%	–39.5%	–54.4%	–24.6%	–23.4%
WEST [% change vs. crates]		–23.3%	–39.5%	–55.9%	–24.7%	–21.2%
EAST [% change vs. crates]		–22.5%	–39.0%	–45.0%	–24.1%	–37.2%
7 biggest (SP, DE, DK, FR, NL, IT, PL) [% change vs. crates]		–23.3%	–39.5%	–55.2%	–24.6%	–22.3%
Number of pens to be replaced [‘000]						
Total EU		2,081.5	1,651.9	1,270.9	2,042.0	1,987.3
WEST		1,762.8	1,399.2	1,042.4	1,730.5	1,738.3
EAST		318.6	252.7	228.6	311.5	249.0
7 biggest producers (SP, DE, DK, FR, NL, IT, PL)		1,660.1	1,317.6	997.3	1,629.2	1,611.6
Total cost of investment in pens and reconstruction of buildings [EUR]						
Total EU		6,672,697,075	5,942,836,322	3,825,800,219	6,599,250,005	6,387,916,493
WEST		5,487,218,452	4,870,353,464	2,957,176,878	5,423,989,639	5,448,425,858
EAST		1,185,478,623	1,072,482,858	868,623,341	1,175,260,366	939,490,636
7 biggest producers (SP, DE, DK, FR, NL, IT, PL)		5,243,011,801	4,661,503,461	2,915,128,670	5,183,938,710	5,113,320,600

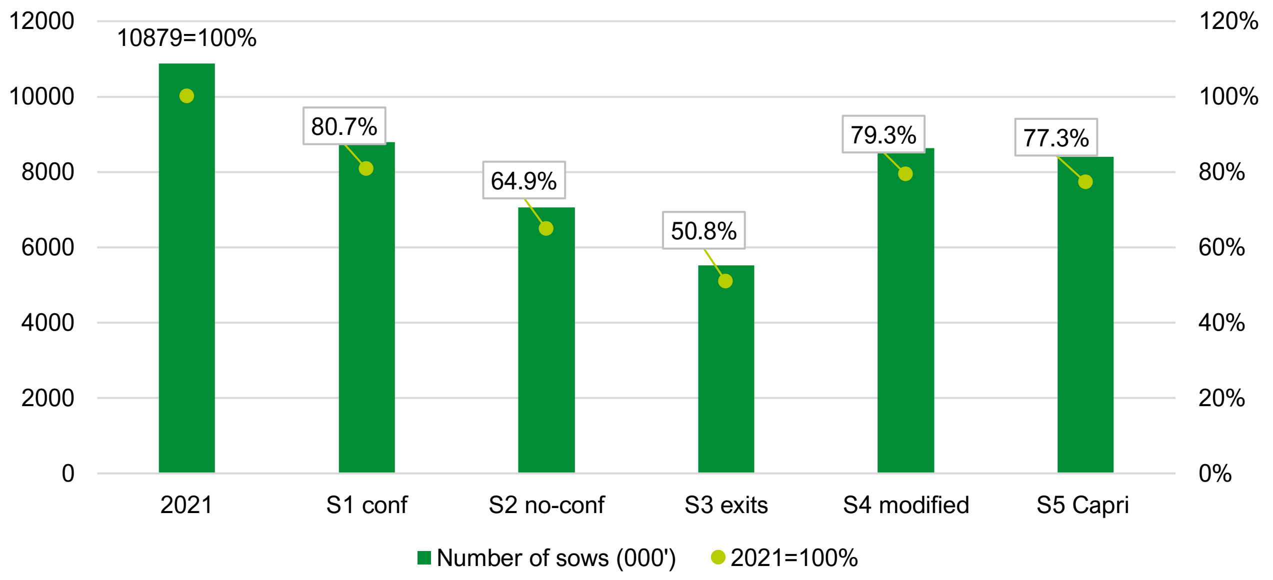
	In Crates	All farms in Free farrowing with confinement – 5.5m² [% change] $S1_{conf}$	All farms in Free farrowing NO confinement – 7m² [% change] $S2_{no\text{-}conf}$	Farm declar. to alternative systems included [% change] $S3_{exit}$	Farm declar. to alternative systems MODIFIED [% change] $S4_{modified}$	Based on CAPRI A scenario results [% change] $S5_{capri}$
Selected variable costs per piglet weaned						
Total EU [EUR]	7.43	8.48	9.02	8.82	8.48	8.48
WEST [EUR]	7.43	8.48	9.01	8.91	8.48	8.48
EAST [EUR]	7.49	8.48	9.07	8.40	8.48	8.48
7 biggest producers (SP, DE, DK, FR, NL, IT, PL)	7.43	8.48	9.01	8.87	8.48	8.48
Total EU [% change vs. crates]		14.1%	21.3%	18.7%	14.0%	14.0%
WEST [% change vs. crates]		14.2%	21.3%	20.0%	14.1%	14.1%
EAST [% change vs. crates]		13.3%	21.1%	12.2%	13.3%	13.3%
7 biggest (SP, DE, DK, FR, NL, IT, PL) [% change vs. crates]		14.1%	21.3%	19.4%	14.1%	14.1%
TOTAL costs of transition (selected variable costs + depreciation of existing buildings + depreciation of new investment) per piglet weaned						
Total EU [EUR]	11.15	14.71	16.69	14.64	14.73	14.64
WEST [EUR]	10.80	14.20	16.04	14.02	14.22	14.22
EAST [EUR]	13.33	17.84	20.67	17.69	17.91	17.91
7 biggest producers (SP, DE, DK, FR, NL, IT, PL)	10.97	14.45	16.35	14.33	14.47	14.42
Total EU [% change vs. crates]		31.9%	49.6%	31.3%	32.1%	31.3%
WEST [% change vs. crates]		31.5%	48.5%	29.8%	31.7%	31.7%
EAST [% change vs. crates]		33.8%	55.1%	32.7%	34.4%	34.4%
7 biggest (SP, DE, DK, FR, NL, IT, PL) [% change vs. crates]		31.7%	49.1%	30.6%	31.9%	31.4%
Selected variable costs per SOW						
Total EU [EUR]	235.95	258.08	272.60	261.32	258.29	258.95
WEST [EUR]	238.98	261.85	276.38	267.63	261.99	261.99
EAST [EUR]	217.24	237.28	251.67	232.59	237.75	237.75
7 biggest producers (SP, DE, DK, FR, NL, IT, PL)	237.35	259.65	274.54	262.59	258.53	258.51
Total EU [% change vs. crates]		9.5%	15.7%	10.9%	9.6%	9.9%
WEST [% change vs. crates]		9.6%	15.7%	12.0%	9.6%	9.6%
EAST [% change vs. crates]		9.2%	15.9%	7.1%	9.4%	9.4%
7 biggest (SP, DE, DK, FR, NL, IT, PL) [% change vs. crates]		9.4%	15.7%	10.6%	8.9%	8.9%
TOTAL costs of transition (selected variable costs + depreciation of existing buildings + depreciation of new investment) per SOW						
Total EU [EUR]	353.0	447.80	504.46	433.58	449.00	447.30
WEST [EUR]	347.6	438.57	491.93	421.20	439.46	439.46
EAST [EUR]	386.8	498.89	573.86	490.04	502.00	502.00
7 biggest producers (SP, DE, DK, FR, NL, IT, PL)	350.5	443.96	498.04	431.11	448.40	448.44

	In Crates	All farms in Free farrowing with confinement – 5.5m² [% change] S1conf	All farms in Free farrowing NO confinement – 7m² [% change] S2no-conf	Farm declar. to alternative systems included [% change] S3exit	Farm declar. to alternative systems MODIFIED [% change] S4modified	Based on CAPRI A scenario results [% change] S5capri
Total EU [% change vs. crates]		26.7%	42.7%	22.6%	27.0%	26.5%
WEST [% change vs. crates]		26.2%	41.5%	21.2%	26.4%	26.4%
EAST [% change vs. crates]		29.0%	48.4%	26.7%	29.8%	29.8%
7 biggest (SP, DE, DK, FR, NL, IT, PL) [% change vs. crates]		26.7%	42.1%	23.0%	27.9%	27.9%

Source: own elaboration based on the farm survey

The total number of sows in the EU-27 in all alternative scenarios is below the level of 2021, the base year scenario with crates (Figures 20 and 21). In particular, this applies to the extreme $S3_{exits}$ scenario in Figure 20, with the highest number of exits from the sector, as declared by surveyed farmers, and concerning 30% of sows kept at those farms (compared with Table 42). Under this scenario, the number of sows in the EU-27 drops from the base 10.8 million to about 5.5 million (by 48%), including reductions due to lower densities in alternative systems. The $S4_{modified}$ scenario and $S5_{Capri}$ might be considered more realistic, and the number of sows is reduced to about 8.6 (S4) and 8.4 (S5) million heads (by 20.7% and 22.7% respectively).

Figure 20: **Number of sows in the EU-27 (thousand heads and percent in relation to the base scenario) in each assessment scenario**

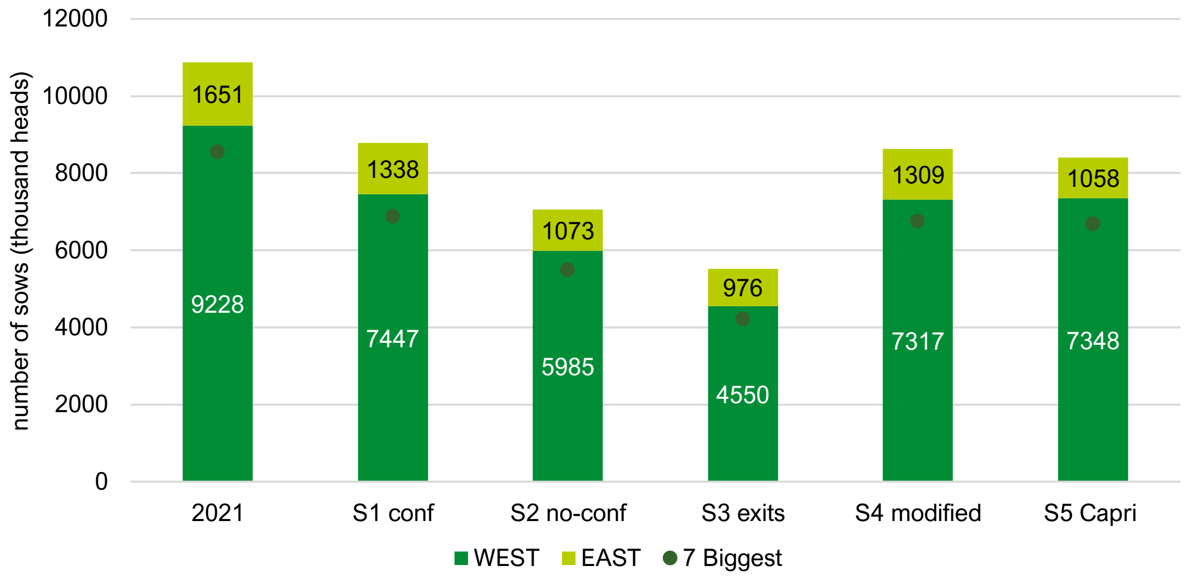


Source: own elaboration

Figure 21 shows a small share of the 'East' cluster of countries in the total number of sows in the EU-27. In the base year, the share of 11 countries classified as 'East' in the total number of sows in the EU was only 15.2%. Almost half of these sows was housed in Poland (6% of the total), which is one of the largest pig producers in the EU (about 654 thousand sows in 2021). Production of piglets is concentrated mainly in the EU western countries and in Poland. The biggest 7 piglet producers in the EU (Spain, Germany, Denmark, France, The Netherlands, Poland and Italy) keep 78.6% of all EU-27 sows.

The most significant drop in the number of sows in the EU-27 characterizes the extreme $S3_{exits}$ scenario with the highest number of exits from the sector (exits in 'East' cluster concern 24% of sows, and 'West' 35.7% of sows), which together with other changes of production parameters and reduction related to lower density in alternative farrowing systems results in a decrease in the number sows by 48%. Under a more realistic scenario $S4_{modified}$, with the modified declarations of farmers (compare with Table 42), the total number of sows is reduced by about 21% both in East and West clusters, as well as in 7 biggest producing countries. Under CAPRI scenario $S5_{capri}$, the total number of sows is reduced by about 22.7%, including by 35.9% in East and by 20.4% in West clusters, as well as 21.9% in the 7 biggest producing countries.

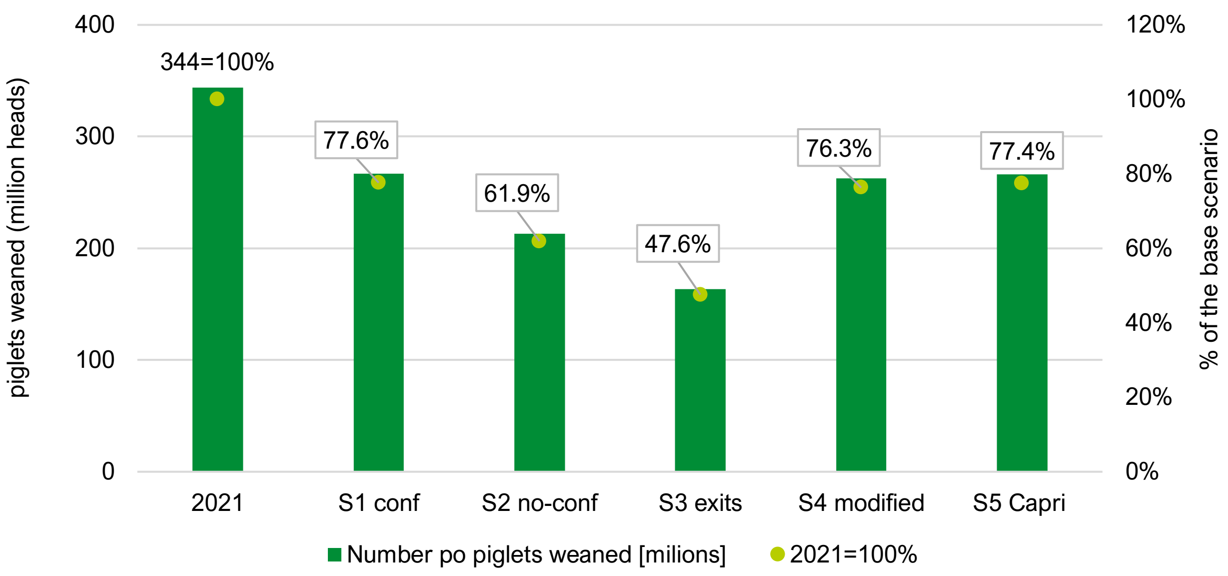
Figure 21: **Number of sows in the EU-27 according to 'EAST', 'WEST' and the seven biggest producing countries (thousand heads) in each assessment scenario**



Source: own elaboration

The number of piglets weaned after the complete transition to alternative farrowing systems (Figure 22) follows changes in the number of sows. Lower production is also influenced by the reduced number of piglets weaned per sow in alternative farrowing systems (by –3.7% in the farrowing system with temporary confinement and –4.3% with no-confinement due to higher mortality of piglets, compare results with Table 44). Thus, in the most extreme scenario $S3_{exits}$, the number of piglets weaned drops from 344 million heads to 164 million heads, by 52.4%. In a more realistic scenario $S4_{modified}$ (modified decisions), this decrease is lower and reaches a 23.7% reduction of piglet production compared to the base scenario, whereas $S5_{capri}$ decrease by 22.6%.

Figure 22: **Number of piglets weaned (million heads and percent in relation to the base scenario) in the EU-27 in each assessment scenario**

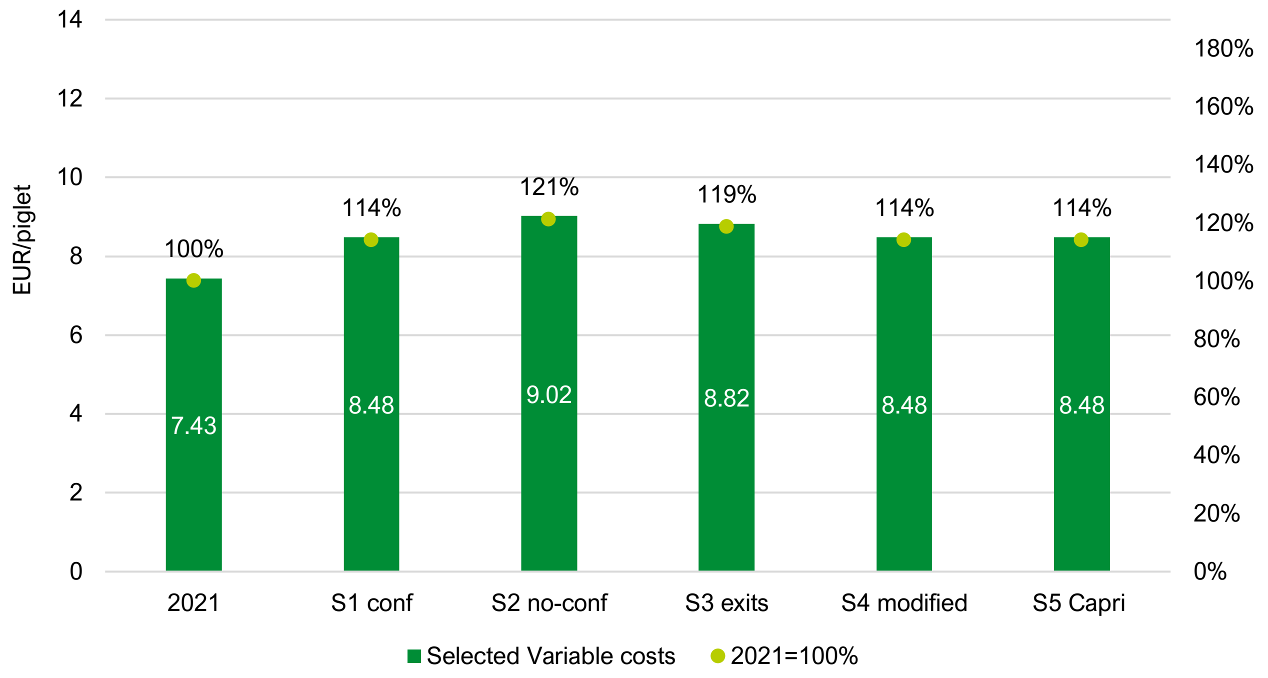


Source: own elaboration

Additional variable and investment costs of transition into free farrowing systems were the categories used to assess the financial impacts of the ban on farrowing crates. Results are presented in Figures 23-28.

In all alternative scenarios, we observe an increase in selected variable costs, which, according to experts, literature and real farm observations, are supposed to be affected by the change in the farrowing system. Those higher costs were related to additional feed consumption by a sow during the lactation period in larger pens with free movement (ca. +7.5%), higher cost of sow replacement (higher sow-culling rate +15%); additional labour cost to service free farrowing pens (by 1-2 min sow per day during lactation); increased vet-med costs by ca. +7.5% and decreased production due to a bit higher mortality of piglets (+15% with confinement and +20% if no-confinement) and a fewer number of litters per sow per year (–1.9%) (see Table 43 and methodology). As a result, selected variable costs per piglet weaned increased by **21%** in theoretical scenario $S2_{no\text{-}conf}$ (assuming that all farms will switch to free farrowing systems without confinement) and by **14%** in more realistic scenario $S4_{modified}$ and $S5_{capri}$, where decisions of farmers about the choice of system and exits were modified according to assumptions for S4 presented in the methodology, and in S5 by CAPRI results.

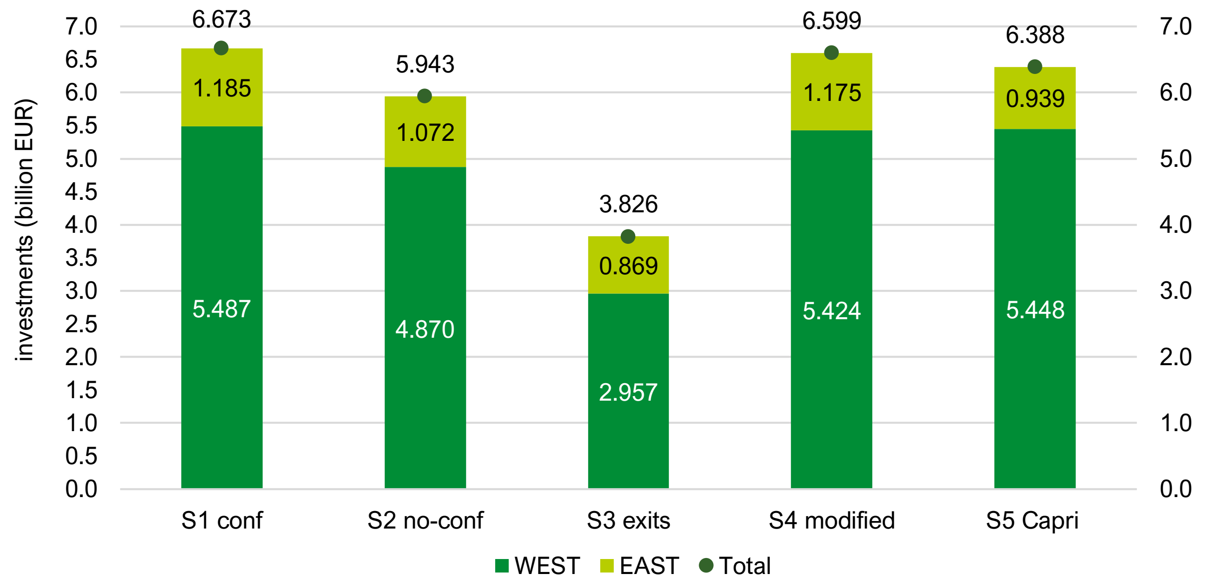
Figure 23: **Selected variable costs per piglet weaned (EUR/piglet) for EU-27 in each assessment scenario**



Source: own elaboration

Transformation to alternative systems will require investments in new pens and reconstruction of current buildings. Investment values, according to the scenario, are illustrated in Figure 24.

