



Research article

Behavioral responses to regulatory push and market pull instruments: Experimental evidence from Danish agriculture

Kassa Tarekegn Erekaló ^{*} , Tove Christensen, Sigrid Denver, Søren Marcus Pedersen

Department of Food and Resource Economics, University of Copenhagen, Rolighedsvej 23, Frederiksberg C, 1958, Denmark

ARTICLE INFO

Keywords:

Policy mix
Emissions tax
Price premium
Land allocation
Randomized experiment
Denmark

ABSTRACT

This study examines how Danish farmers respond to two policy instruments, a tax on conventional farming and a market premium for climate-smart agriculture (CSA), when making land allocation decisions between conventional and CSA. Using a lab-in-the-field experiment with 251 farmers randomly assigned to control, tax, or premium treatments, we compare behavioral responses within the same context. Both instruments significantly increase CSA land allocation relative to the control group. On average, CSA allocation increases by approximately 5 ha (ha) under the tax treatment and 5.5 ha under the premium treatment, corresponding to increases of about 33% relative to the control mean. However, treatment effects vary across production systems: farmers already engaged in organic farming exhibit higher baseline CSA allocation but more moderate adjustments, whereas non-organic farmers show stronger behavioral adjustments. The findings suggest that a regulatory tax and a market-based premium influence land-use decisions and may address different adoption barriers across farmer groups, even when providing similar economic incentives. These findings highlight the importance of accounting for farmer heterogeneity and suggest that tailoring policy mixes to different production systems and sustainability orientations may enhance behavioral change toward agricultural sustainability.

1. Introduction

Denmark's Green Tripartite Agreement aims to achieve net-zero greenhouse gas (GHG) emissions from the agricultural sector by 2045 while substantially reducing nitrogen (N) leaching in line with EU environmental targets (CONCITO, 2024). Climate-smart agriculture (CSA) plays a key role in achieving these objectives, particularly through soil fertility improvement practices that reduce reliance on synthetic nitrogen inputs and lower associated emissions (Haider et al., 2025; Keesstra et al., 2024). Such practices include legume-based cropping systems (crop rotation, intercropping, and cover cropping) (Plaza-Bonilla et al., 2015; Stagnari et al., 2017), the use of alternative organic inputs (manure, compost, green manure, biofertilizers, and organic amendments) (Asghar et al., 2022), and precision agricultural technologies (PA) that optimize fertilizer application and reduce nitrogen losses (Barnes et al., 2019; Papadopoulos et al., 2024). These practices have a high potential to contribute to broader CSA outcomes (Erekaló et al., 2024). For instance, legume-based soil improvement systems can reduce environmental pollution associated with nitrogen leaching and volatilization (Hessel et al., 2022; Nadeem et al., 2019),

while supporting more sustainable and nutritious food and feed systems (Notz et al., 2023). Enhancing farmers' adoption of climate-smart soil improvement practices is therefore crucial for meeting both national climate targets and the EU's Farm to Fork objective of reducing chemical fertilizer use and agricultural GHG emissions (Keesstra et al., 2024; Heyl et al., 2023).

Despite the availability of agri-environmental subsidies, the adoption rate of these practices remains low (Gemtou et al., 2024; Hessel et al., 2022). This gap is driven by a combination of economic, structural, behavioral, and market-related barriers that jointly shape land-use decisions (Brown et al., 2021; Pedersen et al., 2024). Because these constraints differ across production systems and economic contexts, policy responses are likely to be heterogeneous rather than uniform across farmers. Some barriers relate to short-term profitability gaps and transition costs; others stem from risk attitudes, policy uncertainty, or limited and unstable demand for climate-friendly products (Pedersen et al., 2024). Behavioral factors such as status quo bias and perceived loss aversion may further inhibit adoption (Dessart et al., 2019). Because these barriers operate through different channels, focusing on various policy levers likely address them simultaneously (Brunelle et al., 2024);

^{*} Corresponding author.

E-mail address: kt@ifro.ku.dk (K.T. Erekaló).

<https://doi.org/10.1016/j.jenvman.2026.129783>

Received 6 October 2025; Received in revised form 17 April 2026; Accepted 20 April 2026

Available online 29 April 2026

0301-4797/© 2026 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

Di Santo et al., 2024). For instance, regulatory tax instruments discourage environmentally harmful practices by increasing their relative cost (Brunelle et al., 2024), whereas market-based incentives, such as price premiums, can improve expected returns and strengthen demand signals for sustainable agricultural production (Di Santo et al., 2024). This suggests that different policy instruments may address different adoption barriers. Sustained behavioural change may depend on considering alternative policy approaches that operate through different mechanisms (Wreford et al., 2017; Di Santo et al., 2024).

Agriculture remains a major source of GHG emissions in the EU (Stetter et al., 2026), highlighting the need for policy instruments focus on reducing emissions from agricultural production (Spiegel et al., 2025). In Denmark, a proposed agricultural emissions tax aims to place a price on GHG emissions from livestock (methane) and fertilizer use (Expert Group for a Green Tax Reform, 2024), thereby encouraging a shift away from high-emission, fertilizer-intensive farming practices. For instance, imposing a tax on chemical fertilizer can internalize environmental externalities by increasing the relative cost of fertilizer-intensive conventional practices (Johne et al., 2023). While such a tax is expected to influence farmers' production decisions, its behavioral impact remains uncertain, making Denmark a particularly relevant empirical context for examining anticipated behavioral responses.

At the same time, growing demand for sustainably produced food products has increased interest in leveraging demand-side instruments to enhance CSA adoption (Scherer and Verburg, 2017). In this regard, value chain development initiatives such as certification schemes and climate labeling, which can generate price premiums for climate-friendly production stimulate market demand for sustainable production (Alberto et al., 2024; Rossi et al., 2023). In Denmark, policy efforts aim to strengthen plant-based value chains with particular focus on legumes and promote food choices that reduce climate impacts (MFAFD, 2023). This may create market pull effects by enabling farmers to receive price premiums for climate-friendly production. Understanding how farmers respond to such demand-side incentives is particularly relevant in Denmark, where ambitious climate targets coexist with diverse farming systems and a well-developed organic and premium food market (Vos et al., 2025). Together, these developments create a relevant context for comparing regulatory tax instruments and market-based premiums within a single decision environment.

Sustainability transitions are typically shaped by multiple policy instruments rather than single measures (Rogge and Reichardt, 2016; Kern et al., 2019). Recent evidence highlights that substantial emission reductions in agriculture are often associated with policy mixes that combine regulatory, market-based, and informational instruments (Stetter et al., 2026). At the same time, adoption barriers and responses to policy instruments vary across farmers, due to differences in production systems, cost structures, and behavioral characteristics (Erekaló et al., 2025; Gemtoui et al., 2026; Pedersen et al., 2024). Although existing evidences emphasize the importance of considering different policy instruments in addressing agricultural sustainability challenges (Di Santo et al., 2024), evidence that directly comparing farmers' behavioral responses to regulatory and market-based instruments within the same institutional context remains limited. While economic incentives are generally expected to influence production decisions, little experimental evidence exists that compares regulatory tax push and market market-based price premiums pull instruments under controlled conditions. Moreover, relatively little is known about whether responses to alternative policy signals differ across production systems. This gap is particularly relevant in Denmark, where ambitious climate targets coexist with heterogeneous farming systems and a well-developed organic food market (Lund et al., 2013; Vos et al., 2025). To address this gap, this study asks: *How do farmers adjust land allocation decisions in response to a regulatory tax push and market price premium pull, and do these responses differ across production systems?* We examine this question through a behavioral experiment with Danish farmers, enabling causal identification of behavioral responses to regulatory and market-based

instruments under comparable institutional conditions.

While related studies exist, they differ in country context, intervention design, and analytical focus. For example, Thomas et al. (2019) and Feisthauer et al. (2023) conducted lab-in-the-field experiments with German farmers to examine how specific policy design features influence land allocation and technology adoption decisions. Outside experimental settings, Barbato and Strong (2023) explored the perspectives of conventional and organic farmers on adopting carbon-sequestering practices and concerns about voluntary agricultural soil carbon offset markets in the United States, while Sørensen et al. (2025) used a disaggregated dynamic simulation model to assess the structural effects of Denmark's planned GHG tax on livestock production. However, there is limited causal evidence comparing regulatory push and market pull instruments within the same institutional context. A growing body of literature examines farmers' participation in agri-environmental schemes and adoption of sustainable practices, emphasizing the role of behavioral and social factors (de Lauwere et al., 2022; Drescher et al., 2024; Sander et al., 2024; Caria et al., 2025), most existing studies rely on observational or simulation-based approaches. Emerging evidence further shows that accounting for behavioral heterogeneity and temporal dynamics can substantially alter predictions of policy effectiveness (Huber et al., 2023; Bojnec and Fertő, 2025; Fertő and Bojnec, 2025). Policy-oriented research also highlights the importance of economic instruments, such as emissions taxation, in shaping agricultural decisions, particularly in the Danish context (Sørensen et al., 2025; Turna, 2025).

However, causal evidence directly comparing farmers' behavioral responses to alternative policy instruments within a consistent decision-making framework remains scarce. In particular, experimental comparisons between regulatory instruments (e.g., taxes) and market-based incentives (e.g., price premiums) under comparable conditions are limited. This study addresses this gap by providing causal experimental evidence on how farmers adjust land allocation decisions in response to a regulatory tax and a market-based price premium under comparable economic incentives. Using a lab-in-the-field experiment with Danish farmers, we examine whether these instruments generate similar behavioral responses and how these responses vary across production systems. The experimental design enables a direct comparison of how regulatory and market-based policy instruments shape land allocation decisions under comparable economic conditions. The findings contribute to the literature by providing micro-level evidence on how farmers respond to alternative policy instruments and how these responses vary across production systems, offering insights for the design of policies aimed at promoting agricultural sustainability.

2. Conceptual framework and hypotheses

Policy instruments play an improtant role in shaping farmers' decisions to adopt environmentally friendly farming practices (Dean et al., 2023; Piñeiro et al., 2020). In the context of CSA, economic incentives, regulatory measures, and extension services are frequently used to address environmental externalities and promote sustainable production systems. However, barriers to CSA adoption vary across farmers due to differences in production systems and cost structures as well as environmental values and risk preferences. As a result, sustainability transitions are rarely achieved through a single policy instrument; rather, they typically require coordinated policy mixes that combine complementary tools addressing different barriers simultaneously (Howlett and Rayner, 2007; Rogge and Reichardt, 2016; Brunelle et al., 2024). While this study experimentally estimates the individual effects of two instruments, it situates them within a broader policy-mix perspective, recognizing that regulatory tax instruments and market-based price premiums operate through distinct but potentially complementary economic and behavioral channels.

