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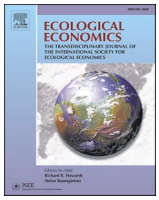

Are German farmers ready for a 'warm restructuring' of the pig sector?

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ABSTRACT

Recent statutory changes have increased the pressure on the German livestock sector to adapt. This paper aims to ascertain the factors affecting German pig farmers' willingness to join a pig farming exit scheme similar to the Dutch 'warm restructuring' programme. The analysis is based on a discrete choice experiment with 346 pig farmers. The results indicate great interest of the respondents in a government-run decommissioning scheme. Differences in the perception of scheme attributes (compensation offered, demolition requirements, restrictions on future barn construction and slurry intake) are highlighted by the results of a latent-class estimation.

1. Introduction

Recent changes in the legislative framework regulating animal welfare and the environmental impacts of livestock farming in Germany have increased the pressure on the sector to adapt. In particular, the 2020 amendment of the German Fertiliser Ordinance (*Düngeverordnung*) and the latest revision of the Livestock Husbandry Ordinance (*Tierschutz-Nutztierhaltungsverordnung*) present considerable challenges for pig farmers. The new legal requirements make costly adjustments necessary, especially for smaller farms, and these extra costs cannot be recouped in a meat sector characterised by cost leadership (WBAE (Wissenschaftlicher Beirat für Agrarpolitik beim Ministerium für Ernährung und Landwirtschaft - Scientific Advisory Council on Agricultural Policy to the Federal Ministry on Food and Agriculture), 2015).

One option for the government to help the farmers who are not able or not willing to fulfil the new legislative framework is the state-subsidised decommissioning of pig farming facilities. The Dutch concept of 'warm restructuring' ('*warme sanering*') is an example of this policy (Wissenschaftliche Dienste des Deutschen Bundestages Scientific Services of the German Bundestag, 2019). The Dutch programme aimed to lower environmentally harmful nitrogen emissions (e.g., groundwater pollution, eutrophication, acidification and air pollution) by demolishing barns and to tackle the country's so-called nitrogen crisis. In the future, buy-outs from pig production will continue in areas with high stocking rates, and from now on livestock farmers with dairy, poultry or pigs located near special areas of conservation (SAC) can also offer their barns for decommissioning (Government of The Netherlands, 2020a). Buy-out programmes may help achieve lower environmental pollution due to intensive pig production and at the same time ensure that farmers can leave pig production 'responsibly'. Otherwise, the changes in legislation can result in barns becoming unusable and drive many farmers out of the market. This may be seen to be in contrast to the aspirations to keep small and medium-sized farms in business.

The present paper aims to establish whether German pig farmers would be interested in an exit scheme if it was available in Germany. It examines how the design of a potential state-run exit scheme would affect pig farmers' willingness to participate. Specifically, we wish to establish how farmers would respond to the requirement to demolish existing pig barns, how they assess bans on re-investing in the pig enterprise or limitations on future slurry intake from other farms. Furthermore, we investigate how pig farmers would respond to softer versions of these requirements, e.g. limiting re-investments to barns with enhanced animal welfare.

To this end, we conducted an online survey with 346 German pig farmers in the summer of 2020. The respondents were asked in a discrete choice experiment to choose among alternative exit schemes and the option not to participate. The data were analysed using a mixed logit and a latent class model (LC).

Discrete choice experiments (DCE) have been widely applied to elicit stakeholders' preferences for the design of contracts in agriculture. In the field of livestock production, DCEs have been used to analyse contracts for a more animal or environmentally friendly production (e.g., Danne and Musshoff, 2017; Latacz-Lohmann and Schreiner, 2019) and the production of GMO-free milk (Schreiner and Latacz-Lohmann, 2015). We wish to demonstrate that DCE can yield valuable information for the effective design of a pig exit scheme before its launch.

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Besides assessing how the design of such a scheme affects farmers' willingness to participate, the LC model revealed preference heterogeneity among decision-makers in making choices. This information may be useful to enhance farmers' participation by identifying farmers who would lend themselves to being a suitable target group for the 'warm restructuring' of German pig farming. Meanwhile, the Green Party in Lower Saxony has launched a legislative proposal to introduce an exit scheme similar to the Dutch 'warm restructuring' programme (State Parliament of Lower Saxony, 2021). The results are also relevant for Belgium, where the launch of a similar programme is being considered (Vilt, 2022) and even for the Netherlands, where the buy-out programme continues.

The next section outlines recent developments in the German pig farming sector and explains the concept of 'warm restructuring'. Section 3 describes the methodology, the design of the questionnaire, the conduct of the survey and possible reasons behind decisions to exit livestock farming. Section 4 presents the results. The final Section 5 critically discusses the findings, places them in the existing literature, draws conclusions for the effective design of a potential pig farming exit scheme in Germany and highlights issues for future research.

2. Structural change in pig farming and the Dutch 'warm restructuring' scheme

In 2019 Germany was among the world's largest exporters of pig meat (Rohlmann et al., 2020). However, intense price competition in international markets has necessitated cost leadership in the production of bulk commodities. German pig farms have responded to this challenge by growing in size (Efken et al., 2015), and a distinct structural change has become evident (WBAE (Wissenschaftlicher Beirat für Agrarpolitik beim Ministerium für Ernährung und Landwirtschaft - Scientific Advisory Council on Agricultural Policy to the Federal Ministry on Food and Agriculture), 2015; Windhorst and Bäurle, 2011). The number of farms has plummeted since farmers with small sow herds in particular decided to cease production. The number of pig fattening farms fell by 20% between 2014 and 2019, in the same period 27% of piglet producers ceased operating (Rohlmann et al., 2020). However, fattening pigs' numbers have only been declining by 6% during the same period (Windhorst and Bäurle, 2011; Rohlmann et al., 2020).

Structural change was accompanied by a massive concentration of pig production in the western part of Lower Saxony and the northern part of North Rhine-Westphalia (Rohlmann et al., 2020). This has led to a range of environmental and societal issues and, consequently, society's acceptance of livestock farming has plummeted in the last few decades (Christoph-Schulz et al., 2018). The political response has been to tighten the regulatory framework for more sustainable livestock farming, for example by banning non-curative interventions, tightening the rules for spreading animal manure, and imposing stricter animal welfare standards through yet another amendment to the Livestock Farming Ordinance.