Figure 24: **Total costs of investments in new pens (in billion EUR) for EU-27 and ‘East’ and ‘West’ countries**



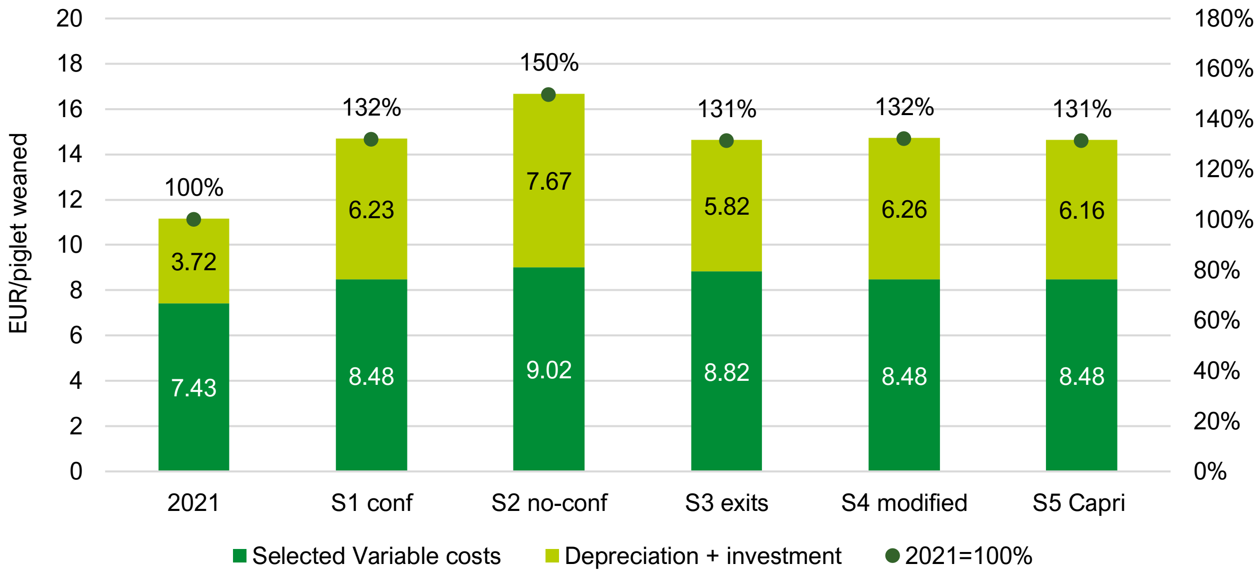
Source: own elaboration

The value of investments was calculated assuming that:

- average cost of the new farrowing pen, which has to replace old and much smaller pens is EUR 1,700;
- average cost of reconstruction of existing buildings is EUR 1,800 per pen, ranging, depending on the scenario and the region EAST/WEST from EUR 1,623 in S3 to EUR 2,146 in S2. . The total cost of investment in the EU-27 pig sector (Figure 24), depending on the scenario, ranges from around EUR 3.8 billion (scenario $S3_{exits}$) to about EUR 6.7 billion (scenario $S1_{conf}$). Investment requirements in the $S5_{capri}$ will amount to EUR 6.4 billion. Due to the structure of sows herds, the highest expected investment costs will be in the ‘West’ cluster of countries (Figure 24).

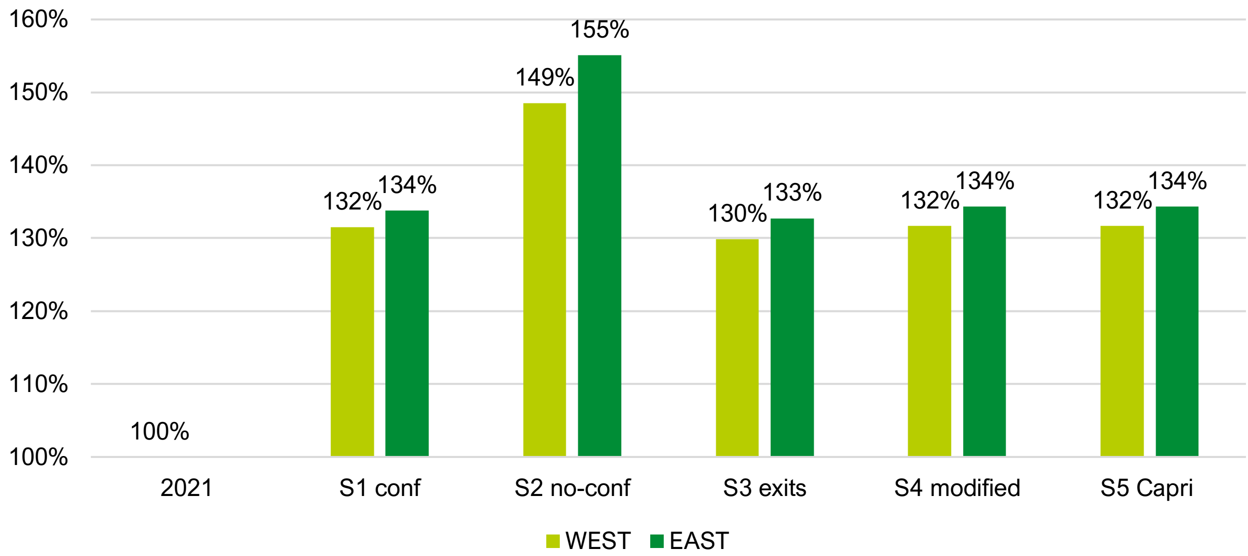
Costs of production, which are expected to change after the introduction of the ban on crates (additional selected variable costs as mentioned above, cost of investment in new pens, costs of depreciation of current buildings with necessary rebuilding), will increase (Figure 25). It is expected that depending on the scenario, the costs per piglet weaned will grow by +31% in scenario $S3_{exits}$, and even by +50% in scenario $S2_{no-conf}$. The most realistic scenarios $S4_{modified}$ and $S5_{capri}$ assume a **32%** increase in production costs per piglet weaned from EUR 11.1 to ca. EUR 14.6. An increase in production costs is observed to be higher in the ‘East’ cluster of countries due to lower efficiency of production and, on average, smaller herds in those countries (Figure 26).

Figure 25: **Total selected costs (selected variable costs + depreciation of existing buildings & equipment and of new investment in pens) per piglet weaned (EUR /piglet) for EU-27 in each assessment scenario**



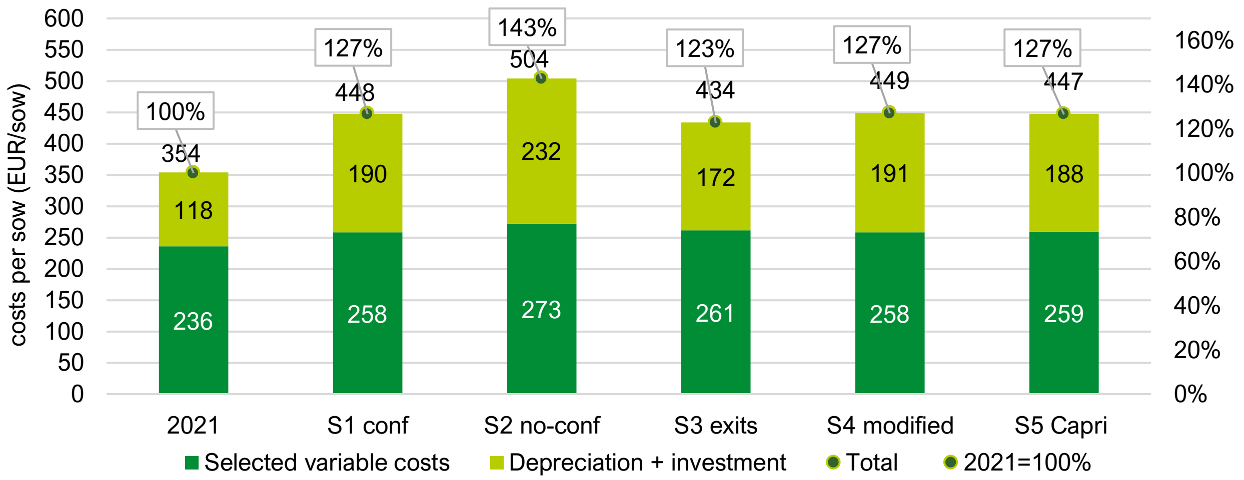
Source: own elaboration

Figure 26: **Percentage difference in total selected costs (selected variable costs + depreciation of existing buildings & equipment and of new investment in pens) per piglet weaned between 'East' and 'West' countries**



Source: own elaboration

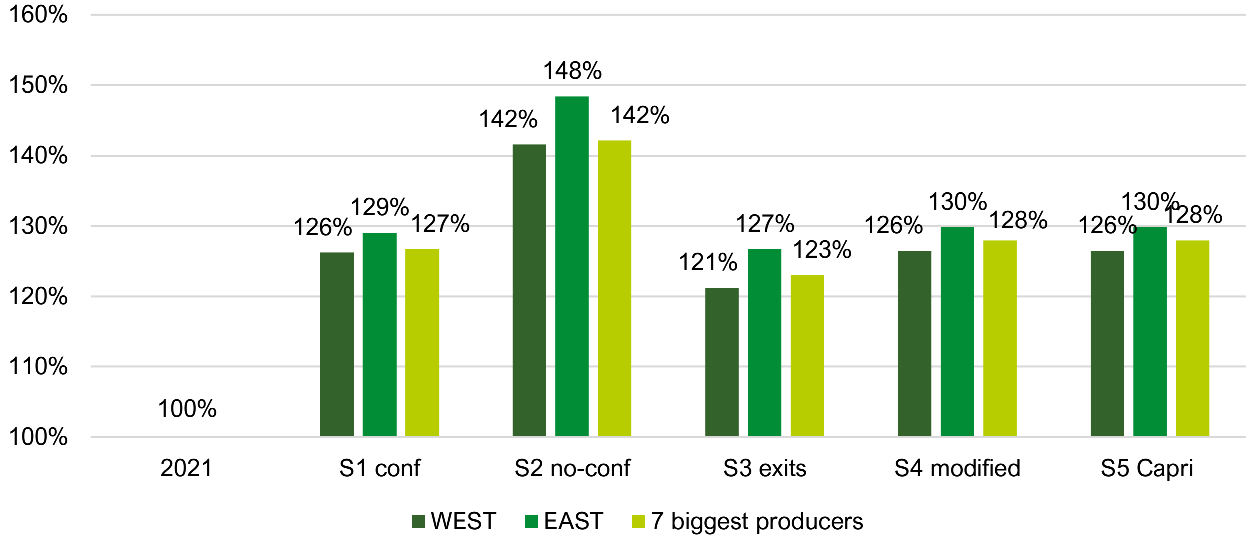
Figure 27: **Total selected costs (selected variable costs + depreciation of existing buildings & equipment and of new investment in pens) per sow (EUR/sow) for EU-27 in each assessment scenario**



Source: own elaboration

Similar observations to those presented in Figures 25 and 26 are observed when we recalculate additional costs of transition into free-farrowing systems per one sow (Figure 27). Costs of production per sow considered in the analysis (additional selected variable costs as mentioned above, cost of investment in new pens, costs of depreciation of current buildings with necessary rebuilding) grow by +23% in scenario $S3_{exits}$ (large share of farm-exit declarations + switch to fattening), and even +43% in scenario $S2_{no\text{-}conf}$ (all farms switch into free farrowing systems with no confinement). In the most realistic scenarios $S4_{modified}$ scenario and $S5_{Capri}$, we expect about a +27% increase in production costs per sow, from 354 EUR/sow in the base 2021 scenario to 449 EUR/sow in scenario $S4_{modified}$.

Figure 28: **Percentage difference in total selected costs (selected variable costs + depreciation and new investment) per sow in 'East' and 'West' and 7 biggest producing countries**



Source: own elaboration

Figure 28 presents the percentage difference in total selected costs (selected variable costs + depreciation and new investment) per sow in 'East' and 'West' clusters as well as in the 7 biggest producing countries. We may observe that 'East' cluster of countries will experience a greater increase in selected costs per sow, which is probably due to lower efficiency of production and, on average, smaller herds in those countries.

Brief concluding remarks

The ban on farrowing crates will reduce sow population and piglet production in the EU due to increased space requirements for sows, a decrease in production efficiency and necessary investments. In the $S4_{modified}$ scenario and $S5_{Capri,}$ which might be considered more realistic, the number of sows is reduced to about 8.6 (S4) and 8.4 (S5) million heads (by 20.7% and 22.7% respectively).

The ban will strengthen the concentration trend in the sector. Exits of small-scale farmers, without successors, will be very likely. Some farmers will probably move to pig-finishing only.

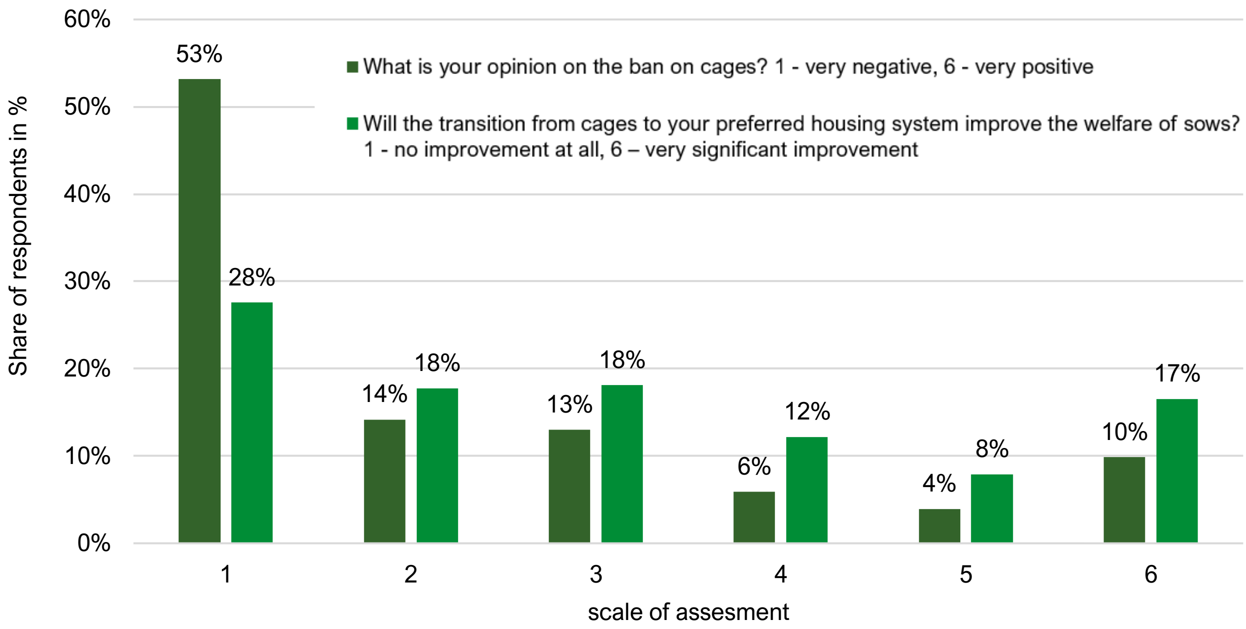
The ban on crates will result in an increase in costs of production related to the farrowing period (increase in vet costs, labour costs, feed costs for sow, decrease in production efficiency related to increased mortality of piglets and higher sow replacement needs). In the most realistic scenarios $S4_{modified}$ scenario and $S5_{Capri}$, we expect about a +27% increase in selected production costs per sow (selected variable costs + depreciation of existing buildings and new investment cost) from 354 EUR/sow in the base 2021 scenario to even 449 EUR/sow in scenario $S4_{modified}$. As calculated per piglet it is a ca. 32% increase in selected production costs per piglet weaned from EUR 11.1 to ca. EUR 14.6 on average. An increase in production costs is observed to be higher in the 'East' cluster of countries due to lower efficiency of production and, on average, smaller herds in those countries.

Transitioning into free farrowing systems will require significant investments in new farrowing pens and rebuilding the existing buildings. Depending on the scenario, investment costs range from around EUR 3.8 billion to around EUR 6.7 billion. Due to the concentration of pig production in Western Europe, the highest expected investment costs will be in the 'West' cluster of countries.

Opinions of farmers on planned ban on farrowing crates

In the first part of the Farm Survey, respondents were asked to answer questions, about their opinions regarding the overall impact of the ban on farrowing crates and the potential to improve the welfare of sows. The 6-point Likert scale was used. Of the total 323 farmers participating in the survey, 254 respondents from 14 countries answered these questions. Results are presented in Figure 29.

Figure 29: **Opinions of farmers on the ban on farrowing crates, percentage share of respondents**



Source: own elaboration

The vast majority of farmers (67%) expressed very negative opinions about the intention to ban the use of farrowing crates (answers 1 and 2). It is worth noting that only 14% of farmers indicated a positive impact of the ban (answers 5 or 6).

Farmers also gave a negative opinion concerning the effects of the reform on the welfare of sows, although the share of definitely negative opinions was smaller. 25% of respondents indicated that they see positive effects on sow welfare (answers 5 and 6) and 46% indicate no improvement in sows' welfare (answers 1 and 2).

Notably, the farmers' opinion on the ban on farrowing crates (mean response 2.3 on the 1-6 scale) was more negative compared to the question about the potential to improve the animal welfare of sows (mean response: 3.1). These differences were statistically significant. Analysis of the results showed that individual farmers largely answered the two questions similarly. Indeed, the Spearman correlation coefficient between individual farmer responses was 0.64. In both questions, the responses neither depend on the country nor the number of sows kept on the farm. It suggests that negative opinions on the ban are commonly shared by farmers, irrespective of the scale of production and other farm and farmer characteristics.

As part of the survey, farmers also had the opportunity to add detailed comments on the proposed reform and its consequences in the open question. Nearly half of the respondents took advantage of this opportunity. The responses were grouped into 6 categories. Table 47 provides a synthetic summary of opinions, while a detailed tabular summary of respondents' opinions can be found in the appendix.

Table 47: **Farmers' most common opinions on the proposed reform (number of comments qualified to each category in brackets, n=160)**

GENERAL OPINION (68)

- 56 answers: senseless reform/disaster to producers/a lot of farm exits/ decreasing competitiveness/ harmful/wrong direction/ overregulation/worsening welfare of piglets/dangerous to workers
- 12 answers: no difference/positive change/useful idea

ANIMAL WELFARE (43)

- 32 answers: significant increase in piglet mortality/ higher mortality of sows
- 11 answers: better welfare of sows

HUMAN WELFARE (13)

- Dangerous to workers/ aggressive sows protecting their piglets/ difficult to find workers

FARM ECONOMICS (36)

- lower productivity and effectiveness/ increased production costs/ high cost of investments/no return on investment/need of EU support for investments/less effective system /more labour needed/ deterioration of working conditions for staff/problems with staff

The vast majority (more than 86%) of comments on the reform and its effects were in a hostile, and pessimistic tone. One of the farmers nicely expressed the main issues related to the welfare aspect of the change of farrowing system: in piglet production, we can imagine a triangle with three welfare goals: 1: the welfare of the sow 2: welfare of piglets 3: the welfare of workers. Our production system must try to achieve all three, but improving one without compromising the other is hard. Clearly, the main benefit of free farrowing stems from the sows' ability to express natural behaviours, e.g. rooting, nest building pre-farrowing, etc. However, there is not yet a comprehensive pen design that will improve or even maintain piglet welfare (the main concern is increased mortality/injury due to this and the cleanness of the pen), leading to poorer piglet welfare. On the other hand, the greater freedom for sows results in greater risk to workers and more difficult handling of the sows, resulting in a greater labour input.

Another problem pointed out by farmers is the negative impact of the transition to free farrowing systems on farm management and the economics of pig production, confirmed to a great extent by farm-level assessments. In farmers' opinion imposing restrictions will result in higher costs, reducing farm incomes. There is a concern that investments will not repay the costs (raised mainly by small-scale farmers) and will not be passed on to the consumer. Some farmers, usually smaller, are even announcing the abandonment of production. Many farmers point out that as a result of the abolition of farrowing crates, the labour inputs will increase, while the shortage of skilled labour will continue in the long term. In addition, human working conditions will deteriorate, with an unwillingness to work in a riskier environment.

Pig producers' organisations and pig breeders also express great concern about the planned ban on the use of farrowing crates. The arguments are as follows:

- The current crates system is based on a solid part of the floor for the sow, in which it is confined – strong enough to handle the weight of the sow – and a soft plastic part for the free movement of the piglets, appropriate to their weight at this age. The plastic part is not able to bear the weight of the sow, so the pens must be completely replaced with new ones and a new solid floor must be provided. Farrowing pens are the most expensive part of farm equipment. The necessity for replacing existing pens and reconstruction of flooring will require huge investment as well as significant disruption in the production cycle due to reconstruction.
- Many farmers from eastern countries made very recently significant investments in the reconstruction of pig barns providing better animal welfare (e.g. the case of Bulgaria, but

probably not only). These would be wasted costs, very likely not compensated at all if the new system was imposed.

- The main factor for piglet mortality during lactation is piglets being smashed by the sow. Even with temporary confinement, this problem is not avoidable but at least diminished. Free-farrowing indoor systems usually cause much higher piglet mortality.
- European consumers have often proven unwilling to pay an additional cost for meat produced under new welfare standards. This is even more true for large-scale buyers such as slaughterhouses and processors, to whom most farmers sell their products. So there is real concern that farmers will not be able to recover from the market any of the investment made to meet these new standards. The transition from the old system to the new one should be accompanied by generous funding from the EU to the producers, otherwise, it will force many producers out of the profession.
- Some farmers expressed views, that there are better ways to improve the welfare of sows which are worthy of support, instead of making huge investments in rebuilding farrowing sections – e.g. group housing of sows out of farrowing period, installing air conditioning, combined with facilitation in obtaining permits for the production of solar energy.

3.1.2. Results of the farm-level assessments for hens

Based on the Farm Survey data, the aggregated impact of the ban on enriched cages has been estimated at the EU-level. In aggregation, all hens kept in cages in 2021 (Table 2) were added to hens already housed in alternative systems. Hens from cages were divided into proportions derived from the sample of surveyed farms (table 6). The number of hens moved was adjusted in line with assumptions made for each of the scenarios and further reduced due to lower density in respective housing systems.

Following the movements of hens, required investments in equipment replacing cages were calculated in all scenarios, with additional costs of investments in new buildings in the $H4_{capri\ eq}$ 'Market equilibrium' scenario.

The main results of aggregation (number of hens, production of eggs and value of investments) are presented in Tables 8-12. All aggregates illustrate the situation in the sector after the transition to alternative systems is completed. Because of the methodology of farm-level assessments applied, namely conducting all financial calculations in fixed prices of the base 2021 year, the year 2035 only indicates the endpoint.