Economic instruments addressing environmental externalities generally function in two ways. First, they can increase the cost of

environmentally harmful practices, thereby internalizing negative externalities and reducing the relative attractiveness of conventional production systems (Ejelöv et al., 2022; Späti et al., 2022). Second, they can increase the returns to sustainable practices by compensating for positive environmental externalities, either through public subsidies or market-based incentives such as certification and value-chain premiums (Brown et al., 2021; Rossi et al., 2023). In the context of this study, these approaches are commonly conceptualized as regulatory push and market demand-pull instruments. Regulatory push instruments typically operate by imposing cost pressure or compliance requirements that destabilize unsustainable regimes (Gnekpe and Plantec, 2023; Entsaló et al., 2023). In agriculture, emissions taxation on fertilizer use has been proposed as a mechanism to internalize environmental damages and shift production incentives (Johne et al., 2023; Yang et al., 2024). By contrast, market-pull instruments stimulate uptake of sustainable practices by strengthening demand signals and enhancing expected returns (Scotti et al., 2025). In this study, the regulatory push instrument is operationalized as a per-hectare emissions tax on conventional farming, while the market-pull instrument is operationalized as a per-hectare premium for CSA production.

From a standard economic perspective, land allocation decisions can be understood through Expected Utility Theory, which assumes that farmers allocate resources in order to maximize expected returns (Feder et al., 1985; Finger et al., 2024). Under this framework, a tax reduces the relative profitability of conventional farming, while a premium increases the relative profitability of CSA. Profit-maximizing farmers would therefore be expected to adjust land allocation toward the relatively more profitable option. However, empirical evidence suggests that farmers' decisions are not driven solely by profit maximization. Behavioral factors including risk attitudes may influence how economic changes are perceived and acted upon (Bocquého et al., 2014; Brown et al., 2021; Franceschinis et al., 2022). To capture a behavioral perspective, this study draws on insights from Cumulative Prospect Theory (Kahneman and Tversky, 1979), which suggests that individuals evaluate outcomes relative to a reference point and may respond differently to gains and losses. In this context, a tax may be perceived as a loss relative to existing profit expectations, whereas a premium may be perceived as a gain. While the experimental design does not estimate loss aversion parameters directly, comparing responses across tax and premium treatments allows exploration of whether behavioral adjustments differ under loss-versus gain-framed policy signals.

2.1. Regulatory push: tax instrument

The first treatment introduces a tax on conventional farming, reflecting the proposed Danish green tax on emissions from agriculture (Sørensen et al., 2025), with a focus on nitrogen-based chemical fertilizers. By increasing the costs associated with fertilizer-intensive practices, the tax reduces the relative profitability of conventional agriculture and creates economic pressure to adjust production strategies (Meyer-Aurich et al., 2020). When the profitability of conventional farming declines relative to what farmers used to have, they may reallocate land towards CSA alternatives, such as legume crops in crop rotation, the use of organic fertilizers (Haider et al., 2025), and the application of precision technologies (Späti et al., 2022). By increasing costs relative to the status quo, the tax may create perceived economic pressure that encourages adjustment toward lower-emission alternatives (Brunelle et al., 2024; Roxburgh et al., 2025). Accordingly, we test hypothesis one (H1): A tax on conventional farming will increase CSA land allocation.

2.2. Market pull: price premium instrument

The second treatment mimics market-based incentives, where food produced by CSA earns a price premium through certification and value-chain mechanisms (Fares and Mamine, 2023; Thompson et al., 2022).

Consumers' WTP a premium for climate-friendly certified food can create a perceived increased demand (Borouhaki et al., 2025) and encourage adoption of sustainable agriculture production methods (Barnes et al., 2022; Bjarklev et al., 2019; Enthoven et al., 2023). Thus, premium prices can be perceived as additional income and reduce the profitability gap between conventional and sustainable farming practices (Assefa et al., 2017; Gütschow et al., 2021; Sarker et al., 2025). This may create perceived gains relative to the status quo, thereby encouraging farmers to adopt sustainable farming practices (Fares and Mamine, 2023; Tschamtké et al., 2015). Accordingly, we test hypothesis two (H2): A premium price for CSA will increase CSA land allocation.

2.3. Heterogeneous responses

Farmers are not a homogeneous group, and variation across production systems may influence how policy signals are interpreted and acted upon (Ha et al., 2024; Gemtoui et al., 2026). Research on farm typologies highlights substantial differences in management practices, input intensity, and market orientation across farming systems (Ricart et al., 2024; Huber et al., 2023). In particular, organic and conventional farms differ in their reliance on synthetic inputs, cost composition, and revenue structures (Verdi et al., 2022; Rey Vicario et al., 2025). Such differences may be associated with variation in how changes in relative profitability induced by taxes or premiums translate into land allocation decisions. Responses to the introduced policy instruments may therefore not be uniform across farmer groups. Organic and conventional farmers differ in their production orientation, input dependency, and cost structures (Verdi et al., 2022; Rey Vicario et al., 2025), which may translate into different behavioral responses to regulatory tax push and market premium pull instruments. We therefore test the following hypothesis: H3: The effects of a regulatory push and a market pull instrument on CSA land allocation differ between organic and non-organic farmers.

3. Methodology

3.1. Experimental design and recruitment

We conducted a lab-in-the-field experiment with Danish farmers to examine land allocation decisions between conventional and CSA practices. Lab-in-the-field experiments combine the contextual realism of field settings with the internal validity of controlled experimental designs, thereby balancing external and internal validity (Gangadharan et al., 2022; Marette et al., 2011; Thomas et al., 2019). By recruiting actual farmers and embedding decisions within realistic farming scenarios, the study mimics real-world decision environments, while randomized treatment assignment ensures causal identification. The experiment was implemented as an online survey using SurveyXACT (<https://www.survey-xact.dk/>). Recruitment of participants and distribution of randomized survey links were managed by the research company ASPECTO (<https://www.aspecto.dk/>) through its national Danish farmer panel (4236 farmers). A sample was drawn to ensure variation in terms of age, farm size (50-100 ha (ha), 101-200ha, and greater than 200ha), and geographic location (five regions) and respondents were randomly assigned to one of the three experimental groups. The farm size categories were defined for the purpose of the study to capture variation across different farm structures, ranging from small to medium-sized to large-scale farms, and to broadly reflect the structure of Danish agriculture.

The implemented an online experimental survey enable participants to complete decision-making tasks via a web-based platform and to engage participants remotely in their familiar environments, allowing researchers to collect data more efficiently, reach broader geographic locations and reduce implementation costs (Arias Puentes and Trujillo, 2025; Rodd, 2024). Despite these strengths, however, some common challenges include maintaining participant attention and ensuring

comprehension as well as facilitating interactive decision-making (Arechar et al., 2018; Rodd, 2024). In our experiment, these limitations were minimized as our study involved no interactive elements and required decisions from only one participant. Another potential issue is the possibility of respondents interacting with others during the experimental task completion, which may affect data reliability. Accessing survey link requires secure login via ASPECTO's web platform, reducing the likelihood of external interference during completion.

Prior to data collection, we conducted power calculations using the *pwr* package in R (Stephane, 2020). Calculations were based on the standard ANOVA framework,¹ assuming a small-to-moderate effect size (Cohen, 1977; $d = 0.21$), a significance level of $\alpha = 0.05$, and desired power of 0.80. This indicated a minimum required sample size of approximately 74 participants per group (i.e. approximately 222 participants in total). To account for anticipated non-response (approximately 50%), 484 farmers were randomly invited from the panel. A pilot test with 25 farmers was conducted in December 2024. Based on feedback, we simplified scenario descriptions and shortened question texts to improve clarity. The final questionnaire was prepared in English, translated into Danish, and cross-checked by co-authors for linguistic accuracy and correct agricultural terminology. Of the invited panel members, 251 farmers completed the experiment between 16 January and 6 March 2025, slightly exceeding the minimum required sample size and ensuring adequate statistical power to detect treatment effects (Burke et al., 2015). The achieved sample size is consistent with the requirements of experimental designs, where statistical power and internal validity are the primary considerations. Internal validity is ensured through random assignment, while drawing participants from a large national farmer panel helps ensure representation across key characteristics such as farm size, age, and geographic location, consistent with the study's sampling criteria. The final sample consisted of 81 respondents in the control group, 81 in the tax treatment group, and 89 in the premium treatment group. The ethical approval for this study was obtained from the University of Copenhagen, with reference number 504-0216/25-7000.

The experimental task consisted of two rounds of land allocation decisions, each representing a hypothetical cropping year (see Supplementary Materials for the full questionnaire). Round 1 captured baseline land allocation preferences and familiarized participants with the decision environment. Round 2 introduced policy instruments and measured post-familiarization responses. For this experiment, the hypothetical land holding of 100ha was chosen by approximating the land holding of Danish farmers, which had an average of 83ha, with more than 20% of farmers owning more than 100ha (Danish Agriculture and Food Council, 2023).

3.2. Description of farming scenarios, experimental groups and incentives structure

3.2.1. Description of farming scenarios and associated profit amounts

The experimental task framed two alternative farming practices: conventional and CSA. CSA was described as soil improvement farming practices including legume-based cropping to enhance soil fertility and reduce reliance on chemical fertilizers (Ditzler et al., 2021; Notz et al., 2023; Stagnari et al., 2017), the use of organic fertilizers as substitute for chemical fertilizers (Asghar et al., 2022; Brenzinger et al., 2021; Zimmermann et al., 2021) and PA technologies to optimize fertilizer application and reduce nitrogen losses (Agrimonti et al., 2021; Takács-György and Takács, 2022). In contrast, the conventional farming

practice was described as fertilizer-intensive production relying on chemical fertilizers applied using standard techniques.