Pig farming in the Netherlands has also been undergoing continuous structural change, particularly between 2006 and 2011. After a slight initial drop in stocking rates, herds were restocked and peaked in 2015 (Hoste, 2017), but pig populations have been falling ever since (Statista, 2020). As in Germany, Dutch citizens are demanding higher animal welfare standards, protection of animal health, reduction in odour nuisance, particulates and pollution, and greater transparency (Wissenschaftliche Dienste des Deutschen Bundestages Scientific Services of the German Bundestag, 2019). To ensure farmers are not needlessly hard hit, the Dutch government provided subsidies within the scope of its so-called 'warm restructuring of pig farming' ('*warme sanering varkenshouderij*') (Wissenschaftliche Dienste des Deutschen Bundestages Scientific Services of the German Bundestag, 2019).

In addition to providing support for structural adjustments, as also intended by the German Ministry of Food and Agriculture (BMEL German Federal Ministry of Food and Agriculture, 2020), the Netherlands provide government support for the closure of a farm's pig production enterprise (Government of The Netherlands, 2020b, 2020c). The Dutch exit scheme is designed to allow farms to cease pig production efficiently and responsibly (Government of The Netherlands, 2020c). It is particularly addressed at farms in provinces with high stocking rates (Noord-Brabant, Limburg, Gelderland, Overijssel and Utrecht) and includes a buyout of some of the production quotas which were introduced in 1998. Participation in the scheme involves the demolition of decommissioned pig barns and a ban on future pig farming in the same location (Government of The Netherlands, 2020b, 2020c). In return, farms receive individual market-based compensation for their production quotas and the capital loss of their barns (Colenbrander, 2018). To be allowed to participate farms needed to be located close to residential homes, had to comply with the decisions on low-emission housing and were not allowed to have participated in other action plans to reduce ammonia emissions (Wissenschaftliche Dienste des Deutschen Bundestages Scientific Services of the German Bundestag, 2019). As stocking rates are still high, the programme continues until 2035, and from now on dairy, pig and poultry farmers can apply for participation if they are located close to SACs (Government of The Netherlands, 2020a).

The Netherlands and Germany are not the only countries with high livestock densities and environmental challenges. Denmark, Belgium and Spain are also among the European member states with the highest number of pigs per 100 inhabitants (Eurostat, 2018). The high stocking rates are often accompanied by environmental problems. At the EU level, the National Emission Reduction Commitments (NERC) seek to lower harmful nitrogen pollutants e.g. ammonia emissions (NH_3) caused by livestock production. Current data shows that the Netherlands, Germany, Denmark and Spain and many others still need to achieve their NH_3 reduction goals for 2030 (European Environment Agency, 2021). Especially, reductions in the vicinity of SACs are of crucial importance, as these nature reserves often seek to protect nitrogen-sensitive species such as mosses (Kelleghan et al., 2021). The EU Habitats Directive (92/43/EEC) prohibits the deterioration of these reserves. Improved environmental protection is therefore the reason why the Belgian government plans to follow the Dutch example and offer buy-outs to pig farmers in Flandern, the region with the highest stocking rates (Vilt, 2022). In Germany, the Green Party of Lower Saxony launched a legislative proposal for a buy-out programme. With the help of such programmes, they want to encourage farmers to switch from pig fattening to other more environmentally friendly types of farming (State Parliament of Lower Saxony, 2021).

3. Methodology

3.1. Experiment design and underlying hypotheses

To assess the preferences of German pig farmers for the design of a potential decommissioning scheme, we conducted a DCE. Table 1 shows

Table 1
Attributes of a stylised pig fattening exit scheme. The attribute levels for non-participation are shown in bold font. (Source: own illustration).

Attribute	Attribute levels
Compensation payment in € per fattening pig place and year	€ **0.00,** € 12.50, € 15.00, € 17.50, € 20.00
Compensation payment in € per sow place and year	€ **0.00,** € 120.00, € 140.00, € 160.00, € 180.00
Demolition	**Not required,** required, required with costs of demolition reimbursed
Barn construction	**Allowed without restrictions,** barns improving animal welfare only, ban on barn construction
Slurry intake from other farms	**Allowed without restrictions,** at the existing level, not permitted at all
Mode of payment	**No payment,** one-off payment, annual payment

the variations of five attributes chosen for the stylised support scheme: the amount of compensation on offer, rules on the demolition of decommissioned pig barns, constraints regarding future building projects, restrictions on organic fertiliser intake from other farms, and mode of payment. In the choice sets used, the compensation payments for sow places were shown to pig fatteners only if they operated a farrow-to-finish system.[1]

In the choice sets, the level of the compensation payment was given in euros per sow place and fattening pig place for each year of its remaining life. The level of payment offered was based on the barn's calculated capitalised earnings value,[2] and calculated using the gross margin from the Schleswig-Holstein specialist pig consultancy service and direct costs from the KTBL database (Schweinespezialberatung Schleswig-Holstein Pig Consultation Service Schleswig-Holstein, 2010–2018; KTBL, 2014). Furthermore, members of farmers' associations and consulting agencies were asked if the values reflected real-life rental prices per barn place. It was assumed that farmers' acceptance grows with an increase in the amount of compensation on offer.

The second attribute varied in relation to the potential demolition of the barn: demolition at farmers' own expense, demolition with costs reimbursed or demolition not required. It was assumed that the obligation to demolish at the farmers' own expense in particular would be evaluated negatively since it diminishes the financial benefit of participating in the scheme. Whether demolition with costs reimbursed was also viewed negatively would depend on farmers' evaluation of subsequent possible uses. Positive aspects of rebuilding include that less farmland would be needed for construction, resulting in lower investment costs (Fuchs, 2018). However, if barns are rebuilt to house other animal species this may lead to lower efficiency in production if, for example, the barn hull does not fit optimally with the new livestock system. The attribute is intended to elicit how farmers view the possibility of continued use.

The third attribute concerned restrictions on future re-investment in pig farming. This attribute ranged from no restrictions (barn building permitted) through re-investments being limited to buildings with higher animal welfare standards (for simplicity with half occupancy), to a complete ban on erecting new pig barns. The last level was expected to have a very negative influence on scheme acceptance. When only animal welfare barns are permitted, this would potentially be evaluated less negatively as schemes already exist to fund these kinds of barns. The attribute was included, because the German public demands higher animal welfare. A lower level of animal welfare is often attributed to too little space per animal (Christoph-Schulz and Rovers, 2020). Furthermore, allowing farmers to invest in animal welfare barns may help keep farm income on a sufficient level to allow them to stay in business even if they discontinue intensive pig production. Since fewer animals are kept on the same surface area, animal welfare barns will also contribute to lower overall emissions.