Below, brief scenario characteristics are reminded to make the analysis of results easier:

$H1_{exits}$ 2035 – 'Extreme Exits' – an extreme situation, assuming all farmers who declared exit in the farm survey would move out of production.

$H2_{no\text{-}exits}$ 2035 – 'No Exits' – another extreme – all farmers continue production, and all hens from the base year 2021 are moved into alternative systems (minus reductions due to lower densities).

$H3_{modified}$ 2035 – 'Modified Exits' – a moderate solution (between $H1_{exits}$ and $H2_{no\text{-}exits}$ scenarios), only more likely exits considered.

$H4_{capri\ eq}$ 2035 – 'Capri Market Equilibrium' – prices of eggs and production set at the level estimated in the CAPRI model (price increase of about 3,5% compared to the base year, production reduced by about 1,5% on average).

Table 48: **Aggregation to the EU scale – Scenario H1$_{exits}$ 2035**

	Base Scenario 2021					2035 'H1exits' Scenario			
	Enriched cages	Barn	Free-range	Organic	Total	Barn	Free-range	Organic	Total
NUMBER OF HENS ['000 heads]									
EAST	67,359	22,536	3,761	899	94,555	52,979	10,476	1,255	64,710 (68.4%)*
WEST	101,425	111,440	44,513	24,063	281,441	166,850	56,735	24,712	248,297 (88.2%)
EU	168,784	133,976	48,273	24,962	375,996	219,829	67,211	25,967	313,007 (83.2%)
ALLOCATION OF HENS [%]									
EAST	71.2	23.8	4.0	1.0	100	81.9	16.2	1.9	100
WEST	36.0	39.6	15.8	8.6	100	67.2	22.8	10.0	100
EU	44.9	35.6	12.8	6.6	100	70.2	21.5	8.3	100
EGGS YIELD [kg/hen/year]									
EAST	18.7	18.1	15.1	14.6	18.3	18.2	15.1	14.7	17.6 (96.0%)
WEST	19.9	19.3	16.0	15.5	18.7	19.4	16.1	15.6	18.3 (97.6%)
EU	19.3	18.7	15.6	15.1	18.4	18.9	15.7	15.2	17.9 (97.2%)
EGG PRODUCTION ['000 tonnes]									
EAST	1,256	408	57	13	1,734	964	159	18	1,141 (65.7%)
WEST	2,015	2,148	714	374	5,251	3,234	916	386	4,536 (86.1%)
EU	3,260	2,510	753	377	6,901	4,154	1,057	396	5,607 (80.9%)
EGGS PRODUCTION – structure [%]									
EAST	72.5	23.5	3.3	0.8	100	84.5	13.9	1.6	100
WEST	38.4	40.9	13.6	7.1	100	71.3	20.2	8.5	100
EU	72.5	23.5	3.3	0.8	100	74.1	18.9	7.1	100
INVESTMENT in equipment for alternative systems [million EUR]									
EAST	–	–	–	–	–	487	114	6	607
WEST	–	–	–	–	–	1,108	269	14	1,391
EU	–	–	–	–	–	1,595	383	20	1,999

* Values in brackets (…%) in the column Total under the H1$_{exits}$ scenario indicate the relation of the Total 2035 and Total 2021.
Source: own elaboration

Table 49: **Aggregation to the EU scale – Scenario $H2_{no\text{-}exits}$ 2035**

	Base Scenario 2021					2035 H2no-exits Scenario			
	Enriched cages	Barn	Free-range	Organic	Total	Barn	Free-range	Organic	Total
NUMBER OF HENS ['000 heads]									
EAST	67,359	22,536	3,761	899	94,555	68,921	13,992	1,442	84,355 (89.2%)
WEST	101,425	111,440	44,513	24,063	281,441	181,283	59,919	24,881	266,083 (94.5%)
EU	168,784	133,976	48,273	24,962	375,996	250,204	73,911	26,323	350,438 (93.2%)
ALLOCATION OF HENS [%]									
EAST	71.2	23.8	4.0	1.0	100	81.7	16.6	1.7	100
WEST	36.0	39.6	15.8	8.6	100	68.1	22.5	9.4	100
EU	44.9	35.6	12.8	6.6	100	71.4	21.1	7.5	100
EGGS YIELD [kg/hen/year]									
EAST	18.7	18.1	15.1	14.6	18.3	18.1	15.1	14.6	17.5 (95.6%)
WEST	19.9	19.3	16.0	15.5	18.7	19.3	16.0	15.5	18.2 (97.5%)
EU	19.3	18.7	15.6	15.1	18.4	18.7	15.6	15.1	17.8 (97.0%)
EGG PRODUCTION ['000 tonnes]									
EAST	1,256	408	57	13	1,734	1,247	211	21	1,479 (85.3%)
WEST	2,015	2,148	714	374	5,251	3,494	961	387	4,842 (92.2%)
EU	3,260	2,510	753	377	6,901	4,688	1,153	398	6,239 (90.4%)
EGG PRODUCTION – structure [%]									
EAST	72.5	23.5	3.3	0.8	100	84.3	14.3	1.4	100
WEST	38.4	40.9	13.6	7.1	100	72.2	19.9	8.0	100
EU	72.5	23.5	3.3	0.8	100	84.3	14.3	1.4	100
INVESTMENT in equipment for alternative systems [million EUR]									
EAST	–	–	–	–	–	742	174	9	925
WEST	–	–	–	–	–	1 397	339	18	1,754
EU	–	–	–	–	–	2 139	513	27	2,679

* Values in brackets (…%) in the column Total under the $H2_{no\text{-}exits}$ scenario indicate the relation of the Total 2035 and Total 2021.
Source: own elaboration

Table 50: **Aggregation to the EU scale – Scenario $H3_{modified}$ 2035**

	Base Scenario 2021					2035 H3modified Scenario			
	Enriched cages	Barn	Free-range	Organic	Total	Barn	Free-range	Organic	Total
NUMBER OF HENS ['000 heads]									
EAST	67,359	22,536	3,761	899	94,555	61,582	12,373	1,356	75,312 (79.6%)*
WEST	101,425	111,440	44,513	24,063	281,441	173,818	58,272	24,793	256,883 (91.3%)
EU	168,784	133,976	48,273	24,962	375,996	235,400	70,645	26,149	332,195 (88.4%)
ALLOCATION OF HENS [%]									
EAST	71.2	23.8	4.0	1.0	100	81.8	16.4	1.8	100
WEST	36.0	39.6	15.8	8.6	100	67.7	22.7	9.7	100
EU	44.9	35.6	12.8	6.6	100	70.9	21.3	7.9	100
EGGS YIELD [kg/hen/year]									
EAST	18.7	18.1	15.1	14.6	18.3	18.1	15.1	14.6	17.6 (95.8%)
WEST	19.9	19.3	16.0	15.5	18.7	19.3	16.1	15.6	18.2 (97.5%)
EU	19.3	18.7	15.6	15.1	18.4	18.8	15.7	15.2	17.8 (97.1%)
EGG PRODUCTION ['000 tonnes]									
EAST	1,256	408	57	13	1,734	1,117	187	20	1,324 (76.3%)
WEST	2,015	2,148	714	374	5,251	3,359	937	386	4,683 (89.0%)
EU	3,260	2,510	753	377	6,901	4,427	1,106	396	5,929 (85.8%)
EGG PRODUCTION – structure [%]									
EAST	72.5	23.5	3.3	0.8	100	84.4	14.1	1.5	100
WEST	38.4	40.9	13.6	7.1	100	71.7	20.0	8.2	100
EU	72.5	23.5	3.3	0.8	100	74.7	18.7	6.7	100
INVESTMENT in equipment for alternative systems [million EUR]									
EAST	–	–	–	–	–	625	146	8	779
WEST	–	–	–	–	–	1,248	303	16	1,566
EU	–	–	–	–	–	1,872	449	24	2,345

* Values in brackets (…%) in the column Total under the $H3_{modified}$ scenario indicate the relation of the Total 2035 and Total 2021.
Source: own elaboration

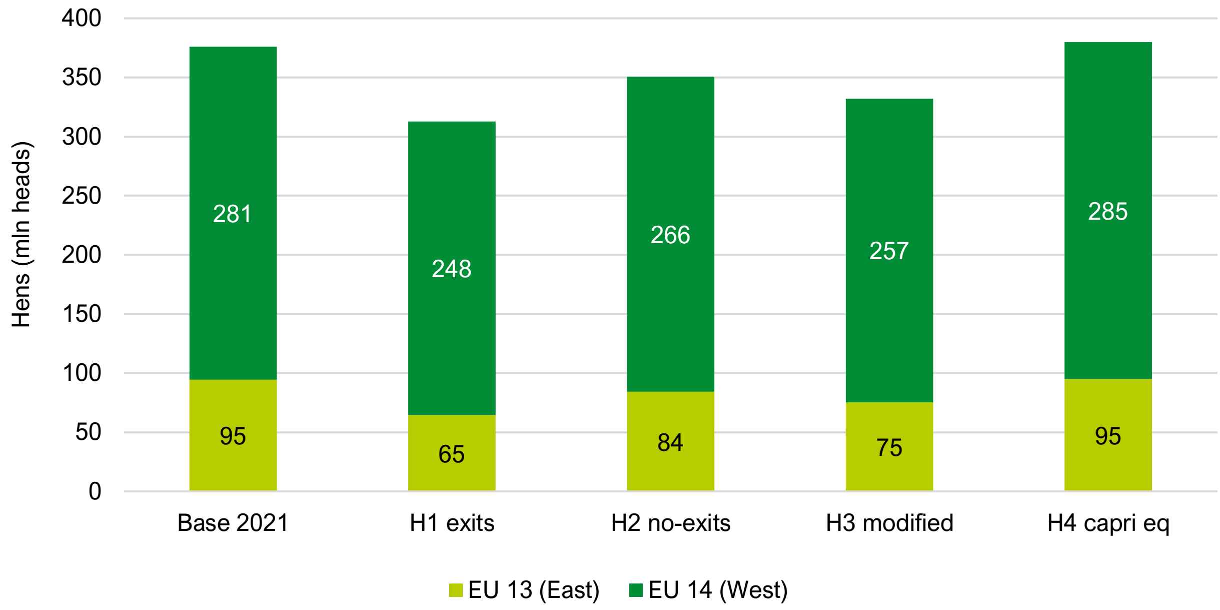
Table 51: **Aggregation to the EU scale – Scenario H4$_{capri\ eq}$ 2035**

	Base Scenario 2021					2035 H4 capri eq Scenario			
	Enriched cages	Barn	Free-range	Organic	Total	Barn	Free-range	Organic	Total
NUMBER OF HENS ['000 heads]									
EAST	67,359	22,536	3,761	899	94,555	77,715	15,932	1,545	95,192 (100.7)*
WEST	101,425	111,440	44,513	24,063	281,441	196,331	63,238	25,057	284,626 (101.1)
EU	168,784	133,976	48,273	24,962	375,996	274,046	79,170	26,602	379,818 (101.0)
ALLOCATION OF HENS [%]									
EAST	71.2	23.8	4.0	1.0	100	81.6	16.7	1.6	100
WEST	36.0	39.6	15.8	8.6	100	69.0	22.2	8.8	100
EU	44.9	35.6	12.8	6.6	100	72.2	20.8	7.0	100
EGGS YIELD [kg/hen/year]									
EAST	18.7	18.1	15.1	14.6	18.3	18.2	15.2	14.7	17.7 (96.1%)
WEST	19.9	19.3	16.0	15.5	18.7	19.4	16.2	15.7	18.4 (98.0%)
EU	19.3	18.7	15.6	15.1	18.4	19.1	16.0	15.6	18.2 (97.5%)
EGG PRODUCTION ['000 tonnes]									
EAST	1,256	408	57	13	1,734	1,417	242	23	1,682 (96.8)
WEST	2,015	2,148	714	374	5,251	3,815	1,023	393	5,230 (96.8)
EU	3,260	2,510	753	377	6,901	5,232	1,265	415	6,912 (98.5)
EGG PRODUCTION – structure [%]									
EAST	72.5	23.5	3.3	0.8	100	84.3	14.4	1.4	100
WEST	38.4	40.9	13.6	7.1	100	72.9	19.6	7.5	100
EU	72.5	23.5	3.3	0.8	100	75.7	18.3	6.0	100
INVESTMENT in equipment for alternative systems and additional buildings [million EUR]									
EAST	–	–	–	–	–	883	207	11	1,101
WEST	–	–	–	–	–	1,698	412	22	2,132
EU	–	–	–	–	–	2,581	619	33	3,232

* Values in brackets (…%) in the column Total under the 'X1' scenario indicate the relation of the Total 2035 and Total 2021.
Source: own elaboration

The total number of hens in the EU-27 in all alternative scenarios is below 2021, the base year scenario level (Figures 30, 31 and 32).

Figure 30: **Number of hens (million heads) in each assessed scenario**



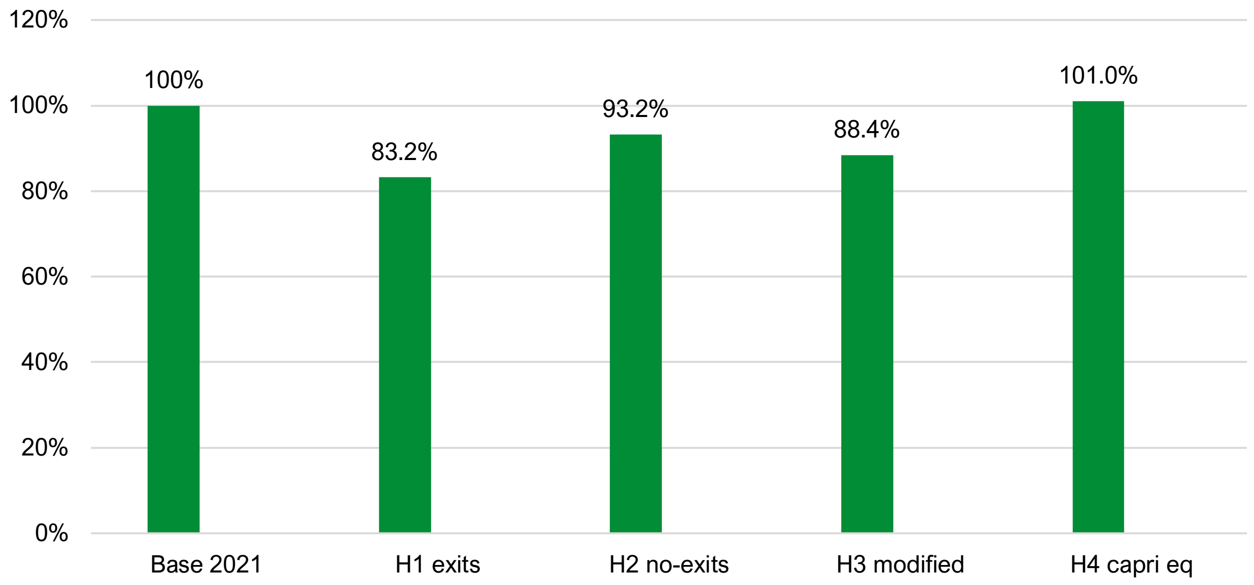
Source: own elaboration

In particular, this applies to the extreme $H1_{exits}$ scenario with the highest number of exits from the sector, as declared by surveyed farmers. Under this scenario, the number of hens in the EU-27 drops from the base 376 million to about 313 million, also considering reductions due to lower densities. Under the $H2_{no\text{-}exits}$ scenario, the number of hens is reduced to about 350 million. However, it is equally unlikely that all farmers making such declarations will exit or there will be no exits at all. Considering long-term concentration trends and a number of older farmers without successors who operate in the sector at present, scenarios $H3_{modified}$ and $H4_{capri\ eq}$ are certainly much more realistic. Based on the farm-level assessments and adjusting the $H4_{capri\ eq}$ scenario to the equilibrium solution of the CAPRI model, it can be concluded that the most likely size of the EU laying hens sector will be within the range of 330 million ($H3_{modified}$) and 379 million ($H4_{capri\ eq}$).

Figure 2a shows a small share of the E13 'East' cluster of countries in the total number of hens in the EU-27. In the base year, the share of 11 countries classified as 'East' in the total number of hens in the EU was only 25,1%, of which more than half were housed in Poland, which is one of the largest egg producers in the EU with the population of about 51 million laying hens in 2021, next after Germany (58 million).

The most significant drop in the number of hens in the EU-27 characterises $H1_{exits}$ 'Extreme Exits' scenario (83.2% of the Base year), while under $H4_{capri\ eq}$ 'Market Equilibrium' scenario number of hens is slightly above (101%) the initial 2021 level (Figure 31).

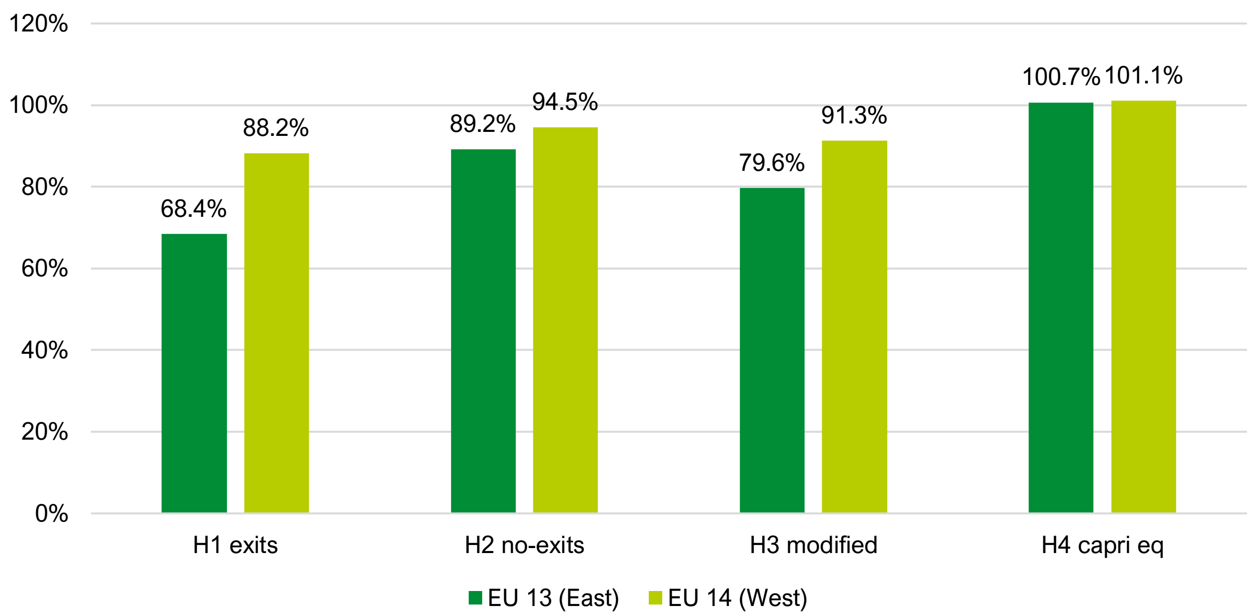
Figure 31: **Total number of hens in relation to the Base scenario (%): EU-27**



Source: own elaboration

Reductions in the number of hens compared to the Base scenario range from 68.4% (scenario $H1_{exits}$, EAST) to 100.7% (scenario $H4_{capri\ eq}$, EAST), as presented in Figure 32.

Figure 32: **Total number of hens in relation to the Base scenario (%): 'East' – 'West'**

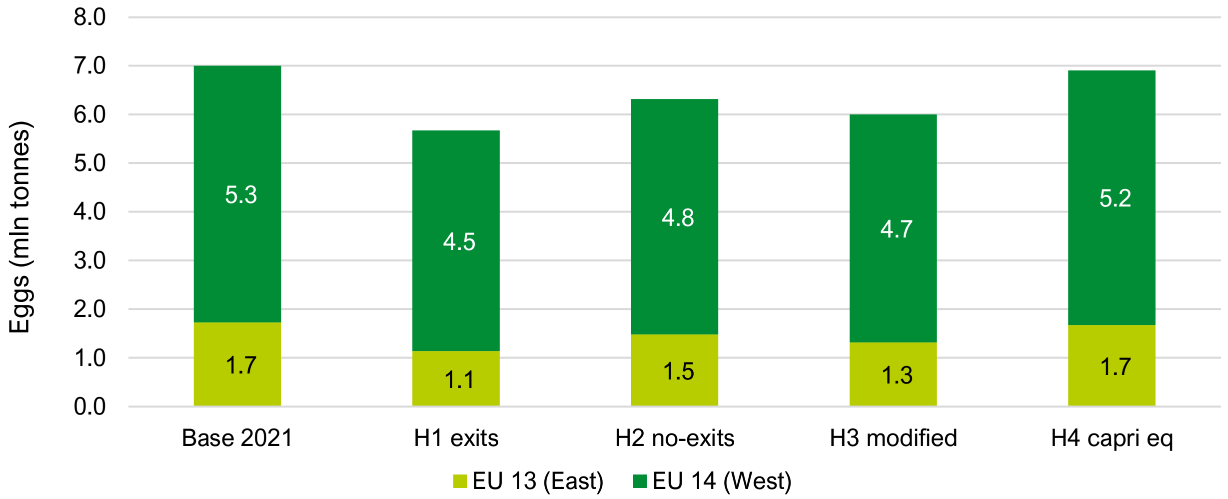


Source: own elaboration

The results reflect assumptions based mainly on the existing situation in the sector and, as it seems, more pessimistic attitudes regarding the future among farmers for the central and east European countries. However, these proportions may change depending on the willingness of consumers to pay higher prices for eggs from alternative systems and the orientation of the agricultural policy to support the transition.

Egg production after the complete transition to alternative systems (Figures 33, 34 and 35) follows changes in the number of laying hens. Lower production is also influenced by slightly reduced yields of eggs.