Following Piñeiro et al. (2020), the farming scenarios were framed to explicitly highlight the trade-off between the short term economic returns and environmental outcomes. Participants were informed that conventional farming offers higher short-term profits but entails long-term environmental costs, whereas CSA involves lower short-term profitability but improves long-term soil fertility and environmental sustainability. This framing is consistent with empirical evidence showing that conventional farming typically yields higher short-term returns than CSA (Sain et al., 2017). To reflect realistic Danish farming conditions, we assumed a gross margin² of 8000 DKK³ per ha for conventional farming as proxy for cereal farming. This value aligns with Danish national farm budget models, where cereal crop gross margins typically range between 5000 and 13,000 DKK per ha depending on crop type and soil quality (SEGES, 2025). For CSA, we assumed a gross margin of 6800 DKK per ha, including a 300 DKK per ha environmental bonus. This represents approximately a 15% lower gross margin than conventional farming, consistent with empirical estimates reporting a 13.13% gross margin gap between organic and conventional systems (Riar et al., 2024). To reinforce the economic-environmental trade-off, a short explanatory note was included at the end of the scenario description, emphasizing the contrast between higher short-term profitability in conventional farming and the long-term sustainability benefits associated with CSA, following the framing approach used by Thomas et al. (2019).

3.2.2. Treatments and control

This experiment employed two policy instruments to examine their effects on CSA adoption decision making. Treatment descriptions included explicit economic consequences and short notes about potential future uncertainty to reflect realistic policy and market dynamics in Round 2.

3.2.2.1. Treatment 1: green tax on conventional farming practices (regulatory push). Participants in this group were informed: "To promote sustainable agricultural practices and reduce environmental impacts, the government has introduced an agricultural emissions tax (including nitrogen leaching, nitrous oxide, and CO₂ emissions) on conventional farming practices based on expert recommendations. This tax is part of a broader strategy to encourage sustainable practices through environmental cost adjustment on conventional farming. This tax is applied due to conventional farming's significant reliance on chemical fertilizers, which contribute to nitrogen leaching into aquatic ecosystems and CO₂ emissions during production and use. Suppose the tax is set at 700 DKK per ha for farmers using conventional methods. Note that the government may revise the tax rate in the future, which could result in an increase, decrease, or removal, depending on policy evaluations and feedback."

3.2.2.2. Treatment 2: premium for CSA (market pull). Participants in this group were informed: "Growing consumer awareness of sustainable agriculture has increased demand for climate-friendly food products. Suppose that you have the opportunity to enter into a contract to deliver climate-friendly products produced by implementing climate-smart agricultural practices. Imagine that these products will receive a special label called "climate-friendly produced food," making them eligible to be sold at a premium price. This premium reflects the market's willingness to pay more for sustainably produced goods. As a result, farmers who adopt climate-smart practices can receive a premium price of 700

¹ Note that even though we have used ANOVA for power calculation, which was prior to data collection, for testing of CSA land allocation across three groups after data collection we have employed the Kruskal-Wallis test since the normality test result for outcome variable was rejected the null-normal distributed.

² Gross margin = production value minus variable input costs (excluding labor and machinery costs).

³ 1 EUR = 7.45 DKK (European Central Bank, August 2025) (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:C_202503806)

DKK per ha through contracts with food companies that offer certified climate-friendly labels. Note that the consumer's willingness to pay for climate-friendly products may increase or decrease in the future, depending on market trends."

3.2.2.3. Control scenario: neutral information. The control group received neutral agricultural background information without any policy modification: "Denmark has a temperate climate with plenty of rain, a flat landscape, and fertile soils. About 60% of Denmark's total area is cultivated. The average farm size is 83 ha, but more than 20% of the farms exceed 100 ha of land." (Danish Agriculture and Food Council, 2023)". This description was included to maintain participant engagement and ensure consistency in task presentation across experimental groups without simply repeating the Round 1 scenario (Feisthauer et al., 2023). The content is purely descriptive and limited to general agricultural statistics; it does not introduce any economic incentives, policy signals, or directional framing related to climate-smart practices, thereby preserving a valid baseline for comparison.

3.2.3. Incentive structure and experimental validity

The incentive mechanism was designed to ensure participant engagement across both decision rounds, maintain internal validity, and remain consistent with the project budget. As described in Section 3.2.1, conventional farming was assigned a higher baseline gross margin than CSA. This differential reflects observed differences in short-term profitability and was introduced to capture the economic trade-off commonly associated with CSA adoption. Without such a differential, the experimental setting would not reflect the profitability gap frequently discussed in the literature, nor would it allow meaningful identification of how policy instruments alter relative economic incentives. The total profit was given by the following formula:

$$\text{Total profit} = (8000 - \tau) \times \text{conventional ha} + (6800 + \pi) \times \text{CSA ha},$$

Where, τ represents a per-hectare tax, while π denotes a per-hectare premium on CSA. The parameter values varied across rounds and experimental groups ($\tau = 0, \pi = 0$ for all groups in Round 1, $\tau = 0, \pi = 0$ for Round 2 in the control group, $\tau = 700, \pi = 0$ for Round 2 in tax, and $\tau = 0, \pi = 700$ for Round 2 in premium). Thus, the tax and premium symmetrically modified relative profitability by 700 DKK per hectare, enabling direct comparison between regulatory (push) and market-based (pull) instruments. Importantly, conventional farming remained more profitable per hectare than CSA in all scenarios; neither treatment reversed the relative profitability ranking. The policy instruments reduced the profitability differential, allowing identification of behavioral adjustments to marginal changes in relative returns without inducing a corner solution.

Participants received a fixed participation fee of 100 DKK to compensate for the time spent completing the questionnaire. In addition, they had a 5% probability of winning a lottery (13 out of 251 participants). Depending on land allocation decisions, lottery winners could earn up to approximately 1600 DKK. The lottery payoff was calculated as:

$$\text{Lottery payoff (DKK)} = \frac{\text{Total profit for allocated land}}{500}$$

The divisor of 500 served as a scaling factor to convert profit into feasible DKK payments while keeping total payouts aligned with the project's lottery budget (20000 DKK). With 13 lottery winners, this ensured a maximum possible payout of 1600 DKK per winner.

Importantly, the 5% lottery winning probability was fixed and identical across all participants, regardless of treatment assignment or land allocation. Although total potential earnings varied with profit levels based on land allocation choices, the probability of winning did not depend on the share of land allocated to either CSA or conventional farming. Because the probability of winning was fixed and independent

of individual decisions, expected monetary earnings were strictly increasing in total profit. Therefore, participants maximized expected payoff by maximizing profit through their land allocation choices, ensuring incentive compatibility. For this experiment, only one randomly selected round was paid for each lottery winner, and lottery winners were randomly drawn from the full sample. Such probabilistic payment mechanisms are widely used in multi-round experimental designs to maintain decision salience. Prior research shows that low-probability lottery incentives generate behavioral responses statistically comparable to fully paid designs, thereby preserving internal validity (Ahles et al., 2024; Aydogan et al., 2024).

3.3. Control variables

To account for potential confounding influences on land allocation decisions, we included a set of behavioral, attitudinal, institutional, and structural control variables identified in prior research on sustainable agriculture adoption. Among behavioral and attitudinal factors, risk aversion has been shown to affect responsiveness to economic policy instruments (Waq et al., 2021). The financial risk aversion construct was measured using multiple Likert-scale items adapted from Degieter et al. (2023) and Feisthauer et al. (2024). Similarly, personal environmental norms construct, which influence the adoption of sustainable practices (Franceschinis et al., 2022), were measured using Likert-scale statements capturing perceived moral obligation toward climate-friendly farming. For both constructs, factor scores were extracted using principal component analysis with varimax rotation and standardized before inclusion in the regression models (see Supplementary Table 2). Institutional trust affects participation in agri-environmental schemes (Bartkowski et al., 2023; Sander et al., 2024). Accordingly, trust in government agricultural policy was measured on a five-point scale ranging from 1 ("no trust at all") to 5 ("complete trust"). Policy and market uncertainty can shape acceptance of environmental instruments (Dewally et al., 2025); therefore, two separate five-point items captured perceived uncertainty regarding (i) government policy changes and (ii) market stability.

Farmers' evaluations of profitability and environmental benefits also play role in adoption decisions-making (Canessa et al., 2024; Vatn et al., 2020; Sarker et al., 2025). Respondents rated agreement with four statements reflecting land allocation motives: (i) minimizing climate impact, (ii) balancing climate benefits and profit, (iii) perceiving climate benefits as insufficient relative to profit loss, and (iv) maximizing profit. Evidence also indicated that past implementation experience influences subsequent adoption behavior (Denny et al., 2019; Kernecker et al., 2020). We constructed an index of prior CSA-related practices implementation based on self-reported responses for five practices that aligned with experimental scenario in this study. Furthermore, awareness of CSA was measured using a categorical variable reflecting respondents' prior familiarity with climate-smart agriculture (Li et al., 2024; Rezaei et al., 2019). Finally, structural farm characteristics including age, farming experience, farm size, main production system, and region, were included as controls based on their documented association with sustainable practice adoption (Amadu et al., 2020; Li et al., 2024). A detailed description of all control variables, coding procedures, and measurement scales is provided in Table Appendix A1.

3.4. Data analysis

3.4.1. Main estimation strategy

The primary outcome variable was hectares of land allocated to CSA in Round 2, measured as the amount of CSA land out of a total of 100 ha. Because the allocation variable is bounded between 0 and 100 ha and exhibits non-normal distributional properties, we first employed the Kruskal-Wallis test, a non-parametric alternative to ANOVA, followed by Dunn's post-hoc test for pairwise group comparisons. For parametric estimation, we employed OLS as the main regression model with two

specifications. Model 1 includes treatment indicators and controls for CSA land allocation in Round 1 to account for baseline variation. Model 2 adds key covariates to assess the stability of treatment effects after controlling for observable farmer characteristics.

3.4.2. Robustness checks

As a robustness check, three additional regression models were employed to assess whether the results of the main model were consistent under alternative specifications. First, we employed OLS regression, considering the change in CSA land allocation for Round 2 and Round 1 as the dependent variable, while using the same set of independent variables as in the main model. Second, we estimated a Tobit regression model employing the same dependent variable with the same independent variables used in the main OLS model to account for potential censoring, as land allocation is bounded between 0 and 100 ha. Third, we estimated a fractional logit model using the proportion of CSA land allocated in Round 2 (CSA hectares divided by 100) to test sensitivity to functional form assumptions.