The fourth attribute related to the intake of slurry from other farms. Farmers in regions with high stocking rates are often paid for accepting slurry from other farms. In some choice sets, this was permitted without any restrictions, in others it was limited to the current level or was completely prohibited. It was assumed that a ban on accepting slurry from other farms would be evaluated negatively because of the associated loss of earnings. Furthermore, farmers potentially value the positive impact of organic fertiliser on soil life and would not want to give this up. The attribute was included to account for the negative effects of nitrogen surpluses associated with intensive livestock production in North-Western Germany and Bavaria (Häussermann et al., 2020). Not allowing farmers to accept slurry will increase slurry transport costs for those continuing with pig production, thus diluting incentives for further investments in these areas.

The final attribute used in the choice sets related to the mode of payment. In some choice sets, a one-off capitalised compensation payment was offered. Another option was an annual payment for the remaining lifetime of the barn. Different preferences are conceivable as a one-off payment could be more attractive to farmers interested in investing in other projects. By contrast, an annual payment could be more attractive due to potentially lower taxation.

The above attributes are intended to derive information necessary for restructuring the sector towards better animal welfare (addressed by 'barn construction' and 'demolition') and environmental protection (addressed by 'barn construction' and 'slurry intake from other farms').

To ascertain the influence of known structural change factors on exit decisions, the questionnaire also featured questions about personal and farm characteristics. Existing studies on structural change demonstrated the positive impact of age and lack of a farm successor on exit decisions (Weiss, 1999; Dong et al., 2010; Pietola et al., 2003). In the past, farmers with a higher level of education have also shown greater probabilities of leaving farming (Dong et al., 2010; Boehlje, 1992). In relation to the farms' characteristics, it was assumed that farmers with larger pig farms would be less willing to participate and give up their pig enterprise. If farmers have old barns, it was presumed that they would be more willing to give these up. They may have problems meeting quality standards and face a poorer level of performance (Dong et al., 2010). If there are links with other business segments, such as photovoltaic installations on roofs or digestion of liquid fertiliser in biogas installations, a negative influence on the acceptance of the scheme was expected. This was also assumed if farms operate in a farrow-to-finish system. In relation to a farm's financial success, it was assumed that farms belonging to the top 25% of the sector would not participate in the schemes.[3] Studies have established that efficient farms in particular prefer not to exit (Foltz, 2004).

To take account of the increasing pressure applied by changes in the law, this study also examined whether operational problems in the past influence exit decisions. The Fertiliser Ordinance (2017) defined a maximum nitrogen surplus of 60 kg N/ha and included a provision for adequate storage space (Fertiliser Ordinance, 2017). Both could lead to greater acceptance of schemes due to the high costs of purchasing or renting additional land for slurry disposal or the need to export slurry to regions with lower livestock densities.

The participants were also asked to rank five statements in order of importance from most important to least important. The objective of this click rating was to ascertain the challenge that farmers currently perceived to be most critical. The click rating was included because the recent changes in legislation and uncertainty about the future of livestock production may have contributed to exit decisions from the branch. The challenges listed were:

- higher animal welfare requirements
- amendment of the Fertiliser Ordinance (water protection)
- abolition of the flat-rate sales tax[4]

[1] Farmers with farrow-to-finish systems keep sows and keep a share of the piglets for fattening.

[2] In business valuation, this is the net present value of future net cash flows from the company's production and sales activities. It is obtained by discounting the expected future payments with a given interest rate. In our case this was calculated for different remaining lifespans and for farms with medium success and divided by the years of the remaining lifetime. In the choice sets, the values were varied around the estimated values (per year).

[3] When farmers participate in industry comparisons, they are usually classified in the top 25%, middle 50% or bottom 25% of their peer group.

[4] The flat-rate sales tax (in German: *Pauschalierung*) is a simplification of the German VAT tax system. Agricultural businesses do not sell their goods or services at the standard VAT rate of 19% or 7%, but at a flat rate of 9.0%. As from 2022, the flat rate has been available only for businesses with an annual turnover of less than € 600,000. At the time of the survey, all farms were eligible for the flat-rate sales tax.

- lack of skilled personnel
- and lack of a farm successor.

The survey was conducted using the online platform Unipark. In the survey, each participant was given three different versions of the stylized exit scheme and the option of non-participation. Each questionnaire included eight choice sets that were randomly assigned to participants. The design was created using the software-package decreate in Stata by minimizing the D-error. It had a D-efficiency of 92.93%. In total 32 choice cards were generated and distributed over the four questionnaire versions. The design was created without using priors, the use of priors was not possible since no existing study covered the same topic and analysed the same attributes. Besides the choice of a particular exit scheme, farmers were asked which of their barns they would offer. Information on the number, the age and size of their barns was elicited beforehand. They were also informed that they can only offer entire barns with all of the places included and that only barns currently used for production are eligible for participation.

An example of a choice card is shown in the appendix together with an English translation of the survey. The accuracy and comprehensibility of the survey were checked by scientific staff, members of a farmers' associations and pig farmers themselves.[5] Participation in the survey was predominantly advertised online (e.g., by email mailing lists, farmer magazines and Facebook groups for pig producers). Farmers had between June and mid-September 2020 to complete the survey.

3.2. Behavioural model to explain the decision to participate

The underlying assumptions of DCE are explained in Hensher et al. (2018) and are briefly reiterated here. Overall, it is assumed that a decision-maker n selects alternative i if the alternative provides the highest utility. Therefore, a participant in the survey will choose a stylised support scheme i if it provides him or her with a higher utility than the other schemes offered or the status quo (no participation). The utility (U_{ni}) of each alternative in the experiment can be divided into an observable part (V_{ni}) and a non-observable part (ε_{ni}). The probability that alternative i is chosen over alternative j is equal to the probability that i provides a higher utility than j:

$$P_{ni} = Prob\left(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}, \forall i, i \neq j\right) \quad (1)$$