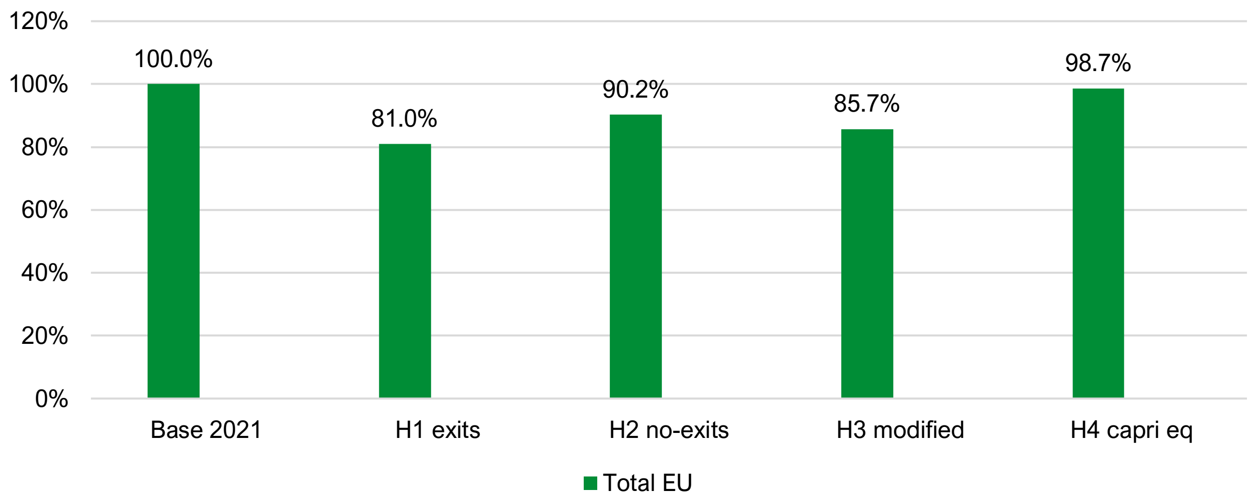
Figure 33: **Production of eggs (million tonnes) in assessment scenarios**



Source: own elaboration

On average, under the extreme $H1_{exits}$ scenario, the total production of eggs in the EU-27 goes down to about 81% of the base (Figure 3b). In the most optimistic solution, $H4_{capri\ eq}$, based on the assumptions from the CAPRI model, production is reduced by 3,4% (Figure 34).

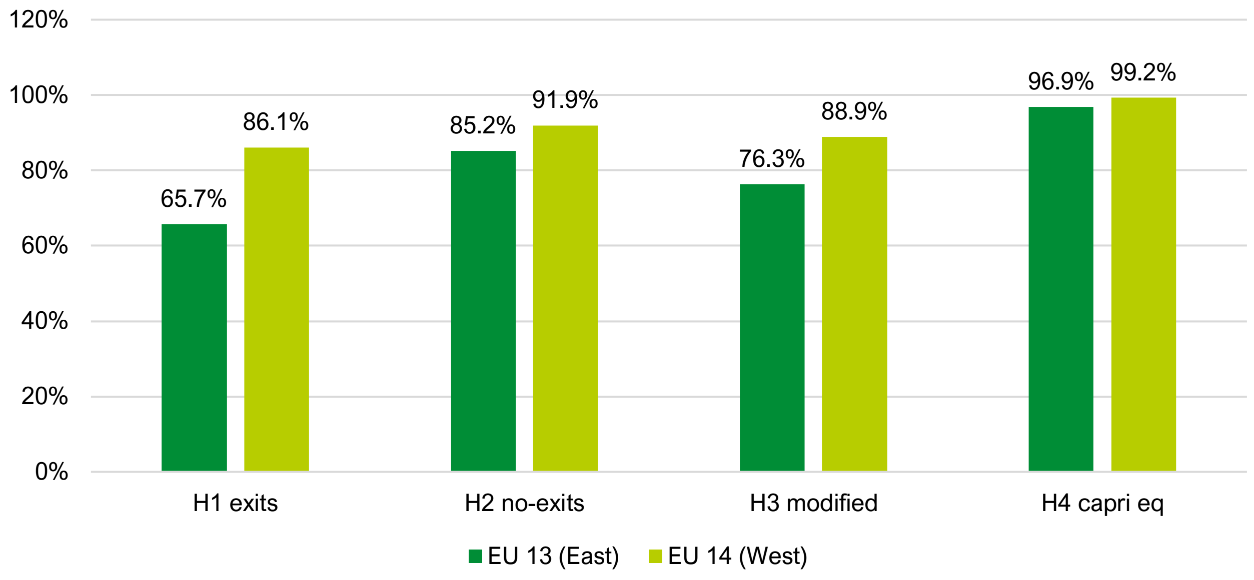
Figure 34: **Production of eggs in assessment scenarios: the base year 2021 = 100%**



Source: own elaboration

In the cluster of 'EAST' countries, the drop in production is slightly more substantial than in the 'WEST' (Figure 35).

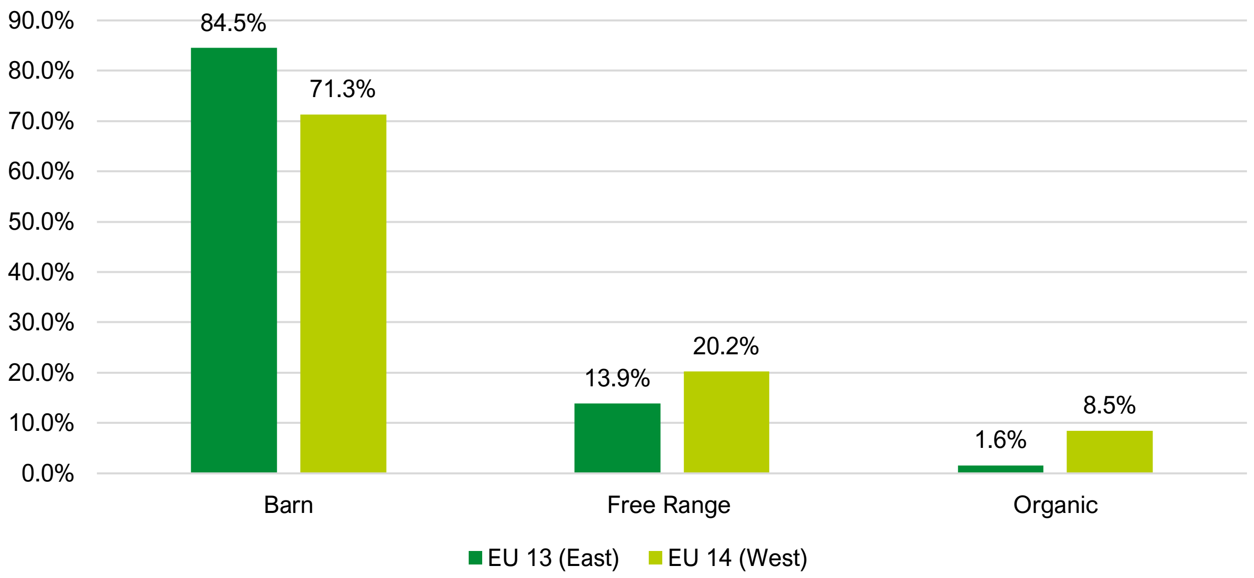
Figure 35: **Production of eggs in assessment scenarios in clusters 'East' and 'West' (the base year is 2021 = 100%)**



Source: own elaboration

Like at present, Barn eggs will dominate the production structure after transition (Figure 36).

Figure 36: **Structure of egg production from alternative systems in the $H4_{capri\ eq}$ 2035 scenario**

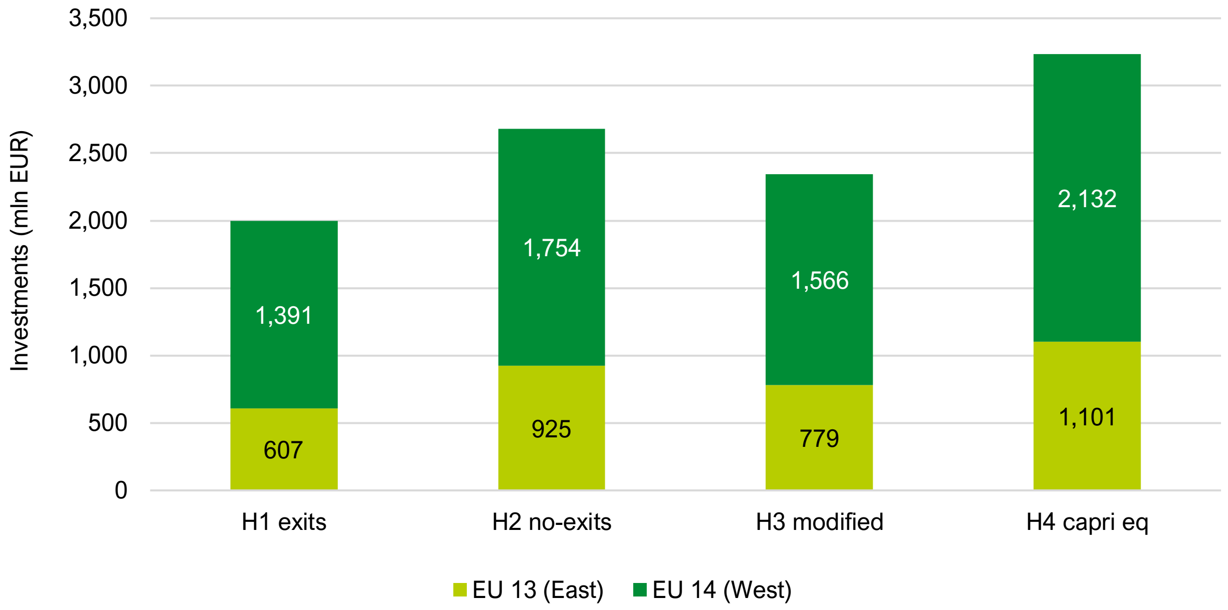


Source: own elaboration

Only the structure for the $H4_{capri\ eq}$ 2035 scenario is presented in Figure 36, but it does not differ significantly in the case of other scenarios (see Tables 8-12). What should be emphasised is a much greater share of Free-range and Organic eggs in the "WEST" cluster of countries, reflecting the initial 2021 basis and declarations of surveyed farmers. However, the proportions may change in the long term, depending on the market situation and consumers' behaviour.

Transformation to alternative systems will require investments. Their values, according to the scenario, are illustrated in Figure 37.

Figure 37: **Value of investments (million EUR) in equipment and buildings in respective scenarios**



Source: own elaboration

Depending on the scenario, the estimated value of investments in all EU-27 countries ranges from about 2 billion EUR (scenario $H1_{exits}$) to about 3.23 billion EUR ($H4_{capri\ eq}$). For the latter, additional investments in new capacities for egg production (buildings) were planned to achieve egg production at the level estimated in the market equilibrium CAPRI model.

Table 52 presents values of Gross Margin from analysed housing systems for the $H4_{capri\ eq}$ 2035 – "Market equilibrium" scenario. Gross Margin calculations for other systems are attached in the Annex. Although there are apparent differences between scenarios, there are not significant, however noticeable differences in the value of Gross Margin (Table 53).

In the calculation, inputs and prices have been adjusted. For all alternative systems, depreciation from investments in equipment replacing cages has been estimated. Only in the $H4_{capri\ eq}$ 2035 "Market equilibrium" scenario, depreciation from additional investments in buildings necessary to reach the production of eggs determined by the CAPRI model was included.

Table 52: **Gross Margins (Revenues minus Variable costs) – sample enriched cages and sample alternative systems after transition (EUR/hen/year, fixed 2021 prices)**

Item	Enriched cages			Voliera (Barn)			Free-range			Organic		
	Volume	Price	Value	Volume	Price	Value	Volume	Price	Value	Volume	Price	Value
Eggs [kg]	19.32	1.21	23.28	18.90	1.24	23.43	15.73	1.33	20.95	15.23	1.69	25.78
Hen end of lay	0.41	0.25	0.10	0.41	0.26	0.11	0.40	0.26	0.11	0.40	0.26	0.41
Revenues total		23.38			23.54			21.05			25.89	
Pullet			3.89			4.01			4.49			5.09
Feed			12.94			13.17			13.45			18.96
Labour			1.96			2.47			2.58			2.72
Total veterinary cost			0.19			0.16			0.18			0.18
Cleaning and disinfection			0.24			0.25			0.28			0.28
Energy			0.41			0.49			0.59			0.59
Services			0.14			0.14			0.14			0.14
Other inputs			0.45			0.44			0.44			0.43
Additional costs – alternative systems*			–			0.13			0.13			0.2
Depreciation**			0.63			0.96			0.14			1.0
Total Variable Costs			20.93			21.25			22.28			28.53
GROSS MARGIN [EUR/hen/year]		2.53			1.33			–2.25			–3.64	
GROSS MARGIN [EUR/kg eggs]		0.131			0.070			–0.143			–0.239	

* Included litter, maintenance of outdoor run;
** Equipment plus additional investments in buildings in $H4_{capri\ eq}$ 2035 only
Source: own elaboration

Financial results vary depending on the scenario (Table 53).

Table 53: **Gross Margins from different housing systems and scenarios (EUR/kg eggs)**

Scenario	Enriched cages	Barn (Voliera)	Free-range	Organic
EUR/kg eggs				
$H1_{exits}$ – 'Extreme Exits'	0.127	0.160	0.171	0.200
$H2_{no\text{-}exits}$ – 'No Exits'	0.127	0.138	0.145	0.164
$H3_{modified}$ – 'Modified Exits'	0.127	0.148	0.156	0.179
$H4_{capri\ eq}$ – 'Market Equilibrium'	0.127	0.070	–0.143	–0.239
Ratio: Enriched cages = 1,0				
$H1_{exits}$ – 'Extreme Exits'	1.00	1.26	1.35	1.57
$H2_{no\text{-}exits}$ – 'No Exits'	1.00	1.09	1.14	1.29
$H3_{modified}$ – 'Modified Exits'	1.00	1.16	1.23	1.41
$H4_{capri\ eq}$ – 'Market Equilibrium'	1.00	0.54	–2.09	–2.82

The lowest Gross Margins characterise the $H2_{no\text{-}exits}$ 2035 scenario. Although the price of eggs is the same in all scenarios, the $H2_{no\text{-}exits}$, in which all farms stay in the sector, including smaller ones, without successors, is apparently the least effective. Exits assumed in other scenarios resulted in an increase of Gross Margins per unit of production.

It should be emphasised that in Gross Margin calculations, the same prices were used for each scenario and respective housing system. This is, to some extent, an oversimplification, but predicting prices for a specific sector structure is not possible in the farm-level assessments, as it can be done in the partial equilibrium CAPRI model. That is why we have constructed $H4_{capri\ eq}$ scenario, which is comparable with the CAPRI model solution (A 2035). In the case of other scenarios, and very likely shifts in prices depending on the demand, consumers' willingness to pay, and possible imports, financial results for different price levels can be estimated with a sensitivity analysis.

Table 54: **Gross Margins from different housing systems in the 'Market Equilibrium' scenario (EUR/kg eggs)**

Cluster of farms	Enriched cages	Barn (Voliera)	Free-range	Organic
EUR/kg eggs				
Sample	0.131	0.070	–0.143	–0.239
EU 13	0.106	0.074	–0.117	–0.186
EU 14	0.150	0.067	–0.164	–0.280
Small	0.114	0.065	–0.149	–0.232
Medium	0.178	0.142	–0.048	–0.116
Large	0.125	0.064	–0.153	–0.254

The comparison of financial results in the $H4_{capri\ eq}$ scenario for clusters of farms shows that all farms are almost equally affected due to the switch to alternative systems.

Brief concluding remarks:

The ban on cages will result in a reduction in egg production in the EU and will require significant investments. The most likely size of the EU laying hens sector will be within the range of 330 million ($H3_{modified}$) and 379 million hens ($H4_{capri\ eq}$). Depending on the scenario, investments in all EU-27 countries ranging from about 2 billion EUR to about 3.23 billion EUR will be required. After the complete transition to alternative systems, egg production follows changes in the number of laying hens. Lower production results also from slightly reduced average yields of eggs, due to the higher share of eggs from free range and organic,.

The ban will strengthen the concentration trend in the egg production sector. Exits of small-scale farmers, and farmers without successors, will be very likely.

Early adopters may benefit from the transition due to attractive prices. Nevertheless, the more hens there prove to be in alternative systems, the lower future market prices and farmers' benefits may be. Financial results at the farm-level are very strongly sensitive to the prices of eggs.

3.2. CAPRI model

In the following section we present the simulated impacts on supply balances and prices, and then highlight the income effects, which are the main drivers of the optimisation philosophy behind CAPRI. To bring everything together, the most important macroeconomic and environmental aspects are also discussed.

The modelling exercise outcomes are reported in percentage differences which represent the net change induced by the new policy (ban on cages) against the CAPRI baseline under specific conditions in the simulation years (2025, 2035 and 2045).

Although the impacts of transitioning to cage-free housing systems on the poultry meat sector is outside the scope of this study, the CAPRI model results are presented for the poultry meat sector too, because of two reasons: (1) spent hens contribute to poultry meat production; and (2) poultry meat is recognised as the main substitute for pork meat.

3.2.1. Impacts on the supply balances

The ban on cages is expected to impact most on the pig sector where the transition to cage-free housing systems lags conspicuously behind the layer sector. Pork meat production in the EU-27 is projected to decline markedly in all scenarios, with a rate inversely proportional to the time frame envisaged for implementing the new policy. Production plummets by 23.6% (Table 55) against the CAPRI baseline when farmers are required to transition immediately (Scenario A). Extending the transition deadline by 10 years (Scenarios B1-2) or by 20 years (Scenarios C1-2) significantly lessens this negative development to between 8.4-0.5%, as these scenarios can more conveniently accommodate for the time factor needed by farmers who want to speed up depreciation of their existing assets and infrastructures. (It shoud nevertheless be pointed out that the CAPRI model does not capture the change in the number of smallholders quitting business, and the gradual shift in the economic size of the average livestock farm, which is likely to happen.)

As introduced previously, Scenarios B2 and C2 could be considered most realistic because the pace of penetration of cage-free production at the individual Member State level during the transition period is taken into account. This allows for differentiating between the presumed level of preparedness of countries for the transition. Scenarios B2 and C2 thereby capture the policy impacts more thoroughly compared to Scenarios B1 and C1, which rather detail the 'current preparedness' impacts. It is to note in this context that e.g. the 4.6 percentage point difference in the changes projected for pork meat supply between Scenarios B1 and B2 is comparable to the 5.1 percentage point difference between the results for Scenarios C1 and C2, and this observation remains valid for the other indicators as well. This implies that the rate of making the transition to cage-free housing systems (i.e. the 'willingness' of farmers) remains relatively stable over time and is independent from the length of the transition period. The Commission is advised to give consideration to this and manage the transition smoothly, instead of implementing a shock scenario.

Depending on the length of the transition period, the decline in the production of pork meat triggers changes across the EU-27 meat supply balances. From the various consequences, the model predicts two major effects: (1) a decrease in the domestic demand for and (2) a weakening of the trade balance of pork meat (Table 55, Figure 38). The decrease in the domestic market use of pork meat is marked only on the short-term horizon for the EU-27, with 8.8% in Scenario A, as consumers adapt to the changes in the availability and price of the product (discussed later) swiftly. As for trade, with less than 200 thousand tonnes of pork meat (live animals and processed products included) sourced from third countries a year on average between 2019-2021 (see Annex 2), the EU-27 is not a major importer of pork meat on the global market. In Scenario A, pork meat imports surge almost eleven-fold in volume terms against the CAPRI baseline as production declines drastically, and net trade of the EU-27 crumbles by 93.5%. However, Scenario A represents the extreme situation with the immediate transition to cage-free housing systems, which is not reasonable. The dependence on imported pig meat appears considerably smaller when the deadline for transitioning is shifted from 2025 to 2035 or 2045, peaking in Scenario B1 with 92.7%, collapsing to 6.9% in Scenario C2. In Scenarios B2 and C2, the share of imported pork meat in the EU-27 domestic consumption increases to a range between 0.9-1.1% from around 0.8% currently, which are changes of negligible magnitude.

The impacts of the new policy on the egg supply balance of the EU-27 are far less pronounced. Even already in Scenario B2, when a 10-year long transition period is allowed for and the natural transition to cage-free housing systems continues as anticipated, the production of eggs is projected to drop by a mere 0.9%, accompanied by a 0.3% decline in the domestic use of the product. The magnitudes of these negative developments further lessen in Scenario C2.

Exports of eggs decrease moderately parallel to the production fallback, while imports rise. But with 49.5 thousand tonnes of eggs (including egg products but excluding hatching eggs) shipped from third countries a year on average between 2019-2021 (see Annex 2), the EU-27 is not a major egg importer either. The projected growth in egg imports changes between 5.0-18.5% against the CAPRI baseline in the different scenarios, which can be judged of low significance given that imported eggs account for a share of around 0.5% in consumption currently.

A small uptake in poultry meat consumption is observed in all scenarios which counterbalances the decline in pork meat and egg consumption to some extent. In Scenario A, the additional domestic demand is satisfied from increasing production and imports, and from decreasing exports. In Scenarios B1-2 and C1-2, the poultry trade balance of the EU-27 seems only slightly affected.

Table 55: **Changes in the pork and poultry meat, and egg balances of the EU-27 against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

	Product	Scenarios				
		A	B1	B2	C1	C2
Supply	Pork meat	–23.6%	–8.4%	–3.8%	–5.6%	–0.5%
	Eggs	–1.4%	–2.0%	–0.9%	–1.9%	–0.5%
	Poultry meat	+2.6%	+0.7%	+0.3%	+0.4%	+0.0%
Domestic market use	Pork meat	–8.8%	–2.0%	–0.9%	–1.1%	–0.2%
	Eggs	–0.2%	–0.6%	–0.3%	–0.6%	–0.2%
	Poultry meat	+3.2%	+0.8%	+0.3%	+0.5%	+0.0%
Imports	Pork meat	+1,086.4%	+92.7%	+37.6%	+43.7%	+6.9%
	Eggs	+18.0%	+18.5%	+8.4%	+17.0%	+5.0%
	Poultry meat	+6.2%	+0.5%	+0.2%	+0.1%	+0.0%
Exports	Pork meat	–87.1%	–39.3%	–16.8%	–24.8%	–2.1%
	Eggs	–7.3%	–7.4%	–3.3%	–7.0%	–2.0%
	Poultry meat	–1.1%	+0.2%	+0.1%	+0.0%	–0.0%
Net trade	Pork meat	–93.5%	–40.0%	–17.1%	–25.2%	–2.1%
	Eggs	–7.5%	–7.6%	–3.4%	–7.1%	–2.0%
	Poultry meat	–1.9%	+0.2%	+0.1%	+0.0%	–0.0%

Source: own elaboration from the CAPRI model results

A comparison of pig farming across the EU macro-regions (EU-14 and EU-13) provides important clues on the scenario outcomes. Regardless of the length of the transition period, the new policy appears to have a lasting dividing effect on the economic performance of the EU-West (EU-14) and EU-East (EU-13) livestock sectors. Irrespective of the length of the transition period, the percentage decline in pork meat supply is considerably higher in the EU-East compared to the EU-West (Table 56, Figure 38, and for changes at the Member State and NUTS-2 levels see Annexes 6 and 7). The stronger resilience of the pig sector in the EU-West is well underlined by the changes in the trade indicators. In fact, the decline in production is better offset by the drop-back in exports (Figure 39), thus trade of EU-West countries with third countries acts more as a buffer, absorbing most of the loss.