3.4.3. Post-experimental validity diagnostics

To assess potential behavioral biases commonly discussed in experimental research, we included two post-experimental self-report measures capturing social desirability bias (SDB) and experimental demand effects (EDE) (Joinson, 1999; Ried et al., 2022). Respondents rated their agreement with the statement: "I made decisions that I believed would reflect positively on me, even if they did not align with my actual preferences" to capture perceived social desirability bias. To assess experimental demand effects, respondents rated agreement with the statement: "I felt free to make decisions based on my preferences, without any influence from the experiment". This measure captures perceived autonomy and potential susceptibility to experimental demand. We examined pairwise correlations between these measures and CSA land allocation in Round 2 to assess whether allocation decisions were systematically associated with perceived social desirability or experimental demand effects. To further evaluate behavioral consistency, we examined correlations between experimental allocation decisions and (i) past CSA implementation experience and (ii) stated future CSA adoption intentions. This provides a behavioral validity check on the alignment between experimental choices and prior behavior or stated intentions (Sheeran et al., 2017). Finally, we assessed whether perceived salience of the monetary incentive influenced allocation decisions. Although the lottery probability was fixed and identical across participants, total earnings were linked to experimental profit and conventional farming yielded higher baseline returns. To examine whether variation in responsiveness was primarily driven by attention to the incentive mechanism rather than treatment-induced changes in relative profitability, we included a post-experimental five-point measure capturing the extent to which respondents considered the lottery opportunity when making their decisions. We first examined pairwise correlations between perceived lottery consideration and CSA allocation. We then included this measure as an additional control variable in regression models to test whether treatment effects remained stable after accounting for perceived incentive salience.

3.4.4. Heterogeneity analysis

Differences in production systems may lead to heterogeneous responses to policy instruments (Mkupete and Davalos, 2025; Pedersen et al., 2020). In particular, organic and conventional farms differ in input use, cost structures, and market orientation, which may condition responsiveness to regulatory and market-based incentives (Thompson et al., 2022; Baker et al., 2020). To test Hypothesis 3, we conducted subgroup analyses based on organic farming orientation. Organic status was captured using a binary indicator reflecting whether farmers reported implementing certified organic practices. To assess differential treatment effects, we included interaction terms between organic status and each treatment indicator in the regression models.

4. Results

4.1. Distribution of CSA land allocation

Before proceeding with further analysis, baseline balance checks were conducted to verify the randomization and distribution of sampled respondents across experimental groups with respect to observed and selected unobserved variables. The descriptive statistics results of the chi-square test showed that randomization was successfully achieved, as no significant differences in observed variables appeared across groups (Supplementary Table 1). However, the balance check suggested a marginally significant difference in organic adoption status across the groups ($p = 0.093$), indicating some variation. Although this result is not statistically significant, it suggests that adopters of organic farming may differ systematically in their attitudes or behaviors from non-adopters across the experimental groups.

The distribution of land allocations (100ha) decisions between CSA and conventional farming by the sampled respondents shows that, in Round 1, mean CSA land allocation was approximately 15 ha in the control and premium groups and 13.4 ha in the tax group (Fig. 1). In Round 2, CSA allocation increased in both treatment groups. The premium group increased to 22.25 ha and the tax group to 20.78 ha. Overall, the increased CSA land allocation corresponded to a rise in CSA land share from around 25%⁴ to 33% in Round 2. Allocation decisions exhibited heterogeneity: some farmers allocated zero hectares to CSA, while others allocated up to 60 ha (Supplementary Table 3).

The Kruskal–Wallis test confirmed significant differences in Round 2 CSA allocation across groups (Supplementary Table 4). Dunn's post-hoc test showed that both treatment groups allocated significantly more land to CSA than the control group, with no significant difference between treatments. The Wilcoxon signed-rank test further indicated a significant within-subject increase from Round 1 to Round 2 (Supplementary Table 5), consistent with treatment-driven behavioral adjustments.

4.2. Treatments effects on CSA land allocation: regression results

We estimated treatment effects on CSA land allocation in Round 2 using two complementary specifications. Model 1 includes treatment indicators and baseline CSA land allocation (Round 1), while Model 2 additionally incorporates attitudinal, socio-economic, and regional controls. Across both specifications, the tax and premium treatments are positive and statistically significant relative to the control group (Table 1). In Model 2, which includes the full set of controls, the tax treatment increases CSA land allocation by approximately 5 ha, while the premium treatment increases allocation by approximately 5.5 ha. Although the premium coefficient is slightly larger in magnitude, a post-estimation test indicates no statistically significant difference between the two treatments ($F(1,247) = 0.11, p = 0.746$). These results suggest that both regulatory push and market pull instruments induce comparable increases in CSA land allocation under the experimental conditions.

Regarding control variables, risk aversion is negatively and significantly associated with CSA land allocation, indicating that more risk-averse farmers are less likely to reallocate land toward CSA. Perceived uncertainty about government policy changes also shows a negative and significant association. Similarly, respondents who reported prioritizing profit maximization in their land allocation decisions allocated significantly less land to CSA. Baseline CSA allocation (Round 1) is positively and significantly associated with Round 2 allocation, suggesting persistence in land-use decisions and possible path dependence. Other attitudinal and structural variables, including past CSA experience,

⁴ The value was calculated as difference between CSA land under each treatment and control group divided by control group's land allocation, expressed as a percentage.

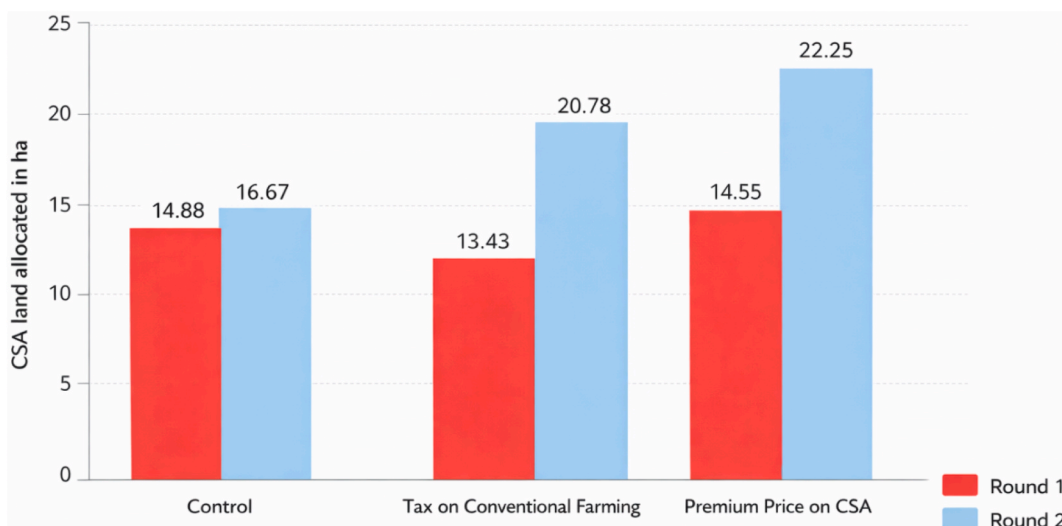


Fig. 1. Average CSA land allocation by experimental groups and rounds (raw data).

Table 1
OLS regression results on the effects of treatments on CSA land allocation (Round 2).

	Model 1	Model 2
VARIABLES	Coeff (St. Err)	Coeff (St. Err)
Tax on chemical fertilization (Yes)	5.584*** (1.350)	4.973***(1.140)
Premium price for CSA (Yes)	5.796*** (1.181)	5.481***(1.268)
Past CSA Experience		1.526(1.957)
Organic adoption status (Organic farmer)		-1.703 (1.110)
Risk aversion factor		-2.303*** (0.629)
Personal norm factor		0.318(0.802)
Trust in government agricultural policies		0.232(1.123)
Uncertainty about government policy changes		-2.438*** (0.716)
Uncertainty about market stability		-0.310(0.848)
CSA Awareness: Heard, not informed		0.576(1.343)
CSA Awareness: Somewhat aware		3.397(2.194)
Minimizing the climate impact motive		0.512(0.938)
Balance climate benefits and profit motive.		0.097(0.843)
Profit outweighs the climate motive.		-0.957(1.065)
Maximizing the profit motive		-2.103** (1.033)
Age (Continuous)		-0.029(0.076)
Farming experience: 11 to 20 years		0.968(1.997)
Farming experience: More than 20 years		1.040(2.644)
Farm size: 101 to 200ha		1.457(1.549)
Farm size: greater than 200ha		0.875(1.255)
CSA land allocation in R1	0.924*** (0.043)	0.811*** (0.063)
Region Zealand (Sjælland)	-0.137(2.417)	-1.203(2.161)
Region of Southern Denmark (Syddanmark)	-1.714(2.220)	-2.497(2.024)
Central Denmark Region (Midtjylland)	-3.806* (2.097)	-3.707** (1.873)
North Denmark Region (Nordjylland)	-1.388(2.452)	-2.574(2.200)
Constant	23.945** (9.989)	4.881** (2.029)
Observations	251	251
R-squared	0.649	0.717

Note: Robust standard errors in parentheses, ***p < 0.01, **p < 0.05, *p < 0.1. Base categories: Awareness CSA: I had never heard of CSA, Farming experience: Less than 10 years, Farm size: less than 100ha, Capital Region of Denmark (Hovedstaden), Model 1: focuses on treatments only, Model 2: adds attitudinal and socio-economic variables. For reference, the regression results based on only treatments are reported in the Supplementary Materials (Table 6). The results confirm that the treatment effects remain consistent with the two model specifications reported here.

personal environmental norms, trust in government, perceived market uncertainty, other motivational categories, and prior CSA awareness, are not statistically significant in the fully specified model. Among structural controls, farmers located in the Central Denmark Region allocated significantly less land to CSA relative to the reference region, indicating potential spatial heterogeneity. Other socio-economic characteristics, including age, farming experience, and main production system type, do not show statistically significant effects. Overall, the treatment effects remain stable across specifications, and model fit improves with the inclusion of controls (adjusted R² increases from 0.649 to 0.717), reinforcing the robustness of the estimated policy effects.

Base categories: Awareness CSA: I had never heard of CSA, Farming experience: Less than 10 years, Farm size: less than 100ha, Capital Region of Denmark (Hovedstaden), Model 1: focuses on treatments only, Model 2: adds attitudinal and socio-economic variables. For reference, the regression results based on only treatments are reported in the Supplementary Table 6. The results confirm that the treatment effects remain consistent with the two model specifications reported here.