The observable part of utility is assumed to be a linear function of the k attributes and their observed levels (x_{ni}). The estimated coefficients β represent the marginal utility of an attribute for respondent n:

$$U_{ni} = \beta_{kn} x_{ik} + \varepsilon_{ni} \quad (2)$$

While initial models such as conditional logit assume a homogenous distribution of preferences across participants, newer models such as mixed logit or latent class models allow for preference heterogeneity. Mixed logit models assume a continuous distribution of these preferences and estimate individual-specific coefficients. The distribution of the estimates can be described by $f(\beta_{kn}|M)$ with M being the moments of the distribution. Mixed logit models are solved by simulation and lead to a model with weighted averages:

$$P_{ni} = \int \left(\frac{exp(x_{ik}\beta_{kn})}{\sum_{j=1}^{J} exp\left(x_{jk}\beta_{kn}\right)} \right) f\left(\beta_{kn}|M\right) d\beta_{kn} \quad (3)$$

Latent class models do not only account for preference heterogeneity. They can also reveal sources of heterogeneity (Train, 2003). They assume a discrete rather than a continuous distribution of preferences. It is assumed that the preference structure within the (latent) preference classes is homogeneous, therefore subgroup-specific coefficients are estimated. The model estimates the class membership probability H_{ns} that an observation n is assigned to a certain class s ($s = 1 \ldots S$). This probability depends on respondent-specific covariates (h_n), their influence is indicated by δ_s:

$$H_{ns} = \frac{exp(\delta_s h_n)}{\sum_{s=1}^{S} exp(\delta_s h_n)} \quad (4)$$

The class-specific predicted probability of choosing a scheme (P_{ni}) in latent class models depends on the class-specific estimates (β_{ks}).

$$P_{ni|s} = \frac{exp(x_{ik}\beta_{ks})}{\sum_{j=1}^{J} exp\left(x_{jk}\beta_{ks}\right)} \quad (5)$$

The overall probability ($Prob_{ni}$) that decision maker n chooses a scheme depends on the predicted probability of choosing a scheme ($P_{ni|s}$) and the predicted probability of belonging to a certain class (H_{ns}):

$$Prob_{ni} = \sum_{s=1}^{S} H_{ns} P_{ni|s} \quad (6)$$

Besides the coefficients, willingness-to-accept (WTA) values were estimated. In models with fixed coefficients (per subgroup), WTA is calculated as the ratio of the coefficient of the attribute of interest (k) and the coefficient of the price attribute (c), in our case the compensation offered (Hensher et al., 2018):

$$\text{WTA} = -\frac{ß_k}{ß_c} \quad (7)$$

For mixed logit models, it is recommended to estimate WTA space. This addresses the criticism that WTA calculated directly from two randomly distributed coefficients would lead to unreasonably high values (Train and Weeks, 2005). When calculating WTA space, the price parameter is normalized and the remaining coefficients represent a direct parametrization of WTA (Hensher et al., 2018).

4. Results

4.1. Descriptive statistics

A total of 346 farmers took part in the survey, who either specialised in fattening pigs or operated a farrow-to-finish system. Table 2 shows the descriptive statistics. Of the producers surveyed, around 49% farmed in the stronghold of pig farming in northwest Germany (postcode areas 26, 49, 48, 27, 33, 32, 59). Since critical neighbourhoods (proximity to SACs) exist throughout Germany, we included all observations (and not only those from northwest Germany) in the analysis.

The average respondent was 45 years old and the majority of respondents (72%) had specialist agricultural training. The average respondent farmed around 157 ha of arable and grassland. The majority of farms (89%) were run full-time. On average 1655 fattening pigs were kept per farm. Farmers operating a farrow-to-finish system kept around 104 sows in addition.

The respondents' farms appear to be a good representation of typical German pig farms. Most German pig fattening farms lie within the range of 1000 to 2000 places, even though German pig farmers keep on average only around 700 pigs. This also holds for sow places on farrow-to-finish farms. Most German farms keep between 100 and 149 sows (Rohlmann et al., 2020). The vast majority of these pigs are kept in standard barns without enhanced animal welfare facilities. Only 1.5% of pigs are kept under organic production standards. Pig production is of high importance for German agriculture, roughly 30% of the agricultural production value comes from pig farming (BMEL (German Federal Ministry of Food and Agriculture), 2022).

[5] This process did not lead to a change of attributes, but to slight changes in the wording to ensure comprehensibility.

Table 2
Descriptive statistics of survey participants (source: own calculation).

Variable	Mean (std. dev.)	Obs.	Description
Age	44.86 (11.48)	346	Participant's age in years
Farming training	0.72	346	Participant has had agricultural training (vocational college, university degree) (dummy)
Full-time farming	0.89	346	Farming is the main occupation (dummy)
Sow places (100 heads)	1.04 (2.18)	127	Sow places on farms with farrow-to-finish systems
Fattening pig places (100 head)	16.55 (17.28)	346	Fattening pig places on the farm
Year of construction	1996.60 (11.94)	346	Average construction years of the pig fattening barns
Farrow-to-finish systems	0.37	346	Farm keeps sows and fattening pigs in a farrow-to-finish system (dummy)
Leased barns	0.05	346	Pig barns are not operated by the participant but leased to other farmers (dummy)
Commercial livestock farming	0.25	346	Alongside agricultural activities, there is also commercial livestock farming (dummy)
Top 25 farms	0.41	346	Farm is in the top 25% of farms in a financial performance ranking (dummy)
Utilised agricultural area (100 ha)	1.57 (2.22)	346	Cultivated arable and grassland in hectares
Operations with dairy	0.03	346	Farmer with dairy (dummy)
Operations with poultry	0.10	346	Farmer with poultry (dummy)
Biogas	0.23	346	Farm digests slurry in a biogas plant (dummy)
Storage	0.40	346	Farm has had to or must still invest in storage within the scope of the amendment of the Fertiliser Ordinance, 2017 (dummy)
Nitrogen balance	0.16	346	Farm has had problems in the past maintaining the balance of 60 kg N/ha (dummy)
Photovoltaics	0.69	346	Farm has photovoltaic installations on pig barn roofs (dummy)
Farm closure	0.12	346	Farm will close in the next 10 years (dummy)
Farm succession	0.41	346	Farm succession is secure (dummy)
Northwest	0.49	346	Farm is located in the northwest of Germany (an area of intensive livestock farming) (dummy)

Approximately 5% of the respondents had already leased their pig barns to other farmers, and around 25% also operated their livestock operations as commercial (rather than agricultural) entities.[6] When asked about plans for the future, 12% of the respondents said they were considering giving up the farm in the next 10 years; 41% of the farmers had a secure successor. The remaining 47% were not yet able to make a statement on their future plans.