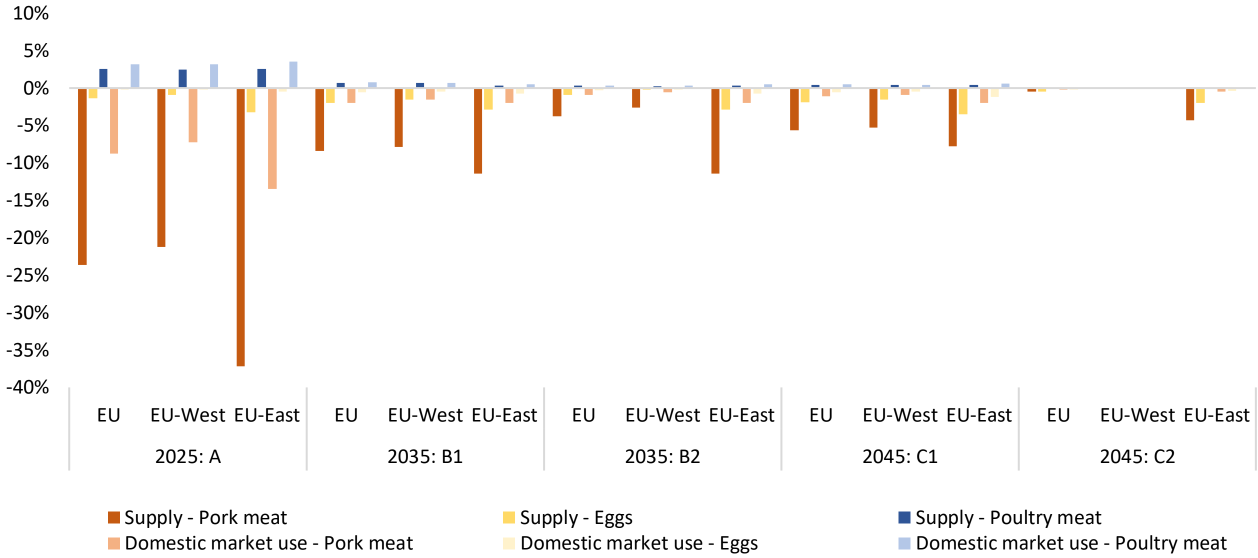
Table 56: **Changes in the pork and poultry meat, and egg balances of the EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

	Product	Scenarios									
		A		B1		B2		C1		C2	
		EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
Supply	Pork meat	–21.2%	–37.2%	–7.9%	–11.4%	–2.6%	–11.4%	–5.3%	–7.8%	+0.0%	–4.3%
	Eggs	–0.9%	–3.2%	–1.5%	–2.9%	–0.2%	–2.9%	–1.5%	–3.5%	–0.1%	–2.0%
	Poultry meat	+2.5%	+2.6%	+0.7%	+0.3%	+0.2%	+0.3%	+0.4%	+0.4%	+0.0%	+0.0%
Domestic market use	Pork meat	–7.2%	–13.5%	–1.5%	–2.0%	–0.6%	–2.0%	–0.9%	–2.0%	–0.1%	–0.5%
	Eggs	–0.2%	–0.5%	–0.5%	–0.7%	–0.2%	–0.7%	–0.5%	–1.2%	–0.1%	–0.4%
	Poultry meat	+3.2%	+3.5%	+0.7%	+0.5%	+0.3%	+0.5%	+0.4%	+0.6%	+0.0%	+0.1%
Imports	Pork meat	+533.8%	+3,135.1%	+75.3%	+131.3%	+35.1%	+43.3%	+35.4%	+66.9%	+7.0%	+6.6%
	Eggs	+18.2%	+17.4%	+19.2%	+17.0%	+8.8%	+7.5%	+17.7%	+15.4%	+5.3%	+4.4%
	Poultry meat	+6.2%	+6.1%	+0.5%	+0.8%	+0.1%	+0.3%	+0.1%	+0.8%	+0.0%	+0.1%
Exports	Pork meat	–86.8%	–96.1%	–38.7%	–56.4%	–15.9%	–41.5%	–24.4%	–36.6%	–1.6%	–13.7%
	Eggs	–6.5%	–8.5%	–7.1%	–8.0%	–1.7%	–5.7%	–6.7%	–7.4%	–0.8%	–3.9%
	Poultry meat	–1.8%	–0.2%	+0.3%	+0.2%	+0.1%	+0.1%	+0.0%	+0.0%	–0.0%	–0.0%
Net trade	Pork meat	–89.6%	–212.0%	–39.2%	–66.9%	–16.1%	–46.2%	–24.6%	–40.5%	–1.7%	–14.4%
	Eggs	–6.7%	–8.6%	–7.2%	–8.1%	–1.7%	–5.8%	–6.9%	–7.5%	–0.8%	–3.9%
	Poultry meat	–2.9%	–0.6%	+0.3%	+0.1%	+0.1%	+0.1%	+0.0%	+0.0%	–0.0%	–0.0%

Source: own elaboration from the CAPRI model results

The new policy impacts on egg production more in the EU-East in Scenarios B2 and C2 (Table 56 and Figure 38), explained by the slower pace of transitioning to cage-free housing systems compared to the EU-West. This implies a more pronounced setback in egg exports from and consumption in this block of countries *vis-á-vis* the EU-14.

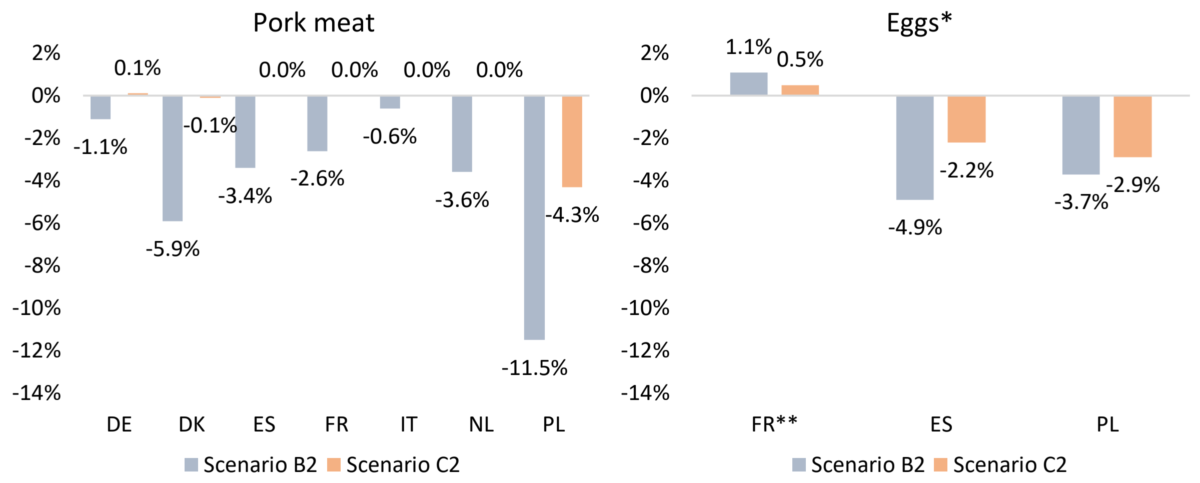
Figure 38: **Changes in the pork and poultry meat, and egg supply and demand of the EU-27, EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**



Source: own elaboration from the CAPRI model results

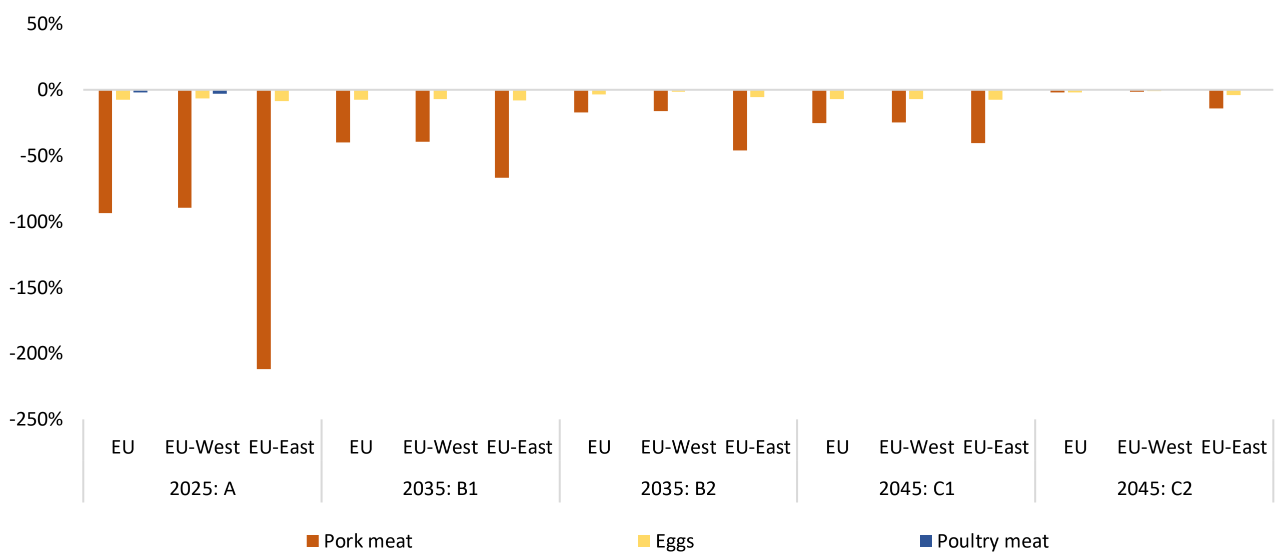
Pork meat consumption in the EU-East is also deemed to decline by a greater extent in all scenarios, leading to a larger but not significant increase in the consumption of poultry meat compared to the EU-West, except for Scenario B1.

Figure 39: **Changes in the production of pork meat and eggs of the major pork meat and egg producing EU Member States against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**



* Major egg producing countries where the transition to cage-free housing systems is less advanced (see Table 42).
** In France, there is a ban already on the use of enriched cages in new and refurbished buildings.
Source: own elaboration from the CAPRI model results (see Annex 6)

Figure 40: **Changes in the net trade of pork and poultry meat, and eggs of the EU-27, EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**



Source: own elaboration from the CAPRI model results

3.2.2. Impacts on prices

Pork meat average producer price surges by 47.4% in the EU-27 compared to a 3.7% increase for eggs against the CAPRI baseline in Scenario A (Table 57). This distinct difference in producer price changes is explained by the difference in the magnitude of changes in pork meat and egg production as discussed above. When allowed for a 10- or 20-year long transition period, the rise in the producer price for pork meat becomes much smaller owing both to a substantial price increase projected in the CAPRI baseline (48.0% by 2045 against 2025) and to a more moderate shock caused by the ban on cages compared to Scenario A under the prevailing market conditions as projected in the CAPRI baseline.

Table 57: **Changes in pork and poultry meat, and egg prices in the EU-27 against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

	Product	Scenarios				
		A	B1	B2	C1	C2
Producer price	Pork meat	+47.4%	+11.0%	+4.3%	+6.2%	+0.6%
	Eggs	+3.7%	+3.8%	+1.4%	+3.5%	+0.8%
	Poultry meat	+1.3%	+0.4%	+0.1%	+0.3%	+0.0%
Consumer price	Pork meat	+15.3%	+3.2%	+1.3%	+1.9%	+0.2%
	Eggs	+1.6%	+1.5%	+0.6%	+1.3%	+0.3%
	Poultry meat	+0.4%	+0.1%	+0.0%	+0.1%	+0.0%

Source: own elaboration from the CAPRI model results

Increases in consumer prices are in part driven by the increases in production costs, resulting in a 15.3% hike for pork meat and in a 1.6% climb for eggs against the CAPRI baseline at the level of the EU-27 in Scenario A. When allowed for a transition period, consumer prices for both products follow a similar pattern to producer prices.

Changes in producer and consumer prices for poultry meat are less significant in all scenarios.

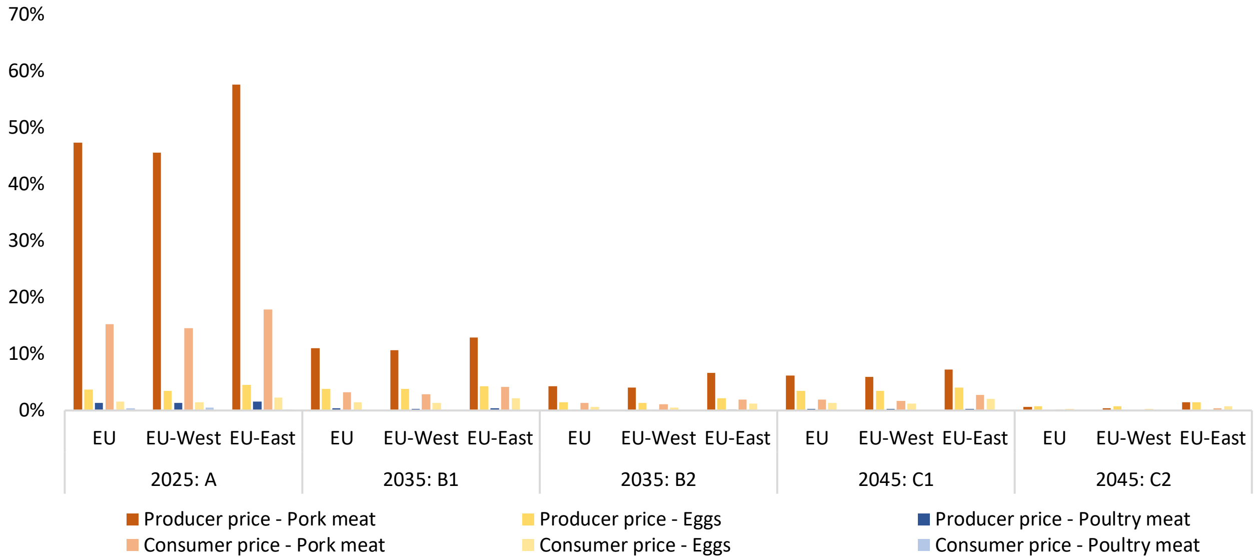
Both producer and consumer prices for pork meat and eggs exhibit a larger increase in the EU-East (Table 58, Figure 41). This is due to the lag in transitioning to cage-free housing systems in the EU-13. It is to note that in the CAPRI baseline, producer prices of pork meat remain at a higher level in the EU-West through the projection period, while for producer prices of eggs, the opposite holds true.

Table 58: **Changes in pork and poultry meat, and egg prices in the EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

	Product	Scenarios									
		A		B1		B2		C1		C2	
		EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
Producer price	Pork meat	+45.6%	+57.6%	+10.7%	+12.9%	+4.0%	+6.6%	+6.0%	+7.2%	+0.4%	+1.5%
	Eggs	+3.5%	+4.5%	+3.8%	+4.3%	+1.3%	+2.2%	+3.5%	+4.0%	+0.7%	+1.5%
	Poultry meat	+1.3%	+1.6%	+0.3%	+0.4%	+0.1%	+0.2%	+0.3%	+0.3%	+0.0%	+0.0%
Consumer price	Pork meat	+14.5%	+17.9%	+2.9%	+4.2%	+1.1%	+1.9%	+1.7%	+2.7%	+0.1%	+0.4%
	Eggs	+1.4%	+2.3%	+1.3%	+2.2%	+0.5%	+1.2%	+1.2%	+2.1%	+0.3%	+0.8%
	Poultry meat	+0.5%	+0.2%	+0.1%	+0.1%	+0.1%	+0.0%	+0.1%	+0.1%	+0.0%	+0.0%

Source: own elaboration from the CAPRI model results

Figure 41: **Changes in pork and poultry meat, and egg prices in the EU-27, EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**



Source: own elaboration from the CAPRI model results

3.2.3. Impacts on agricultural profits

Profits in the pig sector of the EU-27 shrink by a considerable 37.8% against the CAPRI baseline in Scenario A (Table 59), explaining the sizeable decline in pork meat production in the extreme situation when no transition period is provided for. In the egg sector, the impacts are expected to be less severe with profits melting by 0.9% in Scenario A, as a consequence of the substantial advancement in transitioning to cage-free housing systems. Although the estimated impacts on profits in the pig sector appear to gradually erode over time (through Scenarios B1-2 and C1-2), the 14.2% drop in Scenario B2 (full transition by 2035, taking natural transition into account) can still be judged as relatively high.

Contrary to what is observed in the pig and egg sectors, profits in the poultry meat sector soar in Scenario A but show a steadily declining growth rate over time. It is to note however, that the volume of profits realised by the EU-27 poultry meat sector in the CAPRI baseline represent less than a quarter of that generated in the pig sector. This in part explains the limited increase in poultry meat production in Scenario A, and its even more moderate growth against the CAPRI baseline over time.

Table 59: **Changes in the profits of pork and poultry meat, and egg production in the EU-27 against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

Sector	Scenarios				
	A	B1	B2	C1	C2
Pork meat	–37.8%	–28.2%	–14.2%	–14.3%	–1.5%
Eggs	–0.9%	–2.1%	–1.5%	–1.7%	–0.7%
Poultry meat	+20.0%	+4.4%	+2.0%	+1.6%	+0.2%

Source: own elaboration from the CAPRI model results

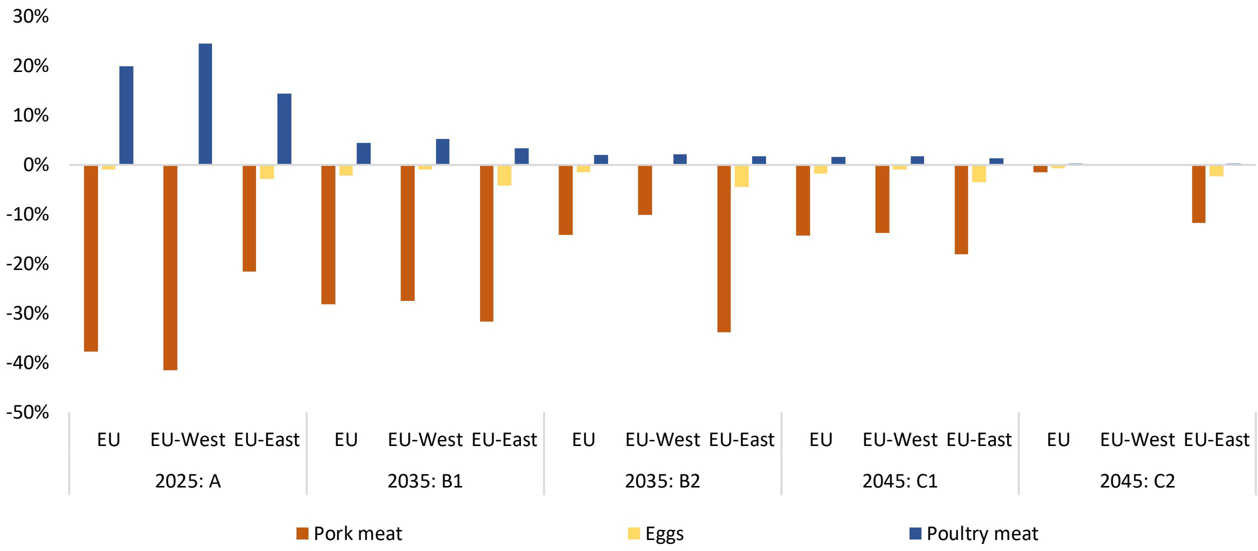
Taking a closer look at the EU macro-regions, the profit loss in the pig sector is markedly higher in the EU-West (41.5%) than in the EU-East (21.6%) in Scenario A (Table 60, Figure 42). However, this position appears to reverse over time owing to the improving relative competitiveness of the pig sector in the EU-West (Scenarios B1 and C1) accompanied by a faster natural transition in those Member States (Scenarios B2 and C2). In the case of egg production, the decline in profits seem more pronounced in the EU-East. Its magnitude even increases from Scenario A to Scenario B2, due to the considerable lag in transitioning to cage-free housing systems *vis-á-vis* the EU-West. As for poultry meat production, the profit gains in the EU-West are almost two times higher in Scenario A but smooth out over time as the supply shocks caused by the transition to cage-free housing systems in the pig sector contract.

Table 60: **Changes in the profits of pork and poultry meat, and egg production in the EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

Sector	Scenarios									
	A		B1		B2		C1		C2	
	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
Pork meat	–41.5%	–21.6%	–27.5%	–31.7%	–10.1%	–33.8%	–13.7%	–18.1%	+0.1%	–11.8%
Eggs	+0.1%	–2.9%	–1.0%	–4.2%	–0.0%	–4.4%	–0.9%	–3.5%	+0.1%	–2.3%
Poultry meat	+24.5%	+14.4%	+5.3%	+3.3%	+2.2%	+1.7%	+1.8%	+1.4%	+0.1%	+0.2%

Source: own elaboration from the CAPRI model results

Figure 42: **Changes in the profits of pork and poultry meat, and egg production in the EU-27, EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**



Source: own elaboration from the CAPRI model results

3.2.4. Income and welfare effects

In Scenario A, when no transition period is provided for, the total income of the EU-27 agriculture drops by 1.7% (Table 61) against the CAPRI baseline, explained primarily by the declining profits in pork meat and egg production, which is not compensated for by the profit increase in poultry meat production. The total output of agricultural activities (EAA output) of the EU-27 increases by 5.8%, driven predominantly by the increase in producer prices in the sectors concerned.

Crop-specific inputs decline slightly, explained primarily by the reduced availability of manure, resulting in a corresponding decrease in crop output. Animal-specific inputs increase by 12.6% owing to the sudden decline in the physical performance of sows and layers in cage-free housing systems, while other inputs expand by a considerable 18.7%, which derives from the 'cost of compliance', including the cost of the necessary investments and the additional expenses in connection with increasing labour intensity. These changes result in a 10.7% increase in EAA inputs. Tariff revenues grow by 7.0% by reason of increasing imports of livestock products.