4.3. Robustness check results

Regression models using the change in CSA land allocation between Round 1 and Round 2 as the dependent variable yield results consistent with the main specifications (see Supplementary Tables 7–9). Across all robustness models, including the change specification, Tobit, and fractional logit models, both the green tax and the CSA premium remain positive and statistically significant predictors of CSA land allocation. As expected, the OLS model using the change specification exhibits lower explanatory power (R²) compared to models that use Round 2 allocation while controlling for baseline allocation. This likely reflects reduced cross-sectional variation once baseline differences are differenced out. Importantly, however, the direction, magnitude, and statistical significance of the treatment effects remain stable across specifications. Moreover, behavioral variables, particularly risk aversion and policy uncertainty, consistently showed a significant association across robustness models, reinforcing the consistency of the main findings.

4.4. Post-experimental bias diagnostics results

Correlation analyses indicate that neither SDB nor EDE significantly associated with CSA land allocation in Round 2 (see Supplementary Table 10). This suggests that allocation decisions were not systematically driven by perceived social expectations or experimenter influence. The absence of significant bias effects is consistent with the anonymous,

online, self-administered survey format, which has been shown to reduce social desirability pressures (Charness et al., 2012; Joinson, 1999; Kaine and Wright, 2024). Similarly, the neutral framing of the experimental tasks may have limited potential demand effects (Ried et al., 2022). Moreover, consistent with Howley and Ocean (2022), random allocation of respondents to experimental groups ensures any socially desirable bias is likely to be evenly distributed across groups. We also observe positive and statistically significant correlations between past CSA experience and Round 2 allocation, as well as between stated future adoption intentions and experimental decisions. These associations suggest behavioral consistency between prior behavior, stated intentions, and experimental choices, supporting the external relevance of the findings (Sheeran et al., 2017). We evaluated whether the incentive structure systematically biased allocation decisions toward conventional farming. Pairwise correlations between lottery consideration and CSA allocation are small and statistically insignificant (see Supplementary Table 11). We further re-estimated both the baseline and fully controlled OLS models including lottery consideration as an additional covariate (see Supplementary Table 12). The coefficient on lottery consideration is small and statistically insignificant across specifications. Importantly, the estimated effects of the tax and premium treatments remain positive, statistically significant, and similar in magnitude when lottery consideration is included. Together, these findings suggest that allocation decisions do not appear to be driven by strategic optimization of lottery payoffs, but rather by treatment-induced changes in relative profitability.

4.5. Heterogeneous analysis results

The next step was to examine whether treatment effects differ between organic and non-organic farmers. Organic farming orientation is not significantly associated with CSA land allocation in the fully specified main model, indicating no average difference in Round 2 allocation after controlling for other characteristics. However, we observe differences in CSA land allocation by organic adoption status (Fig. 2). For instance, the interaction terms that capture whether organic farmers react differently to either tax or premium than non-organic farmers show some differences. The test results in Table Appendix A2 indicate that the interaction terms from the regression results support this interpretation. The Tax \times Organic interaction is negative and marginally significant (-4.7 ha), indicating that non-organic farmers allocate 4.7ha less to CSA compared to organic farmers, consistent with weaker tax responses among organic farmers at the 10% level. The Premium \times Organic interaction is negative but not statistically significant. The CSA land allocation for organic farmers under control was already high at 16.79 ha, but only increased to 19.55ha under tax and 21.15ha under premium (see Fig. 2). Predicted values (Table Appendix A3; Fig. 2) illustrate these differences. Among non-organic farmers, CSA allocation increases from 15.7 ha (control) to 23.1 ha (tax) and 22.8 ha (premium). Among organic farmers, allocation increases from 16.8 ha to approximately 19.6 ha under both instruments, with wider confidence intervals. Conditional average marginal effects (CATEs)⁵ in Table Appendix A4 confirm that non-organic farmers exhibit stronger responses to both treatments ($+7.1$ to $+7.5$ ha, $p < 0.001$), whereas organic farmers show more modest increases ($+2.8$ ha under tax; $+4.4$ ha under premium). These findings suggest that both regulatory and market-based instruments generate stronger marginal adjustments among non-organic farmers, while organic farmers, who already allocate relatively more land to CSA at baseline, exhibit smaller incremental responses.

⁵ CATEs represent a subgroup-specific treatment effects estimates for subpopulations.

5. Discussion

Our findings demonstrate that both regulatory tax and market price premium instruments significantly increase CSA land allocation. The similar effect sizes observed across the two treatments suggest that, when incentives are comparable in magnitude, farmers respond primarily to changes in relative profitability rather than to whether the policy is implemented as a tax or a premium. This is reflected in the comparable increases in CSA allocation, with the tax increasing CSA allocation by approximately 5 ha, and the premium by approximately 5.5 ha relative to the control group. This corresponds to an increase of roughly 32–35% compared with the control group's mean CSA allocation of 16.7 ha in Round 2. Importantly, these effects remain robust across alternative model specifications and when controlling for behavioral, structural, and socio-economic factors. Although CSA was modeled as less profitable than conventional farming in the baseline scenario (a 15% gross margin gap equivalent to 1200 DKK/ha), farmers still allocated a substantial share of land to CSA (approximately 17% on average). This suggests that land allocation decisions are not driven solely by short-term profit maximization, but may also reflect environmental motivations, longer-term soil considerations, or production diversification strategies. This interpretation is consistent with recent literature emphasizing the role of behavioral factors in shaping farmers' adoption decisions (de Lauwere et al., 2022; Drescher et al., 2024; Huber et al., 2023), and aligns with prior research highlighting the importance of pro-environmental values and stewardship norms in agricultural decision-making (Piñeiro et al., 2020). At the same time, the results indicate that such motivations coexist with strong responses to economic incentives. The regulatory tax on conventional farming increased CSA land allocation. In the experiment, the tax reduced conventional farming profitability from 8000 to 7300 DKK/ha and resulted a positive behavioral response by increasing CSA allocation. This suggests that increasing the cost of conventional farming to internalize environmental costs may encourage farmers to reallocate land toward CSA by altering perceived relative profitability. This finding aligns with prior evidence that environmental taxation influences agricultural decision-making by changing relative price incentives (e.g., Johné et al., 2023; Vatn et al., 2020; Sørensen et al., 2025; Turna, 2025). While previous studies have largely relied on simulation or observational approaches, our results provide direct behavioral evidence of how farmers adjust decisions in response to taxation under controlled conditions. The Danish context is particularly relevant given the planned policy on agricultural emissions taxation. However, post-experimental responses indicate limited support, with only 23% of respondents expressing some degree of support. This resistance is consistent with broader evidence showing that carbon and environmental taxes often face stakeholder opposition, even when they are economically efficient and environmentally effective (Carattini et al., 2018). Notably, despite this modest support, farmers adjusted their land allocation in response to the tax in the experimental setting. This divergence between stated support for the policy and experimental land allocation decisions indicates that, in this setting, farmers adjusted their decisions in response to the tax despite limited expressed support for its implementation.

The premium price on CSA treatment also increased CSA land allocation. The increased CSA profitability from profitability from 6800 to 7500 DKK/ha in this study case, and led to a corresponding increase in CSA allocation. This suggests that increasing the perceived returns to CSA can encourage farmers to reallocate land toward CSA by improving relative profitability. Even though CSA remained less profitable than conventional production, farmers significantly increased CSA allocation under premium treatment. This finding is consistent with prior research showing that market-based incentives can promote the adoption of sustainable practices by improving economic returns (e.g., Jespersen et al., 2017; Barnes et al., 2022). This further suggests that reducing market uncertainty plays an important role in encouraging adoption. In Denmark's relatively mature organic food market,

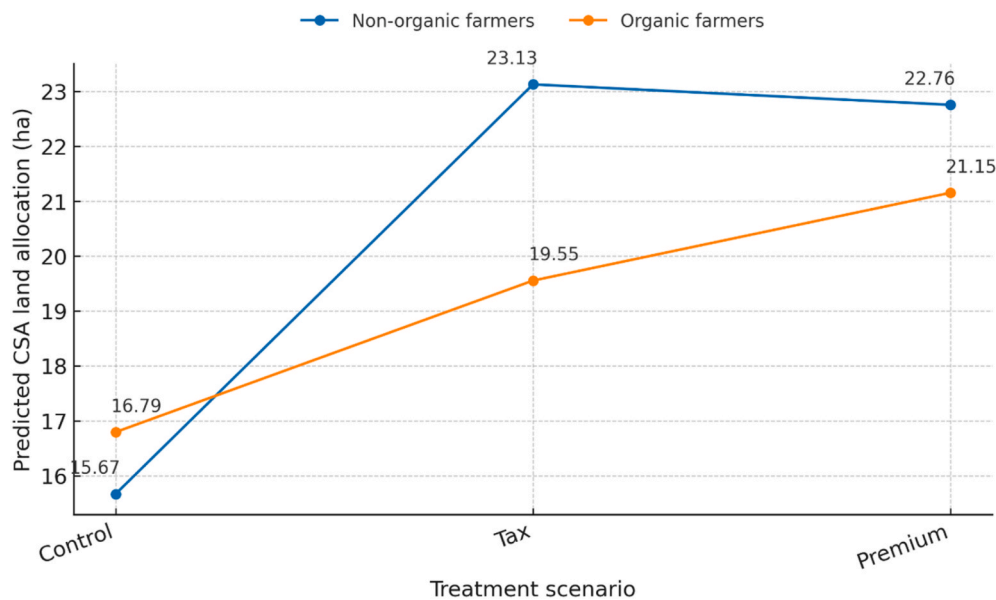


Fig. 2. Predicted CSA land (Round 2) by experimental groups vs organic farming adoption.

additional financial incentives may yield diminishing marginal effects among farmers already engaged in sustainable production systems. This interpretation is consistent with literature suggesting that additional incentives may generate limited behavioral change among intrinsically motivated actors (Gneezy et al., 2020; Deci et al., 1999).