Since intensive pig production causes adverse environmental impacts, the questionnaire also included questions on the environmental impact of the farms, particularly on potential nitrogen surpluses. Sixteen percent of the farmers stated they had problems with nitrogen balance compliance that limits permissible surpluses to a maximum of 60 kg per hectare and year. Forty percent of the respondents stated that they needed to provide additional storage capacity to comply with the requirement to be able to store slurry for at least six months. This requirement was introduced with the 2017 amendment of the Fertiliser Ordinance.[7]

4.2. Estimation results

The estimations were carried out with the statistics software Latent Gold 6 and Stata 16. The estimated mixed logit model had a pseudo-R^2 of 0.286, the latent class model 0.379. Hensher et al. (2018) state that models in this range provide a sufficiently close fit with the data.

4.2.1. Farmers' perception of the stylised buy-out scheme

Table 3 presents the results of the mixed logit estimation. The average predicted probability of choosing a scheme was 61%.[8] The estimated coefficients show how the scheme was perceived by the average participant. As one would expect, the probability of choosing a scheme increased with a higher compensation payment. Furthermore, farmers perceived bans on barn construction and slurry import restrictions negatively. This also holds for the softer versions of these requirements: the respondents disliked slurry imports to be limited to current quantities, and they also rejected the condition that future investments in the pig enterprise be limited to animal welfare barns. Also, the highly significant negative coefficient for the demolition requirement shows that farmers are critical of barn demolition, even when they would get the demolition costs reimbursed. The negative coefficients for

Table 3
Results of mixed logit model to explain farmers' decisions to participate in a pig fattening decommissioning scheme (Source: own calculation with Stata 16).[a]

	Mixed logit model (LL = -2665.06, Pseudo-R^2 =0.286)			
	Coef.	z-value	Std. dev.	z-value
Compensation payment in €/ pig fattening place	0.098***	4.75	0.198***	14.13
Demolition required	−1.298***	8.43	1.446***	8.69
Demolition required with costs reimbursed	−0.414***	3.02	1.498***	10.45
Barn construction (enhanced animal welfare)	−0.394***	3.14	1.076***	7.47
Ban on barn construction	−0.487***	3.72	1.153***	7.76
Slurry import at existing level	−0.236**	2.14	0.584***	3.24
Slurry imports not permitted	−1.209***	8.21	1.249***	7.74
One-off payment	−1.059***	2.64	−0.540*	1.93
Annual payment	−1.196***	3.32	−0.801***	4.55

[a] In total, 346 farmers were surveyed, and every participant answered eight choice sets with four alternatives, yielding 11,072 choice observations (Level of significance: * 90%;** 95%;***99%).

[6] When the livestock units kept per hectare exceed a certain threshold, the livestock enterprise is classified as commercial under German tax law. Commercial animal husbandry is often found for less farmland-dependent animal species, e.g. pigs or poultry. Commercial livestock farming results in tax disadvantages. It is also seen as a proxy for nutrient surpluses (Sorg et al., 2021).

[7] The survey also elicited information on how farmers spread slurry. Statistics show that, until 2015, splash plate spreading was dominant in Germany. After a ban of the technique in 2015, spreading with trailing hoses became the dominant technique. Injection and other techniques with high emission reduction potential are used to smaller extends (Sorg et al., 2021).

[8] The predicted probabilities per observation were calculated using *mixlpred* after *mixlogit* by Hole (2007) with 1000 draws. This resulted an average predicted probability of 39% for the opt-out alternative (no participation). Accordingly, the average predicted probability across all observations of choosing a scheme was 61%. Since individual-specific coefficients were estimated and the model was solved by simulation the predicted probability is a weighted average compared to the predicted probability of a standard conditional logit model (Train, 2003).

the mode of payment attributes show that farmers were generally critical of the schemes.[9]

The highly significant standard deviations of the coefficients indicate that the perception of the scheme's attributes was not homogeneous across participants. Therefore, a latent class model was estimated to identify different classes of farmers with different perceptions of the scheme. The preferred latent class model was chosen by the BIC criterion (Table 4). According to the BIC values, a latent class model with three preference classes provides the best fit with the data. The reduced model does not include the variables 'nitrogen balance', 'storage', 'biogas', 'year of construction' and 'operations with dairy'.[10]

Table 5 presents the chosen reduced model. Two of the estimated preference classes (class 1 and class 3) displayed a high class-specific probability of joining a decommissioning scheme. Together their class shares accounted for roughly 69% of the respondents. Class 3 had a low class-specific probability of joining and accounted for almost a third of the respondents (31% class share).

For respondents in the first preference class, the class-specific predicted probability of joining an exit scheme was 92%. The level of compensation on offer was crucial for them. They rejected demolition without costs being reimbursed. However, they would welcome demolition if the costs were reimbursed. They resisted restrictions on slurry import, be it in the form of a complete ban or a freeze at current levels. Furthermore, the respondents in the first preference class objected to any constraints on re-investing in pig farming. This was found for both a complete ban on barn construction and being limited to building animal welfare barns. This is a clear indication that these farmers plan to continue to invest and develop their pig enterprise. They may thus regard the decommissioning schemes as an option for them to get the demolition of their old barns subsidised and reinvest the money in barns that would meet the stricter legal requirements. This result could not be seen from the mixed logit model.

Respondents who can be assigned to the third preference class also welcomed the scheme. However, they seemed less certain about this decision, their class-specific probability of choosing a support scheme was only 65%. For these farmers, the compensation payment appears less important. They also seem to tolerate the constraint that future investments be limited to pig barns with enhanced animal welfare. Furthermore, respondents belonging to this class rejected a full ban on barn construction as well as stipulations on the intake of livestock manure and the demolition of buildings. The coefficients for the obligations to demolish suggest that they would make alternative subsequent use of the barns.

In comparison, respondents belonging to the second preference class were negative about the scheme, as indicated by the low class-specific probability of participation (9%). They were strongly focused on the offered compensation payments. The highly significant coefficients of the payment mode variables highlight the strong general rejection of the exit scheme by these respondents.

The overall choice probability across the three preference classes was estimated at 62.5%. It was calculated as product of the predicted probability of choosing a scheme and the predicted probability of belonging to a certain class as per Eq. (6). Where farmers chose to participate, on average 1291 fattening places would be given up (min. 31, max. 9901), and 52% of the farmers who had more than one barn offered all their barns. These numbers indicate that not only those farmers planning to discontinue farming might be interested in the schemes. This conclusion is reinforced by the respondents' negative perception of constraints on barn construction found in the above estimations.