Table 61: **Changes in selected macroeconomic indicators for the EU-27 against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

Indicator	Scenarios				
	A	B1	B2	C1	C2
Agricultural income	–1.7%	–1.5%	–0.8%	–1.2%	–0.1%
EAA output	+5.8%	+1.5%	+0.6%	+1.0%	+0.1%
Output crops	–0.8%	–0.3%	–0.1%	–0.2%	–0.0%
Output animals	+12.6%	+3.2%	+1.3%	+2.0%	+0.2%
EAA input	+10.7%	+3.8%	+1.6%	+3.2%	+0.3%
Crop-specific input	–0.8%	–0.3%	–0.1%	–0.1%	–0.0%
Animal-specific input	+12.5%	+4.7%	+1.9%	+4.1%	+0.4%
Other input	+18.7%	+6.6%	+2.9%	+5.5%	+0.6%
Tariff revenues	+7.0%	+1.6%	+1.1%	+1.1%	+0.4%
Consumer purchasing power	–0.1%	–0.0%	–0.0%	–0.0%	+0.0%
Taxpayers' total cost	–0.1%	–0.0%	–0.0%	–0.0%	+0.0%

Source: own elaboration from the CAPRI model results

The impacts related to Scenario A appear to erode substantially when a 10- or 20-year long transition period is provided for, especially when the natural transition to cage-free housing systems continues as anticipated, which has a clear shock-smoothing effect.

The transitioning to cage-free housing systems has a negligible impact on consumer purchasing power and it does not burden taxpayers in any of the scenarios.

3.2.5. Environmental impacts

The environmental impacts for the EU-27 in the different scenarios are reported in Table 62. These are mainly driven by the decrease in pork meat and egg production, and by the decline in the physical performance of sows and layers in alternative housing systems. Except for Scenario A, the increase in GHG emissions and the reduction in the nitrate and phosphate surpluses against the CAPRI baseline are less significant. It is to note that decreasing production (e.g. less manure) and declining physical performance (e.g. more manure per unit of livestock output) have the opposite effect on the environment, *ceteris paribus*. In Scenario A, the considerable decline in ammonium output (5.1%), and in N_2O emissions from manure management (housing and storage) and from manure application (6.2% and 8.2%, respectively) are explained primarily by the substantial drop in pork meat production (22.3%) of the EU-27. The larger decline in N_2O emission from manure management compared to N_2O total emission signifies that manure is an important source of N_2O emissions.

In each of the scenarios, N_2O savings appear more important than CH_4 savings. Since a large part of the N_2O emission is due to the incomplete nitrification/denitrification processes of ammonium, it is reasonable that the trend observed for N_2O also applies to ammonium output. In fact, the percentage changes of ammonium output closely follow that of the gaseous N-losses from manure management (e.g. in scenario C2 both are -0.2%), which indicates that the bulk of the N from manure is ammonium. Unlike N_2O, ammonium does not exert a radiative forcing effect, thus its decline does not impact on GHG emissions. Nevertheless, a slight increase in GHG emissions (expressed in CO_2 equivalent) is noticeable in all scenarios, except for Scenario A, which is ascribed to the increasing reliance on mineral fertiliser use (not shown).

Table 62: **Changes in selected environmental indicators for the EU-27 agricultural sector against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

Indicator	Scenarios				
	A	B1	B2	C1	C2
GHG emissions from agriculture (CO2 eq)	–0.4%	+0.1%	+0.0%	+0.1%	+0.1%
Ammonium output	–5.3%	–2.0%	–1.0%	–1.3%	–0.2%
CH4 total emissions	–1.6%	–0.6%	–0.3%	–0.4%	–0.0%
N2O total emissions	–2.4%	–0.8%	–0.4%	–0.5%	–0.0%
N2O emissions from manure management	–6.2%	–2.4%	–1.1%	–1.5%	–0.2%
N2O emissions from manure application	–8.2%	–3.1%	–1.3%	–2.0%	–0.2%
N surplus total (kg/ha)	–3.4%	–1.3%	–0.6%	–0.8%	–0.1%
N surplus at soil level (kg/ha)	–2.9%	–1.1%	–0.5%	–0.7%	–0.0%
Gaseous N-losses from manure (kg/ha)	–6.2%	–2.3%	–1.2%	–1.5%	–0.2%
N run-off from manure (kg/ha)	–4.8%	–2.0%	–1.0%	–1.3%	–0.2%
N input with manure (kg/ha)	–5.0%	–1.9%	–0.9%	–1.3%	–0.2%
P2O5 surplus total (kg/ha)	–2.4%	–0.9%	–0.5%	–0.6%	–0.0%
P2O5 input with manure (kg/ha)	–3.1%	–1.3%	–0.6%	–0.8%	–0.1%

Source: own elaboration from the CAPRI model results

Of the environmental indicators calculated for the EU-West and East (Table 63), the decline in the values for nutrient inputs and losses of N from manure tends to be more sizeable for the EU-13 by reason of larger reduction in the output of the livestock sectors concerned (see Table 56). In Scenarios B1 and B2, the slight increase in the P_2O_5 surplus in the EU-East is explained by both the more extensive use of mineral fertilisers to compensate for the decreasing availability of phosphate from manure, and a positive manure trade balance. Other than that, nutrient surpluses in both macro-regions either decline or take on negligible positive values in Scenarios B1-2 and C1-2.

Table 63: **Changes in selected environmental indicators for the EU-14 and EU-13 agricultural sectors against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

Indicator	Scenarios									
	A		B1		B2		C1		C2	
	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
N surplus total (kg/ha)	–3.4%	–3.6%	–1.3%	–1.1%	–0.5%	–1.0%	–0.8%	–0.7%	+0.0%	–0.3%
N surplus at soil level (kg/ha)	–3.1%	–2.5%	–1.2%	–0.8%	–0.4%	–0.7%	–0.8%	–0.5%	+0.0%	–0.2%
Gaseous N-losses from manure (kg/ha)	–5.3%	–9.4%	–2.1%	–3.1%	–0.8%	–3.0%	–1.4%	–2.0%	–0.0%	–1.1%
N run-off from manure (kg/ha)	–4.7%	–5.1%	–1.9%	–2.0%	–0.6%	–1.9%	–1.3%	–1.4%	+0.0%	–0.7%

Indicator	Scenarios									
	A		B1		B2		C1		C2	
	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
N input with manure (kg/ha)	–4.6%	–6.9%	–1.8%	–2.4%	–0.6%	–2.3%	–1.2%	–1.5%	+0.0%	–0.8%
P_2O_5 surplus total (kg/ha)	–2.2%	–6.8%	–0.9%	+0.8%	–0.5%	+0.3%	–0.6%	–0.6%	+0.0%	–1.4%
P_2O_5 input with manure (kg/ha)	–2.8%	–4.5%	–1.2%	–1.6%	–0.4%	–1.6%	–0.8%	–1.0%	+0.0%	–0.6%

Source: own elaboration from the CAPRI model results

The general conclusion is that if a longer time period for transitioning to cage-free housing systems is ensured (Scenarios B1-2 and C1-2), the environmental impacts at the level of the EU-27, and of the EU-West and EU-East remain quantifiable but far less notable.

The ban on the use of cages in the EU pig and egg sectors would have a direct effect on the production and consumption of agricultural products in non-EU countries. As for GHG emissions, a 4.2% (or 5.76Mt CO_2 eq, Table 66) increase in the GWP against the CAPRI baseline becomes apparent in non-EU pork meat production (Table 65, Figure 43), driven by decreasing exports of and increasing import demand for pork meat from the EU-27 in Scenario A. This compares to a 22.3% (or 7.94Mt CO_2 eq, Table 66) drop in the GWP of pork meat production in the EU-27 (Table 64), resulting in a 1.3% decline in the GWP of the pig sector at the global level.

Table 64: **Changes in the agricultural global warming potential (GWP) of the EU pork and poultry meat, and egg sectors in CO_2 equivalents (net emissions), in comparison with changes in the net production volumes against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

	Product	Scenarios				
		A	B1	B2	C1	C2
GWP	Pork meat	–22.3%	–7.9%	–3.5%	–5.1%	–0.4%
	Eggs	–0.8%	–1.4%	–0.7%	–1.3%	–0.4%
	Poultry meat	+2.6%	+0.7%	+0.3%	+0.4%	+0.0%
Production	Pork meat	–23.6%	–8.4%	–3.8%	–5.6%	–0.5%
	Eggs	–1.4%	–2.0%	–0.9%	–1.9%	–0.5%
	Poultry meat	+2.6%	+0.7%	+0.3%	+0.4%	+0.0%

Source: own elaboration from the CAPRI model results

The changes in the GWP of the EU egg sector are at a lower scale and strongly correlate to the changes in the volume of egg production, with negligible non-EU leakage effects. As opposed to pork meat and egg production, the GWP of poultry meat production in the EU-27 increases by 2.6% in Scenario A, resulting in a 0.2% increase in the GWP of poultry meat production at the global level, but with a barely quantifiable GWP expansion in non-EU countries.

Table 65: **Changes in the agricultural global warming potential (GWP) of the non-EU and global pork and poultry meat, and egg sectors in CO_2 equivalents (net emissions), in comparison with changes in the net production volumes against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

	Product	Scenarios									
		A		B1		B2		C1		C2	
		non-EU	World	non-EU	World	non-EU	World	non-EU	World	non-EU	World
GWP	Pork meat	+4.2%	–1.3%	+1.7%	–0.2%	+0.7%	–0.1%	+1.0%	–0.1%	+0.1%	–0.0%
	Eggs	+0.0%	–0.1%	+0.1%	–0.1%	+0.0%	–0.0%	+0.1%	–0.0%	+0.0%	+0.0%
	Poultry meat	+0.0%	+0.2%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%
Production	Pork meat	+3.5%	–1.7%	+1.5%	–0.4%	+0.6%	–0.2%	+1.0%	–0.3%	+0.1%	–0.0%
	Eggs	+0.0%	–0.1%	+0.1%	–0.1%	+0.0%	–0.1%	+0.1%	–0.1%	+0.0%	–0.0%
	Poultry meat	+0.1%	+0.3%	+0.0%	+0.1%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%

Source: own elaboration from the CAPRI model results

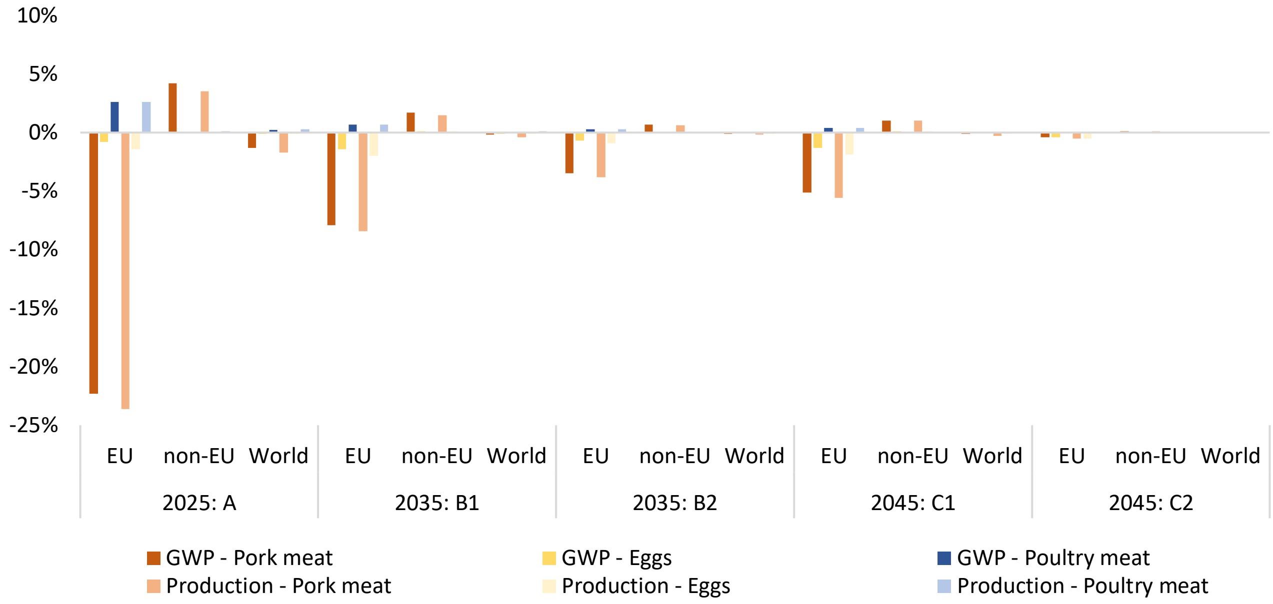
It is to note that GWP savings erode steadily with the increase in the length of the transition period and the anticipated advancement in natural transition to cage-free housing systems in the pig sector both at the EU and the global level.

Table 66: **Absolute changes in the agricultural global warming potential (GWP) of the EU, non-EU and global pork and poultry meat, and egg sectors in CO_2 equivalents (net emissions, 1000t) against the CAPRI baseline in response to the ban on cages in EU livestock farming (5% discount rate)**

Scenarios	Regions	Product		
		Pork meat	Eggs	Poultry meat
A	EU	–7,940.6	–16.1	+132.9
	non-EU	+5,761.3	+6.2	+45.8
	World	–2,179.2	–9.9	+178.7
B1	EU	–2,722.6	–28.0	+37.9
	non-EU	+2,428.0	+15.7	+2.6
	World	–294.6	–12.3	+40.5
B2	EU	–1,215.9	–14.1	+15.1
	non-EU	+999.2	+7.6	–0.2
	World	–216.7	–6.5	+14.9
C1	EU	–1,732.5	–25.4	+23.7
	non-EU	+1,528.6	+19.1	+7.4
	World	–203.91	–6.25	+31.0
C2	EU	–144.2	–7.6	+2.2
	non-EU	+123.9	+6. 9	+0.0
	World	–20.3	–0.7	+2.2

Source: own elaboration from the CAPRI model results

Figure 43: **Changes in the agricultural global warming potential (GWP) of the EU, non-EU and global pork and poultry meat, and egg sectors in CO_2 equivalents (net emissions), in comparison with changes in the net production volumes against the CAPRI baseline in response to the ban on cages in EU livestock farming at the EU, non-EU and global level (5% discount rate)**



Source: own elaboration from the CAPRI model results

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Annexes

Annex 1: **2021 InterPIG data used for the CAPRI database and baseline adjustments**

	AT	BE	CZ	DE	DK	ES	FI	FR	HU	IE	IT	NL	SE
Sow replacement rate	37.7%	45.9%	45.0%	39.5%	54.9%	47.0%	45.0%	46.8%	43.3%	58.6%	40.0%	43.0%	58.2%
Litters per sow/year	2.30	2.37	2.29	2.30	2.24	2.28	2.27	2.33	2.28	2.27	2.24	2.35	2.22
Pre-weaning mortality	11.1%	12.5%	10.8%	15.2%	15.2%	14.5%	14.4%	14.8%	11.9%	11.1%	11.4%	12.1%	16.9%
Feed cost per sow/year (EUR)	817.6	823.0	806.0	736.4	865.2	597.3	780.8	840.6	592.8	1,173.7	848.1	803.2	893.7
Vet-Med and breeding cost per sow/year (EUR)	281.5	173.5	265.9	239.8	269.2	139.5	273.0	237.8	174.7	240.0	320.3	223.1	325.2
Energy cost per sow/year (EUR)	269.2	241.2	226.2	270.7	185.9	224.3	228.9	252.7	185.8	246.4	217.2	199.0	203.6
Building & equipment maintenance per sow place/year (EUR)	53.0	71.7	81.2	79.1	61.2	63.3	113.0	66.7	31.9	144.8	118.5	48.7	63.3
Miscellaneous costs per sow/year (EUR)	59.6	25.3	78.2	96.0	47.2	40.8	28.9	47.9	6.4	55.1	48.0	47.3	59.2
Average cost of labour per sow/year (EUR)	–19.0	82.4	578.2	103.2	124.4	69.5	185.1	87.5	86.7	97.8	20.6	215.5	15.5
Building cost (current value) for convent. farrowing crates per sow place (EUR)	4,330	3,800	1,521	3,526	2,983	1,600	3,871	2,936	4,781	2,150	2,300	2,277	4,320

Source: InterPIG database, 2021

Annex 2: **Main suppliers of pork and poultry meat, and eggs to the EU, 2019-2021**

	2019	2020	2021	2019-2021 average	
	Pork meat* (tonnes cw eq)				
UK	184,359	179,649	110,253	158,087	80.0%
Switzerland	18,695	19,296	19,957	19,316	9.8%
Chile	3,469	2,320	2,302	2,697	1.4%
Norway	4,889	5,426	5,677	5,331	2.7%
Other	9,678	11,602	15,108	12,129	6.1%
Total	221,090	218,293	153,297	197,560	100.0%
	Eggs** (tonnes egg eq)				
UK	33,871	30,414	17,086	27,124	54.7%
Ukraine	12,640	13,479	8,235	11,451	23.1%
USA	4,463	4,667	3,420	4,183	8.4%
Argentina	1,366	1,825	1,940	1,710	3.5%
Other	4,325	5,547	5,361	5,078	10.2%
Total	56,665	55,932	36,042	49,546	100.0%
	Poultry meat*** (tonnes cw eq)				
UK	338,764	293,856	274,248	302,289	35.8%
Brazil	235,521	227,738	251,871	238,377	28.2%
Thailand	172,712	131,374	130,623	144,903	17.2%
Ukraine	133,819	108,669	102,688	115,059	13.6%
Other	52,325	43,077	36,953	44,118	5.2%
Total	933,141	804,714	796,383	844,746	100.0%

* Including fresh and frozen meat, lard, fat, offal, preparations, sausages, salted, dried smoked meat, and live pigs, converted to carcass weight
** Including eggs for consumption and egg products, excluding hatching eggs, converted to eggs
*** Including chicks, fats, fatty livers of ducks and geese, fresh and frozen meat of gallus, turkey, ducks, geese, and other poultry, offal of gallus, turkey, ducks, geese, and other poultry, live poultry, poultry preparations, poultry salted meat in brine, poultry salted livers in brine converted to carcass weight
Source: Eurostat – Comext

Annex 3: **Changes in the pork and poultry meat, and egg balances of the EU-27 against the CAPRI baseline in response to the ban on cages in EU livestock farming, with higher (10%) and lower (2.5%) discount rates**

	Product	Scenarios							
		B1		B2		C1		C2	
		low	high	low	high	low	high	low	high
Supply	Pork meat	–7.6%	–10.3%	–3.3%	–4.7%	–4.5%	–7.5%	–0.4%	–0.7%
	Eggs	–2.0%	–1.9%	–0.9%	–0.8%	–2.0%	–1.9%	–0.5%	–0.5%
	Poultry meat	+0.6%	+0.9%	+0.2%	+0.4%	+0.3%	+0.5%	+0.0%	+0.0%
Domestic market use	Pork meat	–1.8%	–2.6%	–0.8%	–1.2%	–0.9%	–1.6%	–0.1%	–0.2%
	Eggs	–0.6%	–0.6%	–0.3%	–0.2%	–0.6%	–0.6%	–0.2%	–0.2%
	Poultry meat	+0.7%	+1.0%	+0.3%	+0.4%	+0.4%	+0.7%	+0.0%	+0.1%
Imports	Pork meat	+77.5%	+131.7%	+32.4%	+49.9%	+34.4%	+67.9%	+5.6%	+9.9%
	Eggs	+18.7%	+18.0%	+8.5%	+8.2%	+17.1%	+16.6%	+5.0%	+5.0%
	Poultry meat	+0.4%	+0.7%	+0.1%	+0.2%	+0.1%	+0.2%	+0.0%	+0.0%
Exports	Pork meat	–35.2%	–47.6%	–14.9%	–20.7%	–20.8%	–33.6%	–1.7%	–2.9%
	Eggs	–7.5%	–7.3%	–3.3%	–3.2%	–7.1%	–6.9%	–2.0%	–1.9%
	Poultry meat	+0.2%	+0.3%	+0.1%	+0.2%	+0.0%	+0.0%	–0.0%	–0.0%
Net trade	Pork meat	–35.9%	–48.6%	–15.2%	–21.1%	–21.1%	–34.1%	–1.8%	–3.0%
	Eggs	–7.6%	–7.4%	–3.4%	–3.3%	–7.2%	–7.0%	–2.0%	–2.0%
	Poultry meat	+0.2%	+0.2%	+0.1%	+0.2%	–0.0%	+0.0%	–0.0%	–0.0%

Source: own elaboration from the CAPRI model results

Annex 4: **Changes in the pork and poultry meat, and egg balances of the EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming, with higher (10%) discount rate**

	Product	Scenarios							
		B1		B2		C1		C2	
		EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
Supply	Pork meat	–9.7%	–14.3%	–3.2%	–14.4%	–7.1%	–10.4%	+0.0%	–5.9%
	Eggs	–1.4%	–3.6%	–0.2%	–2.8%	–1.4%	–3.5%	–0.1%	–1.9%
	Poultry meat	+0.9%	+0.8%	+0.3%	+0.4%	+0.6%	+0.5%	+0.0%	+0.1%
Domestic market use	Pork meat	–1.9%	–4.6%	–0.7%	–2.5%	–1.2%	–2.9%	–0.1%	–0.6%
	Eggs	–0.5%	–1.2%	–0.1%	–0.7%	–0.4%	–1.1%	–0.1%	–0.4%
	Poultry meat	+0.9%	+1.2%	+0.3%	+0.6%	+0.6%	+0.9%	+0.0%	+0.1%
Imports	Pork meat	+102.9%	+195.7%	+46.2%	+58.1%	+53.3%	+108.8%	+10.1%	+9.5%
	Eggs	+18.6%	+16.7%	+8.5%	+7.4%	+17.2%	+15.2%	+5.3%	+4.3%
	Poultry meat	+0.6%	+1.2%	+0.2%	+0.4%	+0.1%	+1.1%	+0.0%	+0.1%
Exports	Pork meat	–47.0%	–65.0%	–19.8%	–49.7%	–33.1%	–47.9%	–2.3%	–18.9%
	Eggs	–6.9%	–7.9%	–1.6%	–5.6%	–6.6%	–7.4%	–0.8%	–3.8%
	Poultry meat	+0.4%	+0.2%	+0.1%	+0.2%	+0.0%	+0.0%	–0.0%	–0.0%
Net trade	Pork meat	–47.6%	–79.6%	–20.0%	–55.8%	–33.4%	–53.8%	–2.3%	–19.9%
	Eggs	–7.0%	–8.0%	–1.7%	–5.7%	–6.7%	–7.4%	–0.8%	–3.9%
	Poultry meat	+0.2%	+0.2%	+0.1%	+0.2%	–0.0%	+0.0%	–0.0%	–0.0%