The heterogeneity analysis indicates that treatment effects are primarily concentrated among non-organic farmers. Organic farmers, by contrast, start from a higher baseline CSA allocation and show more moderate responses to both instruments. While both organic and conventional farmers increased CSA allocation under the tax and premium treatments, the marginal responses were substantially larger among conventional farmers. However, given the relatively small subgroup sample sizes and wide confidence intervals, these differences should be interpreted with caution. Sample sizes and wide confidence intervals, these differences should be interpreted with caution. However, given the relatively small subgroup sample size and wide confidence intervals, these differences should be interpreted with caution. One possible explanation is that organic farmers are already environmentally oriented and accustomed to sustainability premiums (Han et al., 2021; Leduc et al., 2023). Additional incentives may reduce marginal responses among farmers who have already adopted sustainability-oriented practices (Leduc et al., 2023; Rizzo et al., 2023; Gneezy et al., 2020; Pedersen et al., 2020). In contrast, conventional farmers appear more responsive to changes in relative economic incentives, consistent with evidence that motivational heterogeneity shapes responses to agri-environmental policies (Pedersen et al., 2020). The results suggest that economic policy instruments may play an important role in inducing initial transitions among conventional producers, whereas additional financial incentives may generate smaller marginal adjustments among farmers already engaged in sustainable production systems. This pattern suggests that adoption barriers and policy effectiveness differ across production systems, highlighting the importance of targeting policy instruments to different farmer groups. These results suggest that regulatory tax and market-based premium instruments may lead to broadly similar behavioral responses when economic incentives are aligned, despite differences in their institutional design (Rogge and Reichardt, 2016; Howlett and Rayner, 2013; Stetter et al., 2026). Overall, promoting CSA may require not only appropriate policy instruments but also alignment with farmer characteristics and the specific economic and behavioral barriers they face.

We acknowledge the following limitations. First, although the

experimental scenarios were designed to approximate realistic agricultural trade-offs, land allocation decisions were hypothetical. Monetary incentives were implemented through a low-probability (5%) lottery mechanism. While robustness checks show that perceived lottery consideration did not significantly affect CSA allocation and treatment effects remain stable when controlling for lottery salience, respondents varied in how strongly they considered the lottery. Thus, although the incentive mechanism did not systematically bias results toward conventional allocation, its motivational salience may have differed across participants. Future research could compare probabilistic and deterministic payment schemes to further assess their influence on decision salience and behavioral responses. Second, although the anonymous online format likely reduced social desirability bias and experimental demand effects (Charness et al., 2012; Joinson, 1999; Ried et al., 2022), these were measured using brief self-report items rather than validated multi-item scales. While correlations with CSA allocation were no statistically significant, these diagnostics should be interpreted cautiously.

Third, the experiment employed a single tax and premium level (700 DKK/ha) to enable direct comparison between instruments. Incentive magnitudes were not varied to examine nonlinear or threshold effects. In practice, fertilizer taxes and market premiums differ across contexts. Future research should therefore explore alternative incentive levels to examine how behavioral response patterns vary with the magnitude of economic incentives. Finally, while the treatments were conceptually informed by insights from prospect theory, the study estimates average treatment effects rather than structural behavioral parameters. Future research using experimental designs that explicitly manipulate gain-loss framing and uncertainty conditions could help formally test behavioral asymmetries. Complementing experimental approaches with qualitative interviews could further illuminate how farmers interpret and respond to economic instruments in real-world settings.

6. Conclusion

This study experimentally examined how Danish farmers respond to two policy instruments aimed at promoting CSA: a regulatory emissions tax on conventional farming and a market-based premium for CSA. Our results provide micro-level behavioral evidence on how regulatory push and market-pull instruments influence agricultural land-use decisions within a controlled experimental setting. Under identical experimental conditions, both instruments significantly increased CSA land allocation

relative to the control group. On average, CSA allocation rose from approximately 25% of land in the control condition to about 33% under either policy instrument. The findings also reveal heterogeneous responses across farmer groups. Non-organic farmers exhibited stronger marginal responses to both the tax and the premium, whereas organic farmers displayed higher baseline CSA allocation but more moderate treatment effects. In addition, behavioral and institutional factors, particularly risk aversion and perceived policy uncertainty, were negatively associated with CSA allocation, highlighting that adoption decisions are shaped not only by relative profitability but also by uncertainty perceptions and individual risk profiles. More broadly, the results suggest that both regulatory taxes and market-based premium instruments can influence land allocation decisions through relative economic incentives change. Within this experimental context, the evidence suggests that different farmer segments may respond differently to economic instruments. Accordingly, climate-related agricultural policies may benefit from policy mixes that are tailored to address heterogeneous adoption barriers and differences in sustainability orientation across farmer groups.

CRedit authorship contribution statement

Kassa Tarekegn Erekaló: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tove Christensen:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition. **Sigrid Denver:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Søren Marcus Pedersen:** Writing – review & editing, Validation, Supervision, Resources, Project

Appendixes

Appendix Table A1

Definition and Measurement of Control Variables

Variable	Measurement and Coding	Description
Past CSA experience	Index (0–5); sum of five CSA practices (Yes = 1, No = 0)	Prior implementation of CSA-related practices
Risk aversion (factor score)	Standardized factor score derived from Likert-scale items (1-5)	Financial risk sensitivity and short-term loss avoidance
Personal environmental norms (factor score)	Standardized factor score derived from Likert-scale items (1-5)	Moral obligation toward climate-friendly farming
Trust in government agricultural policy	Continuous (Likert scale, 1-5)	Institutional trust in agricultural sustainability policy
Uncertainty about government policy	Continuous (Likert scale, 1-5)	Perceived regulatory instability
Uncertainty about market stability	Continuous (Likert scale, 1-5)	Perceived demand and price volatility
CSA awareness	Categorical variable	(1) Never heard (base); (2) Heard but not informed; (3) Somewhat aware; (4) Fully aware
Minimize climate impact motive	Continuous (Likert scale, 1-5)	Primary motivation: climate impact reduction
Balance climate benefits and profit motive	Continuous (Likert scale, 1-5)	Equal weighting of environmental benefits and profitability
Climate benefits insufficient relative to profit	Continuous (Likert scale, 1-5)	Perception that climate benefits do not outweigh profit reduction
Maximize profit motive	Continuous (Likert scale, 1-5)	Primary motivation: profit maximization
Age	Continuous (years)	Respondent age
Farming experience	Categorical variable	(1) <10 years (base); (2) 11-20 years; (3) >20 years
Farm size	Categorical variable	(1) <100 ha (base); (2) 101-200 ha; (3) >200 ha
Region	Categorical variable	(1) Capital Region (base); (2) Sjælland; (3) Syddanmark; (4) Midtjylland; (5) Nordjylland

Notes: All Likert-scale items are coded such that higher values indicate stronger agreement or greater influence. Factor scores were derived using principal component/factor analysis and standardized prior to inclusion in regression models. Dummy variables are included for categorical controls, with base categories indicated above.

administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Ethical statement

Ethical approval for this study was obtained from the University of Copenhagen, with reference number 504-0216/25-7000.

Funding

This work was supported by the European Union via the BEATLES Project, Grant No. 101060645.

Declaration of competing interest

We declare no competing interests.

Acknowledgments

The authors express their sincere gratitude to researchers from the Agricultural University of Athens (AUA) and Wageningen University & Research (WUR) for feedback on an earlier version of this manuscript submitted as a deliverable for the Behavioral Change Towards Climate-Smart Agriculture (BEATLES) project. We also thank participants at the first author's PhD status seminar presentation at the University of Copenhagen for helpful comments on an earlier draft. In addition, we thank the Associate Editor and three anonymous reviewers for their constructive suggestions, which helped improve the manuscript. This research was funded by the European Union via the BEATLES Project under EU Grant Agreement No. 101060645.

Appendix Table A2
Heterogeneity analysis on CSA land (Round 2) by organic adoption status

VARIABLES	Model 1	Model 2
	Coeff (St. Err)	Coeff (St. Err)
Tax on chemical fertilization (Yes)	7.461***(1.948)	6.825***(1.762)
Adoption of organic farming (Yes)	1.126(1.279)	1.345(1.744)
Tax × Adoption of organic farming	-4.702*(2.513)	-4.732*(2.680)
Premium price for CSA (Yes)	7.088***(1.863)	6.698***(1.867)
Premium price × Adoption of organic farming	-2.729(1.605)	-3.514(1.969)
Past CSA experience		2.585(1.957)
Risk aversion factor		-2.072***(0.60)
Personal norm factor		0.554(0.819)
Trust in Policy		0.095(1.230)
Policy Uncertainty		-2.553***(0.72)
Market Uncertainty		-0.726(0.822)
Awareness of CSA: Heard, Not Informed		1.312(1.431)
Awareness of CSA: Somewhat Aware		3.375(2.288)
Minimizing the climate impact motive		0.368(0.958)
Balance climate benefits and profit motive.		0.183(0.831)
Profit outweighs the climate motive.		-0.717(1.052)
Maximizing the profit motive		-1.944*(1.010)
Socio-economic variables	No	Yes
Round CSA land allocation	Yes	Yes
Regional categories	Yes	Yes
Constant	18.034***(6.345)	2.442***(0.867)
Observations	251	251
R-squared	0.644	0.715

Note: Awareness of CSA: I had never heard of CSA (base), *Model 1: focuses on treatments only, Model 2: focuses on treatment and other attitudinal and socio-economic variables*, Robust standard errors in parentheses, ***p < 0.01, **p < 0.05, *p < 0.1.

Appendix Table A3
Predicted CSA land allocation by treatment and organic farming adoption type

Organic farming type	Tax	Premium	Predicted CSA Land (ha)	95% Confidence Interval
Non-Adopter	No	No	15.67	[13.95, 17.39]
Non-Adopter	No	Yes	22.76	[19.58, 25.93]
Non-Adopter	Yes	No	23.07	[19.71, 26.55]
Adopter	No	No	16.79	[15.25, 18.34]
Adopter	No	Yes	19.55	[18.30, 23.32]
Adopter	Yes	No	19.55	[16.73, 22.36]

Appendix Table A4
Conditional Average Treatment Effect (CATE) of treatments within organic subgroups

Farmer type	Contrast	AME (ha)	Std. Err.	t	p-value
Non-adopter of organic farming	Tax vs Control	7.46	1.95	3.83	0
Adopter of organic farming	Tax vs Control	2.76	1.6	1.72	0.09
Non-adopter of organic farming	Premium vs Control	7.09	1.86	3.8	0
Adopter of organic farming	Premium vs Control	4.36	1.45	3	0

Appendix B. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvman.2026.129783>.

Data availability

Data will be made available on request.

References

Agrimonti, C., Lauro, M., Visioli, G., 2021. Smart agriculture for food quality: Facing climate change in the 21st century. *Critical Reviews in Food Science and Nutrition* 61 (6), 971–981. <https://doi.org/10.1080/10408398.2020.1749555>.
 Ahles, A., Palma, M.A., Drichoutis, A.C., 2024. Testing the effectiveness of lottery incentives in online experiments. *Am. J. Agric. Econ.* 106 (4), 1435–1453. <https://doi.org/10.1111/ajae.12460>.