WTA values (Table 6) were calculated for the attributes of the support scheme because the coefficients do not provide information about the strength of the effects and thus how important the attributes were (Hensher et al., 2018). The WTA estimates are the marginal rate of substitution between an attribute and the monetary variable. They indicate how much compensation a respondent expects to receive for a one-unit increase in a negatively valued attribute, or how much compensation he or she is willing to give up for a one-unit increase in an attribute that is valued positively.

The WTA estimate for 'demolition required' in Table 6 indicates that respondents belonging to the first preference class would ask for an extra €2.21 per place and year if they were required to demolish their barns at their own cost. By contrast, they were willing to give up €2.33 per place and year if the costs of demolition were reimbursed. When re-investment is either prohibited or restricted to housing facilities with enhanced animal welfare standards, the respondents in the first preference class would request extra annual compensation of approximately €1.00 per pig fattening place. In addition, these respondents were expecting an extra annual payment of €5.14 per pig fattening place if they were banned from importing slurry from other farms. The corresponding figure for limiting slurry intake to current levels was €0.91 per place. These figures highlight that the more restrictive version of the slurry intake constraint is much more important for farmers' decisions than the softer requirement. Also, restrictions on slurry intake were perceived much more negatively than restrictions on barn construction.

The respondents assigned to the second preference class were not in favour of the exit scheme. This can be seen from the very high WTA estimates for the payment mode (around €33 per place), which lie outside the range of compensation payments offered in the choice sets (€12.50 to €20.00 per place, Table 1). This reflects a negative evaluation of the offer as a whole, which could possibly only be overcome by very high payments. The coefficients of all other scheme attributes were not significant (see Table 5). Hence no WTA estimates are displayed for these attributes in Table 6.

4.2.2. Suitable target groups for a buy-out scheme

The covariates (personal and farm characteristics) displayed in Table 5 were used to explain preference class membership. The third preference class was chosen as the reference for the other two classes. The coefficients showed that younger farmers with commercial farms were more likely to be members of the first preference class, welcoming the scheme. Respondents belonging to this class welcomed demolition when costs are reimbursed and seemed to be interested in future investments in pig fattening. Young age in combination with a high degree of specialisation in pig husbandry (as indicated by 'Commercial livestock farming') could explain why they did appear to have plans for

Table 4
BIC-values of the estimated models (Source: own calculation with Latent Gold 6).

	Log-likelihood	BIC
2 Preference class model	−2768.70	5753.72
3 Preference class model	−2654.76	5689.53
3 Preference class model (reduced)	−2656.49	5622.84
4 Preference class model	−2577.05	5697.82
5 Preference class model	−2528.70	5764.81

[9] In this model, the dummy variables for payment mode (annual or one-off payment) only take the value of one when a hypothetical program was chosen. They are thus comparable to alternative-specific constants that would assume the value of one for participation in the scheme. As in linear regressions, the alternative-specific constants capture the average impact on utility of all factors that are not included in the model (Train, 2003). The negative coefficients show that factors not included lead to a negative perception of the scheme.

[10] Whether the variables have explanatory power was determined using the likelihood ratio-test for a mixed logit model. The mixed logit model included the respondent-specific covariates as interaction effects with an alternative-specific constant. The latent class model with all variables is presented in the appendix.

Table 5
Results of the chosen latent class model to explain farmers' decisions to participate in a pig fattening decommissioning scheme (Source: own calculation with Latent Gold 6).

	Latent class model (LL = -2656.49, pseudo-R^2 = 0.379)					
	Class 1		Class 2		Class 3	
Class share (H_{ns})[a]	55.50%		31.00%		13.50%	
Pred. prob. per class ($P_{i|s}$)[b]	92%		9%		65%	
	Coef.	z-value	Coef.	z-value	Coef.	z-value
Attributes of the decommissioning scheme						
Compensation payment in €/ pig fattening place	0.142***	10.93	0.206***	3.60	−0.016	0.28
Demolition required	−0.313***	3.31	−0.470	1.20	−3.355***	7.85
Demolition required with costs reimbursed	0.330***	3.83	0.177	0.49	−3.571***	6.86
Barn construction (enhanced animal welfare)	−0.169**	2.00	−0.081	0.25	−0.029	0.09
Ban on barn construction	−0.142*	1.69	−0.508	1.42	−0.732**	2.22
Slurry import at existing level	−0.129	1.64	0.230	0.68	−0.95***	2.79
Slurry imports not permitted	−0.723***	8.12	−0.146	0.40	−1.228***	2.99
One-off payment	−0.709**	2.18	−6.926***	5.39	2.308*	1.75
Annual payment	−0.772***	2.66	−6.654***	5.75	2.032*	1.72
Respondent-specific covariates						
Farmer is older than 50	−0.894**	2.10	−0.652	1.35	0.000	0.00
Farming training	0.626	1.54	0.348	0.74	0.000	0.00
Farm succession[c]	0.249	0.57	0.599	1.27	0.000	0.00
Full-time farming	0.521	1.00	0.119	0.18	0.000	0.00
Commercial livestock farming	1.366*	1.92	1.652**	2.24	0.000	0.00
Leased barn	−0.358	0.49	−0.362	0.37	0.000	0.00
Farrow-to-finish system	−0.452	0.96	1.461***	2.69	0.000	0.00
Photovoltaics	−0.228	0.55	0.448	0.91	0.000	0.00
Utilised agricultural area (100 ha)	0.284	1.19	0.234	0.96	0.000	0.00
Top 25 farms	0.150	0.34	0.556	1.16	0.000	0.00
North-West	0.218	0.54	0.263	0.59	0.000	0.00
Operations with poultry	−0.112	0.20	−2.853**	2.52	0.000	0.00
Constant	0.278	0.44	−1.348*	1.69	0.000	0.00

(Level of significance: * 90%;** 95%;***99%).

[a] The class membership probabilities (or class shares) were calculated with Latent Gold 6 and represent the posterior probability that a participant is in a certain class. The probability depends on the respondent-specific covariates.

[b] The class-specific choice probability was calculated with Latent Gold 6 and represents the predicted probability of scheme participation conditional on being in a certain class.

[c] The answers 'farm closure' and 'I don't yet know' together form the base for the attribute and take a value of zero when farmers stated that farm succession is not secured.

Table 6
Willingness-to-accept compensation (WTA) per pig place calculated for the significant variables[a].