Source: own elaboration from the CAPRI model results

Annex 5: **Changes in the pork and poultry meat, and egg balances of the EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming, with lower (2.5%) discount rate**

	Product	Scenarios							
		B1		B2		C1		C2	
		EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
Supply	Pork meat	–7.1%	–10.6%	–2.3%	–9.9%	–4.3%	–6.2%	+0.0%	–3.5%
	Eggs	–1.5%	–3.7%	–0.3%	–2.9%	–1.5%	–3.6%	–0.1%	–2.0%
	Poultry meat	+0.6%	+0.6%	+0.2%	+0.3%	+0.3%	+0.3%	+0.0%	+0.0%
Domestic market use	Pork meat	–1.3%	–3.2%	–0.5%	–1.7%	–0.7%	–1.7%	–0.1%	–0.4%
	Eggs	–0.5%	–1.3%	–0.2%	–0.7%	–0.5%	–1.2%	–0.1%	–0.5%
	Poultry meat	+0.6%	+0.8%	+0.2%	+0.4%	+0.4%	+0.5%	+0.0%	+0.1%
Imports	Pork meat	+64.0%	+107.5%	+30.3%	+37.2%	+28.2%	+51.8%	+5.7%	+5.4%
	Eggs	+19.4%	+17.1%	+8.9%	+7.6%	+17.9%	+15.5%	+5.3%	+4.4%
	Poultry meat	+0.4%	+0.7%	+0.1%	+0.2%	+0.1%	+0.6%	+0.0%	+0.1%
Exports	Pork meat	–34.7%	–51.7%	–14.2%	–37.4%	–20.4%	–30.9%	–1.4%	–11.3%
	Eggs	–7.2%	–8.1%	–1.7%	–5.8%	–6.8%	–7.5%	–0.8%	–3.9%
	Poultry meat	+0.3%	+0.1%	+0.1%	+0.1%	+0.0%	+0.0%	–0.0%	–0.0%
Net trade	Pork meat	–35.1%	–60.6%	–14.3%	–41.5%	–20.6%	–34.0%	–1.4%	–11.9%
	Eggs	–7.3%	–8.1%	–1.8%	–5.8%	–6.9%	–7.6%	–0.8%	–3.9%
	Poultry meat	+0.2%	+0.1%	+0.1%	+0.1%	–0.0%	–0.0%	–0.0%	–0.0%

Source: own elaboration from the CAPRI model results

Annex 6: **Changes in pork and poultry meat, and egg production in individual EU Member States against the CAPRI baseline in response to the ban on cages in EU livestock farming, with different discount rates**

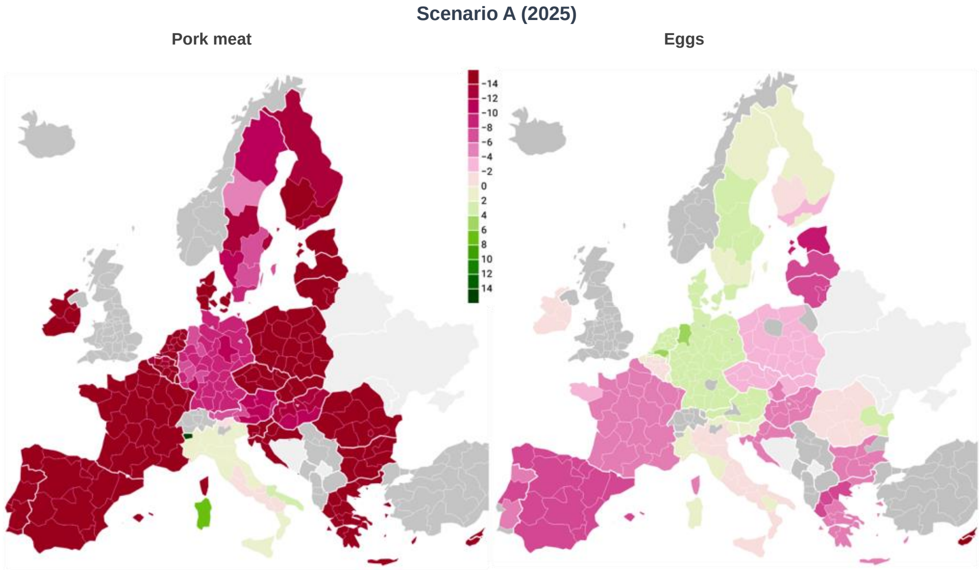
Product		Scenarios												
		A	B1			B2			C1			C2		
		5%	5%	10%	2.5%	5%	10%	2.5%	5%	10%	2.5%	5%	10%	2.5%
AT	Pork meat	–10.3%	–5.1%	–6.2%	–4.6%	–0.9%	–1.1%	–0.9%	–3.3%	–4.4%	–2.7%	+0.1%	+0.2%	+0.1%
	Eggs	+3.7%	+3.6%	+3.6%	+3.6%	+1.1%	+1.1%	+1.1%	+3.2%	+3.2%	+3.2%	+0.6%	+0.6%	+0.6%
	Poultry meat	+2.2%	+0.8%	+1.0%	+0.7%	+0.1%	+0.1%	+0.1%	+0.5%	+0.7%	+0.5%	+0.0%	+0.1%	+0.0%
BE	Pork meat	–13.5%	–5.6%	–6.7%	–5.0%	–1.9%	–2.3%	–1.7%	–3.6%	–4.8%	–3.0%	+0.1%	+0.1%	+0.0%
	Eggs	+0.2%	–1.1%	–1.0%	–1.1%	+1.0%	+1.0%	+1.0%	–1.0%	–1.0%	–1.1%	+0.4%	+0.4%	+0.4%
	Poultry meat	+2.0%	+0.5%	+0.6%	+0.5%	+0.3%	+0.3%	+0.2%	+0.4%	+0.5%	+0.3%	+0.0%	+0.0%	+0.0%
DE	Pork meat	–8.2%	–4.0%	–4.7%	–3.6%	–1.1%	–1.4%	–1.0%	–2.8%	–3.6%	–2.3%	+0.1%	+0.1%	+0.1%
	Eggs	+3.7%	+2.8%	+2.8%	+2.8%	+0.9%	+0.9%	+0.9%	+2.4%	+2.4%	+2.4%	+0.5%	+0.5%	+0.5%
	Poultry meat	+3.1%	+0.9%	+1.1%	+0.8%	+0.0%	+0.0%	+0.0%	+0.5%	+0.7%	+0.5%	+0.0%	+0.0%	+0.0%
DK	Pork meat	–54.9%	–19.1%	–23.8%	–16.9%	–5.9%	–7.4%	–5.3%	–11.8%	–16.3%	–9.6%	–0.1%	–0.1%	–0.1%
	Eggs	+2.4%	+1.9%	+1.9%	+1.9%	+1.2%	+1.2%	+1.2%	+1.5%	+1.6%	+1.5%	+0.6%	+0.6%	+0.6%
	Poultry meat	+2.7%	+0.9%	+1.1%	+0.8%	+0.4%	+0.4%	+0.3%	+0.5%	+0.7%	+0.4%	+0.0%	+0.1%	+0.0%
EL	Pork meat	–58.3%	–22.0%	–26.1%	–20.1%	–10.3%	–11.6%	–9.7%	–14.1%	–19.5%	–11.5%	–2.4%	–3.4%	–1.9%
	Eggs	–6.1%	–6.0%	–6.0%	–6.0%	–3.4%	–3.3%	–3.4%	–5.3%	–5.2%	–5.3%	–0.7%	–0.7%	–0.7%
	Poultry meat	+2.5%	+0.6%	+0.8%	+0.5%	+0.3%	+0.4%	+0.2%	+0.3%	+0.5%	+0.3%	+0.0%	+0.0%	+0.0%
ES	Pork meat	–27.8%	–9.8%	–12.0%	–8.8%	–3.4%	–4.1%	–3.0%	–6.7%	–8.9%	–5.5%	+0.0%	+0.0%	+0.0%
	Eggs	–6.7%	–6.6%	–6.6%	–6.6%	–4.9%	–4.9%	–5.0%	–5.8%	–5.7%	–5.8%	–2.2%	–2.2%	–2.2%
	Poultry meat	+2.1%	+0.4%	+0.6%	+0.4%	+0.1%	+0.2%	+0.1%	+0.2%	+0.4%	+0.2%	+0.0%	+0.0%	–0.1%

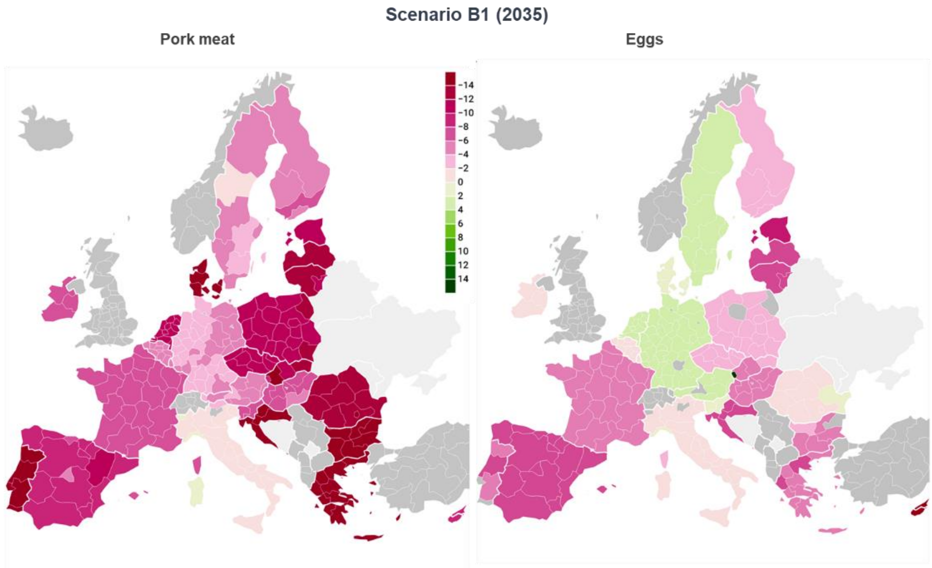
Product		Scenarios												
		A	B1			B2			C1			C2		
		5%	5%	10%	2.5%	5%	10%	2.5%	5%	10%	2.5%	5%	10%	2.5%
FI	Pork meat	−15.8%	−5.7%	−7.0%	−5.1%	−0.9%	−1.1%	−0.8%	−3.8%	−5.1%	−3.1%	+0.1%	+0.1%	+0.1%
	Eggs	−2.0%	−2.9%	−2.8%	−3.0%	−0.2%	−0.2%	−0.3%	−2.7%	−2.6%	−2.8%	+0.5%	+0.5%	+0.5%
	Poultry meat	+2.6%	+0.8%	+1.0%	+0.7%	+0.3%	+0.4%	+0.3%	+0.4%	+0.6%	+0.3%	+0.0%	+0.1%	+0.0%
FR	Pork meat	−19.9%	−6.9%	−8.4%	−6.2%	−2.6%	−3.1%	−2.3%	−4.5%	−6.0%	−3.7%	+0.0%	+0.0%	+0.0%
	Eggs	−4.3%	−5.3%	−5.2%	−5.3%	+1.1%	+1.2%	+1.1%	−5.3%	−5.3%	−5.3%	+0.5%	+0.5%	+0.5%
	Poultry meat	+2.5%	+0.5%	+0.7%	+0.4%	+0.4%	+0.5%	+0.3%	+0.2%	+0.4%	+0.2%	+0.1%	+0.1%	+0.0%
IE	Pork meat	−22.2%	−7.6%	−9.3%	−6.9%	−2.9%	−3.5%	−2.6%	−4.9%	−6.6%	−4.1%	−0.2%	−0.3%	−0.2%
	Eggs	−1.6%	−1.9%	−1.8%	−1.9%	−2.4%	−2.4%	−2.4%	−1.7%	−1.7%	−1.8%	−1.5%	−1.5%	−1.5%
	Poultry meat	+3.1%	+1.0%	+1.2%	+0.8%	+0.4%	+0.5%	+0.4%	+0.5%	+0.7%	+0.4%	+0.0%	+0.0%	+0.0%
IT	Pork meat	+0.2%	−1.6%	−1.7%	−1.6%	−0.6%	−0.7%	−0.5%	−1.5%	−1.8%	−1.2%	+0.0%	+0.0%	+0.0%
	Eggs	−0.2%	−0.4%	−0.4%	−0.5%	+1.2%	+1.2%	+1.2%	−0.5%	−0.5%	−0.5%	+0.6%	+0.6%	+0.6%
	Poultry meat	+2.3%	+0.7%	+0.9%	+0.6%	+0.4%	+0.5%	+0.3%	+0.4%	+0.6%	+0.3%	+0.1%	+0.1%	+0.1%
LU	Pork meat	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Eggs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Poultry meat	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
NL	Pork meat	−32.7%	−10.5%	−12.9%	−9.4%	−3.6%	−4.4%	−3.2%	−6.7%	−8.9%	−5.5%	+0.0%	+0.0%	+0.0%
	Eggs	+3.4%	+2.4%	+2.5%	+2.4%	+1.3%	+1.3%	+1.3%	+2.0%	+2.1%	+2.0%	+0.5%	+0.6%	+0.5%
	Poultry meat	+3.0%	+1.0%	+1.2%	+0.9%	+0.5%	+0.6%	+0.4%	+0.7%	+0.9%	+0.6%	+0.1%	+0.1%	+0.1%
PT	Pork meat	−54.4%	−17.3%	−21.5%	−15.4%	−6.1%	−7.6%	−5.4%	−11.3%	−15.4%	−9.3%	−0.1%	−0.1%	−0.1%
	Eggs	−6.2%	−6.3%	−6.3%	−6.4%	−6.7%	−6.7%	−6.8%	−5.5%	−5.5%	−5.5%	−4.7%	−4.7%	−4.7%
	Poultry meat	+2.9%	+0.8%	+1.0%	+0.7%	+0.3%	+0.4%	+0.2%	+0.4%	+0.6%	+0.3%	+0.0%	+0.0%	+0.0%
SE	Pork meat	−9.3%	−4.4%	−5.2%	−4.0%	−1.2%	−1.4%	−1.1%	−3.0%	−4.0%	−2.5%	+0.1%	+0.2%	+0.1%
	Eggs	+2.4%	+2.9%	+2.9%	+3.0%	+1.1%	+1.1%	+1.1%	+2.7%	+2.7%	+2.7%	+0.6%	+0.6%	+0.6%
	Poultry meat	+1.4%	+0.6%	+0.7%	+0.5%	+0.3%	+0.3%	+0.2%	+0.5%	+0.5%	+0.4%	+0.1%	+0.1%	+0.1%
BG	Pork meat	−74.5%	−22.1%	−27.5%	−19.6%	−19.2%	−24.4%	−16.7%	−13.4%	−18.3%	−10.7%	−6.7%	−9.4%	−5.6%
	Eggs	−4.5%	−4.6%	−4.5%	−4.6%	−4.4%	−4.3%	−4.4%	−4.3%	−4.2%	−4.3%	−3.9%	−3.8%	−3.9%
	Poultry meat	+2.3%	+0.7%	+0.9%	+0.6%	+0.4%	+0.5%	+0.3%	+0.3%	+0.5%	+0.2%	−0.1%	+0.0%	−0.1%
CY	Pork meat	−30.3%	−9.9%	−11.9%	−9.0%	−10.1%	−12.7%	−8.8%	−7.0%	−9.1%	−5.6%	−4.0%	−5.5%	−3.4%
	Eggs	−16.4%	−17.6%	−17.4%	−17.7%	−2.8%	−2.7%	−2.9%	−15.4%	−15.2%	−15.4%	−25.7%	−25.6%	−25.7%
	Poultry meat	+5.1%	+1.1%	+1.6%	+0.9%	+0.9%	+1.2%	+0.8%	+0.4%	+0.8%	+0.2%	−0.5%	−0.4%	−0.5%
CZ	Pork meat	−34.9%	−10.9%	−13.2%	−9.8%	−10.8%	−13.6%	−9.3%	−7.0%	−9.3%	−5.6%	−4.0%	−5.5%	−3.3%
	Eggs	−3.1%	−3.8%	−3.7%	−3.8%	+2.1%	+2.2%	+2.1%	−3.4%	−3.3%	−3.4%	+1.2%	+1.2%	+1.2%
	Poultry meat	+2.9%	+0.8%	+1.0%	+0.7%	+0.5%	+0.7%	+0.5%	+0.4%	+0.6%	+0.3%	+0.1%	+0.2%	+0.1%
EE	Pork meat	−36.0%	−11.3%	−13.7%	−10.2%	−11.0%	−13.9%	−9.5%	−7.6%	−10.2%	−6.0%	−4.2%	−5.8%	−3.5%
	Eggs	−9.9%	−10.0%	−10.0%	−10.0%	−9.4%	−9.3%	−9.4%	−9.2%	−9.2%	−9.2%	−8.3%	−8.3%	−8.3%
	Poultry meat	+2.1%	+0.5%	+0.6%	+0.4%	+0.1%	+0.2%	+0.1%	+0.3%	+0.4%	+0.2%	−0.1%	+0.0%	−0.1%
HR	Pork meat	−55.8%	−19.3%	−22.8%	−17.7%	−17.0%	−21.6%	−14.7%	−13.7%	−17.2%	−10.8%	−5.2%	−7.3%	−4.3%
	Eggs	−4.3%	−6.2%	−6.1%	−6.3%	−2.1%	−2.0%	−2.1%	−5.9%	−5.8%	−6.0%	+0.8%	+0.8%	+0.8%
	Poultry meat	+2.4%	+0.4%	+0.5%	+0.3%	+0.3%	+0.4%	+0.2%	+0.3%	+0.4%	+0.2%	+0.1%	+0.1%	+0.1%
HU	Pork meat	−12.2%	−6.6%	−7.4%	−5.9%	−7.5%	−9.5%	−6.5%	−4.4%	−5.9%	−3.4%	−3.2%	−4.6%	−2.7%
	Eggs	−4.4%	−5.0%	−4.9%	−5.0%	−6.2%	−6.2%	−6.2%	−4.5%	−4.5%	−4.6%	−6.2%	−6.1%	−6.2%
	Poultry meat	+2.6%	+0.7%	+0.9%	+0.6%	+0.3%	+0.4%	+0.3%	+0.4%	+0.5%	+0.3%	+0.0%	+0.0%	+0.0%

Product		Scenarios												
		A	B1			B2			C1			C2		
		5%	5%	10%	2.5%	5%	10%	2.5%	5%	10%	2.5%	5%	10%	2.5%
LT	Pork meat	–27.0%	–10.2%	–11.9%	–9.4%	–9.5%	–12.0%	–8.2%	–6.8%	–9.3%	–5.4%	–3.3%	–4.6%	–2.8%
	Eggs	–7.5%	–7.8%	–7.8%	–7.8%	–6.4%	–6.4%	–6.4%	–7.3%	–7.3%	–7.3%	–4.4%	–4.4%	–4.4%
	Poultry meat	+2.0%	+0.5%	+0.6%	+0.4%	+0.2%	+0.3%	+0.2%	+0.3%	+0.4%	+0.2%	+0.0%	+0.0%	+0.0%
LV	Pork meat	–41.2%	–12.3%	–15.0%	–11.0%	–11.7%	–14.7%	–10.1%	–8.2%	–10.9%	–6.5%	–4.4%	–6.0%	–3.6%
	Eggs	–6.6%	–7.0%	–7.0%	–7.0%	–7.0%	–6.9%	–7.0%	–6.6%	–6.5%	–6.6%	–5.3%	–5.3%	–5.3%
	Poultry meat	+2.0%	+0.5%	+0.6%	+0.4%	+0.1%	+0.2%	+0.1%	+0.3%	+0.4%	+0.2%	–0.1%	+0.0%	–0.1%
MT	Pork meat	–26.6%	–8.8%	–10.6%	–8.0%	–9.2%	–11.5%	–7.9%	–6.3%	–8.3%	–5.0%	–3.7%	–5.0%	–3.0%
	Eggs	–25.3%	–26.1%	–25.9%	–26.2%	–27.6%	–27.5%	–27.7%	–22.7%	–22.6%	–22.8%	–24.7%	–24.7%	–24.7%
	Poultry meat	+2.7%	–2.0%	–1.6%	–2.2%	–2.7%	–2.4%	–2.8%	–3.2%	–2.9%	–3.3%	–4.0%	–4.0%	–4.1%
PL	Pork meat	–40.0%	–12.0%	–14.6%	–10.7%	–11.5%	–14.5%	–10.0%	–7.8%	–10.5%	–6.2%	–4.3%	–6.0%	–3.6%
	Eggs	–3.2%	–3.8%	–3.7%	–3.8%	–3.7%	–3.7%	–3.7%	–3.5%	–3.5%	–3.5%	–2.9%	–2.9%	–2.9%
	Poultry meat	+2.5%	+0.6%	+0.8%	+0.5%	+0.3%	+0.4%	+0.2%	+0.4%	+0.5%	+0.3%	+0.0%	+0.1%	+0.0%
RO	Pork meat	–41.0%	–12.8%	–15.8%	–11.4%	–12.2%	–15.4%	–10.6%	–8.5%	–11.6%	–6.7%	–4.6%	–6.4%	–3.8%
	Eggs	–0.2%	–1.1%	–1.0%	–1.2%	–1.7%	–1.6%	–1.8%	–1.3%	–1.3%	–1.3%	+1.2%	+1.2%	+1.2%
	Poultry meat	+2.9%	+0.9%	+1.1%	+0.8%	+0.5%	+0.7%	+0.4%	+0.4%	+0.5%	+0.3%	+0.1%	+0.2%	+0.1%
SK	Pork meat	–39.3%	–13.3%	–15.9%	–11.8%	–12.7%	–16.1%	–11.1%	–8.5%	–11.7%	–6.7%	–5.0%	–7.0%	–4.1%
	Eggs	–4.1%	–3.4%	–3.0%	–3.6%	+3.1%	+3.5%	+2.9%	–3.6%	–3.1%	–3.7%	+1.6%	+2.0%	+1.5%
	Poultry meat	+2.2%	+1.5%	+1.9%	+1.3%	+1.2%	+1.5%	+1.1%	+1.0%	+1.5%	+0.8%	+0.5%	+0.7%	+0.4%
SL	Pork meat	–19.6%	–7.0%	–8.4%	–6.4%	–7.9%	–9.9%	–6.8%	–5.2%	–6.8%	–4.1%	–3.3%	–4.5%	–2.7%
	Eggs	+1.6%	+0.9%	+1.0%	+0.9%	+2.1%	+2.1%	+2.1%	+0.7%	+0.8%	+0.7%	+1.2%	+1.2%	+1.2%
	Poultry meat	+3.0%	+0.9%	+1.1%	+0.8%	+0.5%	+0.7%	+0.5%	+0.5%	+0.6%	+0.4%	+0.1%	+0.1%	+0.1%