Amadu, F.O., McNamara, P.E., Miller, D.C., 2020. Understanding the adoption of climate-smart agriculture: a farm-level typology with empirical evidence from southern Malawi. *World Dev.* 126, 104692. <https://doi.org/10.1016/j.worlddev.2019.104692>.
 Arechar, A.A., Gächter, S., Molleman, L., 2018. Conducting interactive experiments online. *Exp. Econ.* 21 (1), 99–131. <https://doi.org/10.1007/s10683-017-9527-2>.
 Arias Puentes, C.P., Trujillo, C.A., 2025. The role of online experiments in the understanding of sustainable consumption behaviors: a systematic methodological literature review. *Int. J. Consum. Stud.* 49 (2), e70033. <https://doi.org/10.1111/ijcs.70033>.
 Asghar, W., Akça, M.O., Akça, H., Tarf, O.J., Kataoka, R., Turgay, O.C., 2022. Alternative strategies to synthetic chemical fertilizers: Revitalization of soil quality for sustainable agriculture using organic-based approaches. In: *New and Future*

- Developments in Microbial Biotechnology and Bioengineering. Elsevier, pp. 1–30. <https://doi.org/10.1016/B978-0-323-85581-5.00003-3>.
- Assefa, T.T., Meuwissen, M.P.M., Oude Lansink, A.G.J.M., 2017. Price risk perceptions and management strategies in selected European food supply chains: an exploratory approach. *NJAS - Wageningen J. Life Sci.* 80 (1), 15–26. <https://doi.org/10.1016/j.njas.2016.11.002>.
- Aydogan, I., Berger, L., Thérout, V., 2024. Pay all subjects or pay only some? An experiment on decision-making under risk and ambiguity. *J. Econ. Psychol.* 104, 102757. <https://doi.org/10.1016/j.joep.2024.102757>.
- Baker, B.P., Green, T.A., Loker, A.J., 2020. Biological control and integrated pest management in organic and conventional systems. *Biol. Control* 140, 104095. <https://doi.org/10.1016/j.biocontrol.2019.104095>.
- Barbato, C.T., Strong, A.L., 2023. Farmer perspectives on carbon markets incentivizing agricultural soil carbon sequestration. *Npj Climate Action* 2 (1), 26. <https://doi.org/10.1038/s44168-023-00055-4>.
- Barnes, A., Hansson, H., Billaudet, L., Leduc, G., Tasevska, G.M., Ryan, M., Thompson, B., Toma, L., Duvaléix-Tréguer, S., Tzouramani, I., 2022. European farmer perspectives and their adoption of ecological practices. *EuroChoices* 21 (3), 5–12. <https://doi.org/10.1111/1746-692X.12371>.
- Barnes, A.P., Soto, I., Eory, V., Beck, B., Balafoutis, A.T., Sanchez, B., Vangeyte, J., Fountas, S., van der Wal, T., Gómez-Barbero, M., 2019. Influencing incentives for precision agricultural technologies within European arable farming systems. *Environ. Sci. Pol.* 93, 66–74. <https://doi.org/10.1016/j.envsci.2018.12.014>.
- Bartkowski, B., Beckmann, M., Bednár, M., Biffi, S., Domingo-Marimon, C., Mesaroš, M., Schüller, C., Sarapatka, B., Tarčák, S., Václavík, T., Ziv, G., Wittstock, F., 2023. Adoption and potential of agri-environmental schemes in Europe: cross-regional evidence from interviews with farmers. *People Nat.* 5 (5), 1610–1621. <https://doi.org/10.1002/pan3.10526>.
- Bjarklev, A., Kjærgård, B., Jelsø, E., Haugaard-Nielsen, H., 2019. Fostering sustainability in new value chains for (Re)Adopting underutilized crops. *Eur. J. Sustain. Dev.* 8 (1). <https://doi.org/10.14207/ejsd.2019.v8n1p1>.
- Bocquého, G., Jacquet, F., Reynaud, A., 2014. Expected utility or prospect theory maximisers? Assessing farmers' risk behaviour from field-experiment data. *Eur. Rev. Agric. Econ.* 41 (1), 135–172. <https://doi.org/10.1093/erae/jbt006>.
- Bojnec, Š., Fertó, I., 2025. Exploring the drivers of farm sustained participation in agri-environmental programmes. *Agric. Econ.* 13, 50. <https://doi.org/10.1186/s40100-025-00396-0>.
- Borouhaki, M., Olsen, T.L., Zhou, Q., 2025. Green premiums or economic pitfalls? Unraveling the profitability puzzle of credence attributes in agricultural supply chains. *Int. J. Prod. Econ.* 289. <https://doi.org/10.1016/j.ijpe.2025.109718>.
- Brenzinger, K., Costa, O.Y.A., Ho, A., Koorneef, G., Robroek, B., Molenaar, D., Korthals, G., Bodelier, P.L.E., 2021. Steering microbiomes by organic amendments towards climate-smart agricultural soils. *Biology and Fertility of Soils* 57 (8), 1053–1074. <https://doi.org/10.1007/s00374-021-01599-5>.
- Brown, C., Kovács, E., Herzog, L., Villamayor-Tomas, S., Albizua, A., Galanaki, A., Grammatikopoulou, I., McCracken, D., Olsson, J.A., Zinngrebe, Y., 2021. Simplistic understandings of farmer motivations could undermine the environmental potential of the common agricultural policy. *Land Use Policy* 101, 105136. <https://doi.org/10.1016/j.landusepol.2020.105136>.
- Brunelle, T., Chakir, R., Carpentier, A., Dorin, B., Goll, D., Guilpart, N., Maggi, F., Makowski, D., Nesme, T., Roosen, J., Tang, F.H.M., 2024. Reducing chemical inputs in agriculture requires a system change. *Communications Earth & Environment* 5 (1), 369. <https://doi.org/10.1038/s43247-024-01533-1>.
- Burke, J.F., Sussman, J.B., Kent, D.M., Hayward, R.A., 2015. Three simple rules to ensure reasonably credible subgroup analyses. *BMJ* h5651. <https://doi.org/10.1136/bmj.h5651>.
- Canessa, C., Ait-Sidhoum, A., Wunder, S., Sauer, J., 2024. What matters most in determining European farmers' participation in agri-environmental measures? A systematic review of the quantitative literature. *Land Use Policy* 140, 107094. <https://doi.org/10.1016/j.landusepol.2024.107094>.
- Carattini, S., Carvalho, M., Fankhauser, S., 2018. Overcoming public resistance to carbon taxes. *WIREs Clim. Change* 9 (5), e531. <https://doi.org/10.1002/wcc.531>.
- Caria, O., Canales, C., Fabian Frick, F., Sauer, J., 2025. The role of behavioural factors in accepting agri-environmental contracts – evidence from a Q-method and thematic analysis in Germany. *Ecol. Econ.* 231, 108544. <https://doi.org/10.1016/j.ecolecon.2025.108544>.
- Charness, G., Gneezy, U., Kuhn, M.A., 2012. Experimental methods: Between-subject and within-subject design. *J. Econ. Behav. Organ.* 81 (1), 1–8. <https://doi.org/10.1016/j.jebo.2011.08.009>.
- Cohen, J., 1977. *Statistical Power Analysis for the Behavioral Sciences*. Elsevier. <https://doi.org/10.1016/C2013-0-10517-X>.
- CONCITO. 2024. Paving the Way for Agriculture Emission Reductions – the Danish Case. <https://concito.dk/en/node/3817>.
- Danish Agriculture & Food Council, 2023. Facts & figures: denmark – a food and farming country. <https://agricultureandfood.dk/media/m1qfuju/lf-facts-and-figures-2023.pdf>.
- Dean, A.J., Eberhard, R., Baresi, U., Coggan, A., Deane, F., Hamman, E., Helmstedt, K.J., Loechel, B., Jarvis, D., Mayfield, H., Stevens, L., Taylor, B., Vella, K., 2023. Scrutinizing the impact of policy instruments on adoption of agricultural conservation practices using Bayesian expert models. *Conserv. Lett.* 16 (6), e12988. <https://doi.org/10.1111/conl.12988>.
- Deci, E.L., Koestner, R., Ryan, R.M., 1999. A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychol. Bull.* 125 (6), 627–668. <https://doi.org/10.1037/0033-2909.125.6.627>.
- de Lauwere, C.C., et al., 2022. Social psychological factors drive farmers' adoption of environmental best management practices. *J. Environ. Manag.* 318, 115574. <https://doi.org/10.1016/j.jenvman.2022.115574>.
- Denny, R.C.H., Marquart-Pyatt, S.T., Houser, M., 2019. Understanding the past and present and predicting the future: farmers' use of multiple nutrient best management practices in the upper midwest. *Soc. Nat. Resour.* 32 (7), 807–826. <https://doi.org/10.1080/08941920.2019.1574045>.
- Dessart, F.J., Barreiro-Hurlé, J., Van Bavel, R., 2019. Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review. *Eur. Rev. Agric. Econ.* 46 (3), 417–471. <https://doi.org/10.1093/erae/jbz019>.
- Dewally, K., Bark, R.H., Harwood, A.R., Lovett, A.A., 2025. Learning from the past and embracing future opportunities: perceptions of new Environmental Land Management Schemes and private nature markets. *J. Rural Stud.* 119, 103723. <https://doi.org/10.1016/j.jrurstud.2025.103723>.
- Di Santo, N., Del Giudice, T., Sisto, R., 2024. Policy mixes in rural areas: a scoping literature review. *Italian Review of Agricultural Economics* 79 (3), 83–99. <https://doi.org/10.36253/rea-15149>.
- Ditzler, L., Van Apeldoorn, D.F., Pellegrini, F., Antichi, D., Barberi, P., Rossing, W.A.H., 2021. Current research on the ecosystem service potential of legume inclusive cropping systems in Europe. A review. *Agron. Sustain. Dev.* 41 (2), 26. <https://doi.org/10.1007/s13593-021-00678-z>.
- Drescher, M., et al., 2024. Behavioral drivers of farmers' participation in agri-environmental and climate schemes. *Land Use Policy* 137, 106993. <https://doi.org/10.1016/j.landusepol.2024.106993>.
- Ejelöv, E., Harring, N., Hansla, A., Jagers, S., Nilsson, A., 2022. Push, pull, or Inform—An empirical taxonomy of environmental Policy support in Sweden. *J. Publ. Pol.* 42 (3), 529–552. <https://doi.org/10.1017/S0143814X21000271>.
- Entsalo, H., Kalimo, H., Kautto, P., Turunen, T., 2023. Analysing regulatory instruments in sustainability transitions: a combined 'intervention points' and 'roles of law' approach to the European Union's Ecodesign framework. *Sustain. Prod. Consum.* 42, 125–137. <https://doi.org/10.1016/j.spc.2023.09.013>.
- Enthoven, L., Skambracks, M., Van Den Broeck, G., 2023. Improving the design of local short food supply chains: farmers' views in Wallonia, Belgium. *J. Rural Stud.* 97, 573–582. <https://doi.org/10.1016/j.jrurstud.2023.01.016>.
- Erekaló, K.T., Gemtou, M., Kornelis, M., Pedersen, S.M., Christensen, T., Denver, S., 2025. Understanding the behavioral factors influencing farmers' future adoption of climate-smart agriculture: a multi-group analysis. *J. Clean. Prod.* 510, 145632. <https://doi.org/10.1016/j.jclepro.2025.145632>.
- Erekaló, K.T., Pedersen, S.M., Christensen, T., Denver, S., Fountas, S., Isakhanyan, G., 2024. Review on the contribution of farming practices and technologies towards climate-smart agricultural outcomes in a European context. In: *Smart Agricultural Technology*, 100413. <https://doi.org/10.1016/j.atech.2024.100413>.
- Expert Group for a Green Tax Reform, 2024. *Green Tax Reform: Final Report*. <https://sk.m.dk/media/tngb1b4r/green-tax-reform-final-report.pdf>.
- Fares, M., Mamine, F., 2023. Relative Importance of Barriers and Levers to Intercropping Systems Adoption: A Comparison of Farms and Co-Operatives. *Sustainability* 15 (8), 6652. <https://doi.org/10.3390/su15086652>.
- Feder, G., Just, R.E., Zilberman, D., 1985. Adoption of agricultural innovations in Developing Countries: a Survey. *Econ. Dev. Cult. Change* 33 (2), 255–258.
- Feisthauer, P., Hartmann, M., Börner, J., 2023. Adoption intentions of smart weeding technologies—A lab-in-the-field experiment with German crop farmers. *Q Open* 4 (1). <https://doi.org/10.1093/qopen/qaoc002>.
- Feisthauer, P., Hartmann, M., Börner, J., 2024. Behavioral factors driving farmers' intentions to adopt spot spraying for sustainable weed control. *J. Environ. Manag.* 353, 120218. <https://doi.org/10.1016/j.jenvman.2024.120218>.
- Fertó, I., Bojnec, Š., 2025. Understanding the temporal dynamics of agri-environmental climate scheme adoption. *J. Environ. Plann. Manag.* 1–33. <https://doi.org/10.1080/09640568.2025.2587266>.
- Finger, R., Garcia, V., McCallum, C., Rommel, J., 2024. A note on European farmers' preferences under cumulative prospect theory. *J. Agric. Econ.* 75 (1), 465–472. <https://doi.org/10.1111/1477-9552.12565>.
- Franceschini, C., Liebe, U., Thieme, M., Meyerhoff, J., Field, D., McBratney, A., 2022. The effect of social and personal norms on stated preferences for multiple soil functions: evidence from Australia and Italy. *Aust. J. Agric. Resour. Econ.* 66 (2), 335–362. <https://doi.org/10.1111/1467-8489.12466>.
- Gangadharan, L., Jain, T., Maitra, P., Vecchi, J., 2022. Lab-in-the-field experiments: Perspectives from research on gender. *The Japanese Economic Review* 73 (1), 31–59. <https://doi.org/10.1007/s42973-021-00088-6>.
- Gemtou, M., Kakkavou, K., Anastasiou, E., Fountas, S., Pedersen, S.M., Isakhanyan, G., Erekaló, K.T., Pazos-Vidal, S., 2024. Farmers' transition to climate-smart agriculture: a systematic review of the decision-making factors affecting adoption. *Sustainability* 16 (7), 2828. <https://doi.org/10.3390/su16072828>.
- Gemtou, M., Kornelis, M., Isakhanyan, G., Pedersen, S.M., Fountas, S., Puggaard, L., Bienzobas Adrián, J., Izco Zabala, A., 2026. Sowing the seeds of change: unveiling farmer types to promote climate-smart agriculture adoption in Europe. *J. Rural Stud.* 123, 104043. <https://doi.org/10.1016/j.jrurstud.2026.104043>.
- Gneezy, U., Kajackaite, A., Meier, S., 2020. Incentive-Based interventions. In: Hagger, M. S., Cameron, L.D., Hamilton, K., Hankonen, N., Lintunen, T. (Eds.), *The Handbook of Behavior Change*, first ed. Cambridge University Press, pp. 523–536. <https://doi.org/10.1017/9781108677318.036>.
- Gnekpe, C., Plantec, Q., 2023. Regulatory push-pull and technological knowledge dynamics of circular economy innovation. *Technol. Forecast. Soc. Change* 196, 122767. <https://doi.org/10.1016/j.techfore.2023.122767>.