	Latent class model					
	Class 1		Class 2[b]		Class 3[c]	
	WTA	s.e.	WTA	s.e.	WTA	s.e.
Demolition required	2.21	0.75	0.00	0.00	0.00	0.00
Demolition required with costs reimbursed	−2.33	0.56	0.00	0.00	0.00	0.00
Barn construction (enhanced animal welfare)	1.19	0.62	0.00	0.00	0.00	0.00
Ban on barn construction	1.00	0.63	0.00	0.00	0.00	0.00
Slurry import at existing level	0.91	0.59	0.00	0.00	0.00	0.00
Slurry import not permitted	5.14	0.86	0.00	0.00	0.00	0.00
One-off payment	5.01	1.93	33.68	4.59	0.00	0.00
Annual payment	5.46	1.64	32.36	4.20	0.00	0.00

(Source: own calculation with Stata 16 and Latent Gold 6).

[a] WTA estimates for the latent class model were calculated from the ratio of the coefficients.

[b] WTA estimates were only calculated for attributes with significant coefficients, otherwise zero.

[c] WTA estimates were not calculated for the third preference class as the price coefficient was insignificant.

further investment in pig farming.

Respondents belonging to the second preference class were also more specialised in pig farming ('Commercial livestock farming') and more likely to operate farrow-to-finish systems.[11] Furthermore, they tended to belong to the top 25% of pig farmers even though the effect just misses a level of significance. They were also less likely to have a poultry unit besides the pig enterprise.

Respondents assigned to the third preference class were older than those in the first preference class, and less specialised in pig production than the other preference classes ('Commercial livestock farming'). Furthermore, they were less likely to operate farrow-to-finish systems than farmers in the second preference class, and more likely to have poultry as an additional livestock enterprise. Their higher age and lower degree of specialisation in pig farming might explain why they are open towards exit schemes. Their engagement in poultry production could indicate that they would like to reuse barns for poultry and could explain their negative perception of the demolition requirements.

A deeper analysis of the data showed that the barns of farmers in the third preference class have earlier construction dates. At the time of the survey, their barns were on average 26 years old, while those in the first and second preference classes were 24 and 20 years old, respectively.

[11] A separate model estimation for farrow-to-finish farms only is provided in the appendix. As indicated by the latent class model, farmers operating a farrow-to-finish system were generally less likely to choose a scheme. The average predicted probability of choosing a scheme was 40% for the mixed logit model.

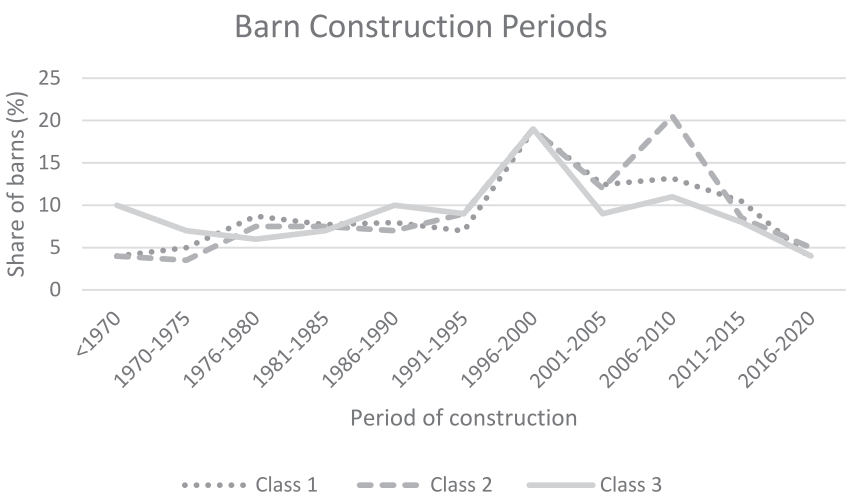

Fig. 1. Periods over which the respondents' barns were constructed (Source: own illustration).

Fig. 1 depicts the share of barns erected over certain periods. It shows that barns belonging to farmers in the third class were mostly erected between 1996 and 2000. Farmers in the first class also erected barns in the earlier period, but they also constructed additional barns later on. The farmers in class two seem to have even more barns that were constructed in later periods.

The variables 'Nitrogen balance', 'Storage' and 'Northwest' were included in the model to ascertain whether farms with poor environmental performance face particularly great challenges and were more likely to participate in the exit scheme. However, the variables had no influence. This, finding and the high share of farmers considering support schemes in general, suggest that all farms face major challenges regardless of their current environmental impact. This is also shown by the results of the click-rating. The objective of the click rating was to ascertain which current challenges farmers perceived to be particularly critical, with the greatest challenge ranked first and the least important ranked last (fifth). Among almost all participants, the increasing demands on animal welfare were cited as the greatest challenge (51% ranked it first), followed by increasing requirements for water protection, which led to the amendment of the Fertiliser Ordinance (20% ranked it first). Of less significance were the abolition of the flat-rate sales tax (9% first rank), lack of specialist staff (7%) and lack of a farm successor (4%). This uncertainty in respect of the changing legislation is difficult to capture through personal and farm characteristics.[12]

5. Discussion and conclusion

The objective of this paper was to determine the acceptability of a hypothetical scheme for a state-subsidised exit from pig fattening in Germany. The predicted probability of joining such a scheme was 61% in the mixed logit model. In the latent class estimations, the overall probability of opting for a scheme was estimated at 62.5%. The high acceptance rate is explained by a changing legal framework, fluctuating market revenues, and uncertainty about future political framework conditions for the sector. This has been underlined by the numerous demonstrations against the German government's legislative packages organised by the new farmers' movement 'Land Creates Connections' and is also highlighted by the results of the click-rating. The recent changes in legislation were considered to be the most challenging factors.

When interpreting the results, the situation for German pig farmers at the time of the survey needs to be considered. Towards the end of the survey period, the industry was hit by the outbreak of African Swine Fever, triggering a pork market crisis. The tense situation has led to calls for emergency aid from the government and is likely to have influenced farmers' willingness to participate in the stylised exit scheme. Still, the results, in general, seem to coincide with general expectations: farmers specialising in pig production ('Commerical livestock farming') and operating a farrow-to-finish system are less likely to join the scheme (class 2), whereas older farmers and farmers who are less specialised in pig production showed interest (class 3). The largest target group for the scheme, however, are younger farmers who specialise in pig production and who might be interested in a version of the scheme that allows them to reinvest in pig housing (class 1). They would thus regard the scheme as a subsidised modernisation programme for their pig enterprises.