Source: own elaboration from the CAPRI model results

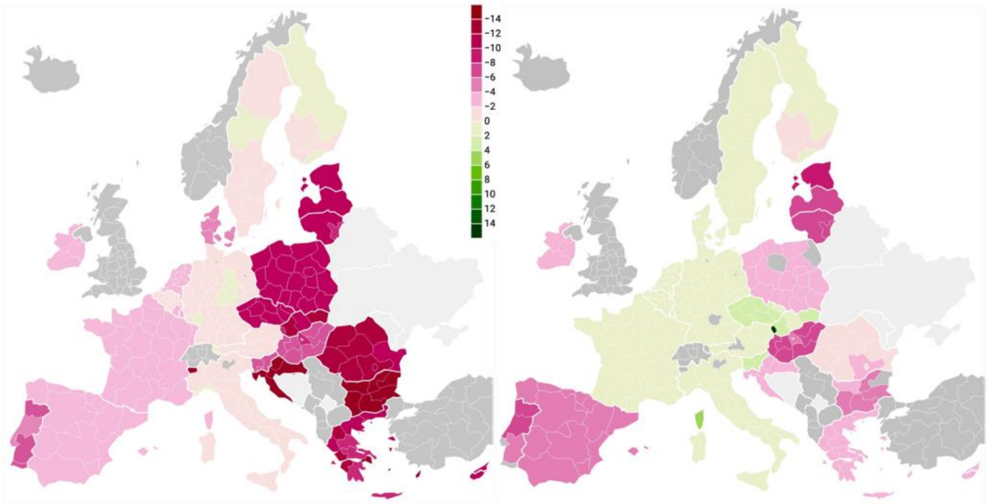
Annex 7: **Changes in pork meat and egg production at the NUTS-2 level of individual EU Member States against the CAPRI baseline in response to the ban on cages in EU livestock farming, with 5% discount rate**





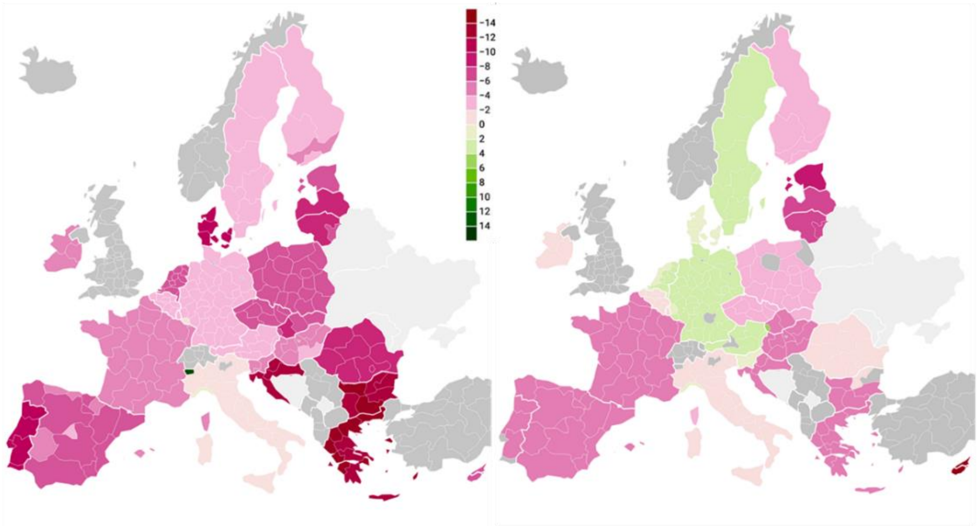
Scenario B2 (2035)

Pork meat **Eggs**



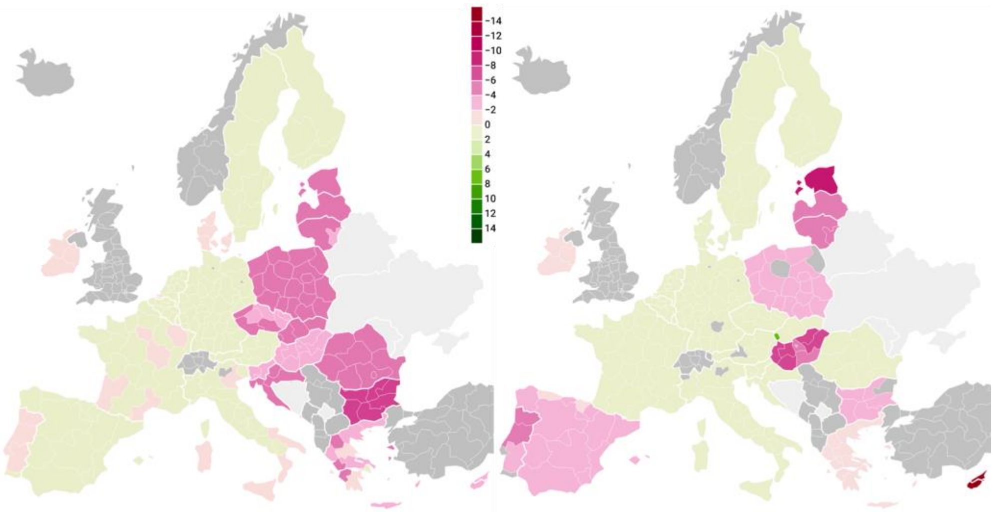
Scenario C1 (2045)

Pork meat **Eggs**



Scenario C2 (2045)

Pork meat **Eggs**



Source: own elaboration from the CAPRI model results

Annex 8: **Changes in pork and poultry meat, and egg prices in the EU-27 against the CAPRI baseline in response to the ban on cages in EU livestock farming, with higher (10%) and lower (2.5%) discount rates**

	Product	Scenarios							
		B1		B2		C1		C2	
		low	high	low	high	low	high	low	high
Consumer price	Pork meat	+2.8%	+4.1%	+1.1%	+1.6%	+1.5%	+2.7%	+0.2%	+0.3%
	Eggs	+1.5%	+1.4%	+0.6%	+0.6%	+1.3%	+1.3%	+0.3%	+0.3%
	Poultry meat	+0.1%	+0.2%	+0.0%	+0.1%	+0.1%	+0.2%	+0.0%	+0.0%
Producer price	Pork meat	+9.6%	+14.2%	+3.8%	+5.5%	+5.1%	+8.8%	+0.5%	+0.8%
	Eggs	+3.9%	+3.8%	+1.4%	+1.4%	+3.5%	+3.5%	+0.8%	+0.8%
	Poultry meat	+0.3%	+0.5%	+0.1%	+0.2%	+0.3%	+0.4%	+0.0%	+0.0%

Source: own elaboration from the CAPRI model results

Annex 9: **Changes in pork and poultry meat, and egg prices in the EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming, with higher (10%) discount rate**

	Product	Scenarios							
		B1		B2		C1		C2	
		EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
Consumer price	Pork meat	+3.7%	+5.4%	+1.3%	+2.5%	+2.4%	+3.8%	+0.2%	+0.5%
	Eggs	+1.3%	+2.2%	+0.5%	+1.2%	+1.2%	+2.1%	+0.3%	+0.8%
	Poultry meat	+0.2%	+0.1%	+0.1%	+0.0%	+0.2%	+0.1%	+0.0%	+0.0%
Producer price	Pork meat	+13.8%	+16.4%	+5.0%	+8.5%	+8.5%	+10.3%	+0.6%	+2.1%
	Eggs	+3.7%	+4.3%	+1.3%	+2.2%	+3.4%	+4.0%	+0.7%	+1.5%
	Poultry meat	+0.4%	+0.5%	+0.2%	+0.2%	+0.4%	+0.4%	+0.0%	+0.0%

Source: own elaboration from the CAPRI model results

Annex 10: **Changes in pork and poultry meat, and egg prices in the EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming, with lower (2.5%) discount rate**

	Product	Scenarios							
		B1		B2		C1		C2	
		EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
Consumer price	Pork meat	+2.5%	+3.7%	+0.9%	+1.7%	+1.4%	+2.2%	+0.1%	+0.3%
	Eggs	+1.3%	+2.2%	+0.5%	+1.2%	+1.2%	+2.1%	+0.3%	+0.8%
	Poultry meat	+0.1%	+0.1%	+0.1%	+0.0%	+0.1%	+0.1%	+0.0%	+0.0%
Producer price	Pork meat	+9.4%	+11.3%	+3.5%	+5.8%	+4.9%	+5.9%	+0.4%	+1.2%
	Eggs	+3.8%	+4.3%	+1.3%	+2.2%	+3.5%	+4.0%	+0.7%	+1.5%
	Poultry meat	+0.3%	+0.4%	+0.1%	+0.1%	+0.3%	+0.3%	+0.0%	+0.0%

Source: own elaboration from the CAPRI model results

Annex 11: **Changes in the profits of pork and poultry meat, and egg production in the EU-27 against the CAPRI baseline in response to the ban on cages in EU livestock farming, with higher (10%) and lower (2.5%) discount rates**

Sector	Scenarios							
	B1		B2		C1		C2	
	low	high	low	high	low	high	low	high
Pork meat	–26.3%	–31.2%	–12.9%	–16.5%	–12.0%	–18.4%	–1.3%	–2.0%
Eggs	–2.1%	–2.0%	–1.5%	–1.4%	–1.8%	–1.6%	–0.7%	–0.7%
Poultry meat	+3.9%	+5.5%	+1.8%	+2.5%	+1.3%	+2.3%	+0.1%	+0.3%

Source: own elaboration from the CAPRI model results

Annex 12: **Changes in the profits of pork and poultry meat, and egg production in the EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming, with higher (10%) discount rate**

Sector	Scenarios							
	B1		B2		C1		C2	
	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
Pork meat	–30.1%	–36.4%	–11.8%	–39.4%	–17.7%	–23.3%	+0.2%	–16.4%
Eggs	–0.9%	–4.1%	+0.0%	–4.3%	–0.8%	–3.4%	+0.1%	–2.3%
Poultry meat	+6.7%	+4.1%	+2.8%	+2.2%	+2.5%	+2.0%	+0.2%	+0.3%

Source: own elaboration from the CAPRI model results

Annex 13: **Changes in the profits of pork and poultry meat, and egg production in the EU-14 and EU-13 against the CAPRI baseline in response to the ban on cages in EU livestock farming, with lower (2.5%) discount rate**

Sector	Scenarios							
	B1		B2		C1		C2	
	EU–14	EU–13	EU–14	EU–13	EU–14	EU–13	EU–14	EU–13
Pork meat	–25.6%	–29.3%	–9.2%	–30.6%	–11.5%	–15.3%	+0.1%	–9.7%
Eggs	–1.1%	–4.2%	–0.1%	–4.5%	–0.9%	–3.5%	+0.1%	–2.3%
Poultry meat	+4.6%	+2.9%	+2.0%	+1.5%	+1.5%	+1.2%	+0.1%	+0.2%

Source: own elaboration from the CAPRI model results

Annex 14: **Changes in selected macroeconomic indicators for the EU-27 against the CAPRI baseline in response to the ban on cages in EU livestock farming, with higher (10%) and lower (2.5%) discount rates**

Indicator	Scenarios							
	B1		B2		C1		C2	
	low	high	low	high	low	high	low	high
Agricultural income	–1.4%	–1.7%	–0.7%	–0.9%	–1.0%	–1.5%	–0.1%	–0.2%
EAA output	+1.3%	+1.8%	+0.5%	+0.7%	+0.8%	+1.3%	+0.1%	+0.1%
Output crops	–0.2%	–0.3%	–0.1%	–0.2%	–0.1%	–0.2%	+0.0%	–0.0%
Output animals	+2.9%	+4.0%	+1.1%	+1.5%	+1.7%	+2.7%	+0.2%	+0.2%
EAA input	+3.4%	+4.5%	+1.5%	+1.9%	+2.7%	+4.3%	+0.3%	+0.4%
Crop-specific input	–0.2%	–0.3%	–0.1%	–0.2%	–0.1%	–0.2%	+0.0%	–0.0%
Animal-specific input	+4.2%	+5.7%	+1.7%	+2.3%	+3.6%	+5.5%	+0.3%	+0.5%
Other input	+6.0%	+7.7%	+2.6%	+3.5%	+4.6%	+7.2%	+0.5%	+0.7%
Tariff revenues	+1.4%	+2.0%	+1.0%	+1.4%	+0.9%	+1.5%	+0.3%	+0.5%
Consumer purchasing power	–0.0%	–0.0%	–0.0%	–0.0%	–0.0%	–0.0%	+0.0%	+0.0%
Taxpayers' total cost	–0.0%	–0.0%	–0.0%	–0.0%	–0.0%	–0.0%	+0.0%	+0.0%

Source: own elaboration from the CAPRI model results

Annex 15: **Changes in selected environmental indicators for the EU-27 agricultural sector against the CAPRI baseline in response to the ban on cages in EU livestock farming, with higher (10%) and lower (2.5%) discount rates**

Indicator	Scenarios							
	B1		B2		C1		C2	
	low	high	low	high	low	high	low	high
GHG emissions from agriculture (in 1000t)	+0.1%	+0.1%	+0.1%	+0.0%	+0.1%	+0.1%	+0.1%	+0.1%
Ammonium output	–1.8%	–2.4%	–0.9%	–1.3%	–1.0%	–1.8%	–0.2%	–0.3%
CH4 total emissions	–0.5%	–0.7%	–0.2%	–0.3%	–0.3%	–0.5%	–0.0%	–0.0%
N2O total emissions	–0.7%	–1.0%	–0.3%	–0.5%	–0.4%	–0.7%	–0.0%	–0.1%
N2O emissions from manure management	–2.1%	–2.9%	–1.0%	–1.4%	–1.3%	–2.1%	–0.2%	–0.3%
N2O emissions from manure application	–2.8%	–3.8%	–1.2%	–1.7%	–1.6%	–2.7%	–0.2%	–0.3%
N surplus total (kg/ha)	–1.1%	–1.6%	–0.5%	–0.8%	–0.7%	–1.1%	–0.1%	–0.1%
N surplus at soil level (kg/ha)	–0.9%	–1.3%	–0.4%	–0.6%	–0.6%	–1.0%	–0.0%	–0.1%
Gaseous N-losses from manure (kg/ha)	–2.1%	–2.8%	–1.1%	–1.5%	–1.2%	–2.1%	–0.2%	–0.3%
N run-off from manure (kg/ha)	–1.8%	–2.4%	–0.9%	–1.3%	–1.1%	–1.7%	–0.2%	–0.3%
N input with manure (kg/ha)	–1.7%	–2.4%	–0.8%	–1.1%	–1.0%	–1.7%	–0.1%	–0.2%
P2O5 surplus total (kg/ha)	–0.8%	–1.1%	–0.4%	–0.6%	–0.5%	–0.8%	–0.0%	–0.0%
P2O5 input with manure (kg/ha)	–1.1%	–1.6%	–0.6%	–0.8%	–0.7%	–1.1%	–0.1%	–0.2%

Source: own elaboration from the CAPRI model results

Annex 16: **Changes in selected environmental indicators for the EU-14 and EU-13 agricultural sectors against the CAPRI baseline in response to the ban on cages in EU livestock farming, with higher (10%) discount rate**

Indicator	Scenarios							
	B1		B2		C1		C2	
	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
N surplus total (kg/ha)	–1.6%	–1.3%	–0.6%	–1.3%	–1.2%	–1.0%	+0.0%	–0.5%
N surplus at soil level (kg/ha)	–1.4%	–0.9%	–0.5%	–0.9%	–1.1%	–0.7%	+0.0%	–0.3%
Gaseous N-losses from manure (kg/ha)	–2.6%	–3.7%	–0.9%	–3.7%	–1.9%	–2.7%	–0.0%	–1.5%
N run-off from manure (kg/ha)	–2.4%	–2.3%	–0.8%	–2.4%	–1.7%	–1.8%	+0.0%	–1.0%
N input with manure (kg/ha)	–2.3%	–2.8%	–0.7%	–2.8%	–1.6%	–2.0%	+0.0%	–1.2%
P2O5 surplus total (kg/ha)	–1.1%	+1.0%	–0.6%	+0.5%	–0.8%	–0.2%	+0.0%	–1.6%
P2O5 input with manure (kg/ha)	–1.5%	–1.9%	–0.5%	–2.0%	–1.1%	–1.3%	+0.0%	–0.9%

Source: own elaboration from the CAPRI model results

Annex 17: **Changes in selected environmental indicators for the EU-14 and EU-13 agricultural sectors against the CAPRI baseline in response to the ban on cages in EU livestock farming, with lower (2.5%) discount rate**

Indicator	Scenarios							
	B1		B2		C1		C2	
	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13	EU-14	EU-13
N surplus total (kg/ha)	–1.2%	–1.0%	–0.4%	–0.9%	–0.7%	–0.6%	+0.0%	–0.3%
N surplus at soil level (kg/ha)	–1.0%	–0.7%	–0.4%	–0.6%	–0.6%	–0.4%	+0.0%	–0.2%
Gaseous N-losses from manure (kg/ha)	–1.9%	–2.8%	–0.7%	–2.6%	–1.1%	–1.7%	–0.0%	–0.9%
N run-off from manure (kg/ha)	–1.7%	–1.9%	–0.6%	–1.7%	–1.0%	–1.1%	+0.0%	–0.6%
N input with manure (kg/ha)	–1.6%	–2.1%	–0.5%	–2.0%	–1.0%	–1.3%	+0.0%	–0.7%
P2O5 surplus total (kg/ha)	–0.8%	+0.6%	–0.4%	+0.2%	–0.5%	–0.8%	+0.0%	–1.4%
P2O5 input with manure (kg/ha)	–1.1%	–1.5%	–0.4%	–1.4%	–0.6%	–0.8%	+0.0%	–0.5%

Source: own elaboration from the CAPRI model results

Annex 18: **Changes in the agricultural global warming potential (GWP) of the EU pork and poultry meat, and egg sectors in CO_2 equivalents (net emissions), in comparison with changes in the net production volumes against the CAPRI baseline in response to the ban on cages in EU livestock farming, with higher (10%) and lower (2.5%) discount rates**

Product		Scenarios							
		B1		B2		C1		C2	
		low	high	low	high	low	high	low	high
GWP	Pork meat	–7.0%	–9.7%	–3.1%	–4.4%	–4.1%	–7.0%	–0.4%	–0.6%
	Eggs	–1.4%	–1.4%	–0.7%	–0.7%	–1.3%	–1.3%	–0.4%	–0.4%
	Poultry meat	+0.6%	+0.9%	+0.2%	+0.4%	+0.3%	+0.6%	+0.0%	+0.1%
Production	Pork meat	–7.7%	–10.6%	–3.3%	–4.6%	–4.6%	–7.5%	–0.4%	–0.7%
	Eggs	–2.0%	–2.0%	–0.9%	–0.9%	–2.0%	–1.9%	–0.5%	–0.5%
	Poultry meat	+0.6%	+0.9%	+0.2%	+0.4%	+0.3%	+0.6%	+0.0%	+0.1%

Source: own elaboration from the CAPRI model results

Annex 19: **Changes in the agricultural global warming potential (GWP) of the non-EU and global pork and poultry meat, and egg sectors in CO_2 equivalents (net emissions), in comparison with changes in the net production volumes against the CAPRI baseline in response to the ban on cages in EU livestock farming, with higher (10%) discount rate**

Product		Scenarios							
		B1		B2		C1		C2	
		non-EU	World	non-EU	World	non-EU	World	non-EU	World
GWP	Pork meat	+2.0%	–0.2%	+0.9%	–0.2%	+1.3%	–0.2%	+0.1%	–0.0%
	Eggs	+0.1%	–0.1%	+0.0%	–0.0%	+0.1%	–0.0%	+0.0%	+0.0%
	Poultry meat	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%
Production	Pork meat	+1.8%	–0.5%	+0.8%	–0.2%	+1.3%	–0.4%	+0.1%	–0.1%
	Eggs	+0.0%	–0.1%	+0.0%	–0.1%	+0.1%	–0.1%	+0.0%	–0.0%
	Poultry meat	+0.0%	+0.1%	+0.0%	+0.0%	+0.0%	+0.1%	+0.0%	+0.0%

Source: own elaboration from the CAPRI model results

Annex 20: **Changes in the agricultural global warming potential (GWP) of the non-EU and global pork and poultry meat, and egg sectors in CO_2 equivalents (net emissions), in comparison with changes in the net production volumes against the CAPRI baseline in response to the ban on cages in EU livestock farming, with lower (2.5%) discount rate**

Product		Scenarios							
		B1		B2		C1		C2	
		non-EU	World	non-EU	World	non-EU	World	non-EU	World
GWP	Pork meat	+1.5%	–0.2%	+0.6%	–0.1%	+0.8%	–0.1%	+0.1%	–0.0%
	Eggs	+0.1%	–0.1%	+0.1%	–0.0%	+0.1%	–0.0%	+0.0%	+0.0%
	Poultry meat	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%
Production	Pork meat	+1.3%	–0.4%	+0.6%	–0.2%	+0.8%	–0.2%	+0.1%	–0.0%
	Eggs	+0.1%	–0.1%	+0.0%	–0.0%	+0.1%	–0.1%	+0.0%	–0.0%
	Poultry meat	+0.0%	+0.1%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%	+0.0%

Source: own elaboration from the CAPRI model results