The coefficients of the scheme's attributes provide valuable information as to the issues that need to be considered before the launch of an exit scheme. The coefficient of the price attribute had the expected sign: higher compensation increased the probability of participation, although this does not seem to hold universally. The latent class estimations revealed that the compensation payment was of less importance for farmers belonging to the third preference class while these farmers were concerned about restrictive requirements of the exit scheme. This may be explained by the older age of the farmers and their barns. The period over which these farmers would receive a compensation payment is shorter. This would lead to lower expected overall payments because the compensation payment was offered in Euro per pig place and year of the remaining life of the barn. Also, farmers assigned to the third preference class may already consider their retirement and thus the sales value of their farms. Restrictions on slurry intake and barn construction can reduce the market value of a farm. This may explain why they are more concerned about the restrictive requirements of the exit scheme than the compensation payment on offer.

The estimates for the willing farmers (class 1 and class 3) further revealed a negative attitude towards tight restrictions on the intake of slurry from other farms and a ban on building barns. A full ban on importing slurry was significantly negative while limiting it to the current level was evaluated less negatively. Financially this can be explained by the ensuing need to purchase mineral fertilisers, but also by the income forgone from importing livestock manure from other farms. A full ban thus needs to be carefully balanced against the key objective of 'warm restructuring' to reduce damage to the environment caused by nitrogen surpluses.

Another important scheme attribute was a potential ban on new barn buildings. To achieve the objectives of protecting the environment and

[12] Most the respondents chose the tightened animal welfare standards and the stricter requirements for water protection first. This led to low variation in the data set and might explain why these factors had no influence in the estimation.

enhancing animal welfare, it might be politically desirable to reduce animal populations, especially in the strongholds of livestock production. Implementation of an exit scheme can therefore only be recommended if it contains restrictions on permissions for new barn buildings, e.g. limiting re-investments to barns with enhanced animal welfare standards. Such restrictions, however, lower farmers' willingness to participate. Again, a careful balance needs to be struck between targeting the scheme's objectives on the one hand and enticing a sufficient number of farmers into the scheme on the other.

The farm and personal characteristics considered in the regressions potentially shed light on suitable target groups and show that the objectives of the scheme need to be precisely specified. Should it support a switch to more sustainable, animal welfare-oriented livestock farming with old barns being decommissioned? If so, a suitable target group would be farmers who display the characteristics of the first preference class, i.e. younger farmers specialising in pig production and willing to grow the pig enterprise - even though additional programmes supporting their investments in animal welfare may be necessary. If, however, the primary objective is to reduce animal numbers in a region for environmental reasons, then the third preference class could be the suitable target group. These farmers were already older and appeared to be less specialised. They may thus consider the exit scheme as a kind of early retirement scheme. However, to the extent they have planned to leave the agricultural sector anyhow the scheme may contribute to windfall gains.

The high degree of preference heterogeneity revealed by the latent class estimations suggests that designing a one-size-fits-all exit scheme seems an impossible task. Targeting farmers belonging to the first preference class (the largest class) would require easing restrictions on slurry import and re-investment in the pig unit. These are the younger, forward-looking farmers specialised in pig production. They would not participate if they had to comply with provisions limiting their future earning capacity. Farmers in class one would probably be more interested in a restructuring (rather than an exit) scheme, which actively offers sustainable business development perspectives either within the pig industry or outside. Alternatively, these farmers would have to be 'bought in' by offering a very high payment rate which, in turn, would lead to vast windfall profits for older pig producers.

A potential solution to this design problem is to allocate decommissioning contracts at auction rather than offering farmers a blanket payment. Price-discriminating auctions are the main allocation and price discovery mechanism for fishing vessel buyout schemes (Schilizzi and Latacz-Lohmann, 2012). Besides the bid amount, the bid selection mechanism could take account of the expected environmental benefits of individual bids, for example by considering the proximity to nitrate-sensitive ecosystems, or whether farmers are located in regions with particularly high nitrogen surpluses. Auctions could potentially significantly reduce the budgetary costs of implementing the exit scheme (Schilizzi and Latacz-Lohmann, 2007). In the Netherlands, enterprises received farm-specific offers to keep costs as low as possible (Wissenschaftliche Dienste des Deutschen Bundestages Scientific Services of the German Bundestag, 2019).

The estimation of latent classes also allows us to make predictions about the future structure of the pig sector - after the completion of an exit programme. Of particular interest in this context is the question of which farmers will continue to exist. This will depend to a great extent on the design of the scheme. If the scheme meets the aspirations of farmers in class one, i.e. younger specialist pig producers willing to reinvest, it is likely to result in a more sustainable, animal welfare friendly and possibly more productive pig sector. This hypothesis is supported by research findings suggesting that younger livestock farmers are more open towards both innovative techniques that could reduce emissions (McBride and Daberkow, 2003; Gebrezgabher et al., 2015; Thiermann and Latacz-Lohmann, 2022), and programmes aiming at improved animal welfare in pig fattening (Latacz-Lohmann and Schreiner, 2019). This openness in combination with the farmers' positive perception of barn demolition against cost reimbursement suggests that these farmers will manage the balancing act between societal desires and farm profitability.

The other group of pig producers that will continue to exist after the completion of an exit scheme are the farmers assigned to the second preference class. They were not interested in the stylised scheme. They were stronger associated with commercial animal husbandry, farrow-to-finish systems and had they a tendency to consider themselves among the top 25% pig producers. Their current success suggests that these farmers will continue to rely on conventional hog farming and maintain their current business model of cost leadership. Comparing both classes, it is difficult to predict which class will be more successful in the future. An initial assessment suggests that reorientation towards greater animal welfare does not mean that farms become less efficient despite lower stocking rates (Uehleke et al., 2020).

State-funded buyout schemes are critically debated, this calls for a more in-depth analysis before launching such schemes in practice. It was surprising that in the latent class estimations only a few of the personal characteristics turned out to affect choices. Many farmers commented on the questionnaire that giving up pig farming is an emotional decision. One farmer stressed that he would like his barns to be demolished because looking at the empty stables would feel like a personal failure. Personal factors and social norms such as relations to neighbours or parents' expectations or their self-perception as an entrepreneur could be considered in future research. The influence of emotions on choices is well documented in the literature (Araña and León, 2009; Páez et al., 2008). They could provide additional important clues for the design of an advertising campaign for an exit scheme.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecolecon.2023.107853.

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