- Gütschow, M., Bartkowski, B., Felipe-Lucia, M.R., 2021. Farmers' action space to adopt sustainable practices: a study of arable farming in Saxony. *Reg. Environ. Change* 21 (4), 103. <https://doi.org/10.1007/s10113-021-01848-1>.
- Ha, T.M., Manevska-Tasevska, G., Weiß, M., Hansson, H., 2024. Heterogeneity in farmers' stage of behavioural change in intercropping adoption: an application of the Transtheoretical Model. *Agricultural and Food Economics* 12 (1). <https://doi.org/10.1186/s40100-024-00306-w>. Article 12.
- Haider, S., Song, J., Bai, J., Wang, X., Ren, G., Bai, Y., Huang, Y., Shah, T., Feng, Y., 2025. Toward low-emission agriculture: synergistic contribution of inorganic nitrogen and organic fertilizers to GHG emissions and strategies for mitigation. *Plants* 14 (10), 1551. <https://doi.org/10.3390/plants14101551>.
- Han, G., Arbuckle, J.G., Grudens-Schuck, N., 2021. Motivations, goals, and benefits associated with organic grain farming by producers in Iowa, U.S. *Agric. Syst.* 191, 103175. <https://doi.org/10.1016/j.agsy.2021.103175>.
- Hessel, R., Wyseure, G., Panagea, I.S., Alaoui, A., Reed, M.S., Van Delden, H., Muro, M., Mills, J., Oenema, O., Areal, F., Van Den Elsen, E., Verzaandvoort, S., Assinck, F., Elsen, A., Lipiec, J., Koutroulis, A., O'Sullivan, L., Bolinder, M.A., Fleksens, L., et al., 2022. Soil-improving cropping systems for sustainable and profitable farming in Europe. *Land* 11 (6), 780. <https://doi.org/10.3390/land11060780>.
- Heyl, K., Ekaradt, F., Roos, P., Garske, B., 2023. Achieving the nutrient reduction objective of the Farm to Fork Strategy. An assessment of CAP subsidies for precision fertilization and sustainable agricultural practices in Germany. *Front. Sustain. Food Syst.* 7, 1088640. <https://doi.org/10.3389/fsufs.2023.1088640>.
- Howlett, M., Rayner, J., 2013. Patching vs packaging in policy formulation: complementarity and goodness of fit in policy portfolios. *Pol. Soc.* 32 (2), 170–182. <https://doi.org/10.1016/j.polsoc.2013.05.003>.
- Howley, P., Ocean, N., 2022. Can nudging only get you so far? Testing for nudge combination effects. *Eur. Rev. Agric. Econ.* 49 (5), 1086–1112. <https://doi.org/10.1093/erae/jbab041>.
- Howlett, M., Rayner, J., 2007. Design principles for policy mixes: cohesion and coherence in 'new governance arrangements'. *Pol. Soc.* 26 (4), 1–18.
- Huber, R., Bartkowski, B., Brown, C., Benni, N., Feil, J.-H., Grohmann, P., Joormann, I., Leonhardt, H., Mitter, H., Müller, B., 2023. Farm typologies for understanding farm systems and improving agricultural policy. *Agric. Syst.* 213, 103800. <https://doi.org/10.1016/j.agsy.2023.103800>.
- Jespersen, L.M., Baggesen, D.L., Fog, E., Halsnaes, K., Hermansen, J.E., Andreasen, L., Strandberg, B., Sørensen, J.T., Halberg, N., 2017. Contribution of organic farming to public goods in Denmark. *Org. Agric.* 7 (3), 243–266. <https://doi.org/10.1007/s13165-017-0193-7>.
- Johne, C., Schröder, E., Ward, H., 2023. The distributional effects of a nitrogen tax: evidence from Germany. *Ecol. Econ.* 208, 107815. <https://doi.org/10.1016/j.ecolecon.2023.107815>.
- Joinson, A., 1999. Social desirability, anonymity, and internet-based questionnaires. *Behav. Res. Methods Instrum. Comput.* 31 (3), 433–438. <https://doi.org/10.3758/bf03200723>.
- Kahneman, D., Tversky, A., 1979. Prospect theory: an analysis of decision under risk. *Econometrica* 47 (2), 263. <https://doi.org/10.2307/1914185>.
- Kaine, G., Wright, V., 2024. Social desirability bias and the prevalence of self-reported conservation behaviour among farmers. *Sustainability* 16 (22), 9658. <https://doi.org/10.3390/su16229658>.
- Keesstra, S.D., Chenu, C., Munkholm, L.J., Cornu, S., Kuikman, P.J., Thorsøe, M.H., Besse-Lototskaya, A., Visser, S.M., 2024. European agricultural soil management: Towards climate-smart and sustainability, knowledge needs and research approaches. *European Journal of Soil Science* 75 (1), e13437. <https://doi.org/10.1111/ejss.13437>.
- Kern, F., Rogge, K.S., Howlett, M., 2019. Policy mixes for sustainability transitions: new approaches and insights through bridging innovation and policy studies. *Res. Pol.* 48 (10), 103832. <https://doi.org/10.1016/j.respol.2019.103832>.
- Kernecker, M., Knierim, A., Wurbs, A., Kraus, T., Borges, F., 2020. Experience versus expectation: farmers' perceptions of smart farming technologies for cropping systems across Europe. *Precis. Agric.* 21 (1), 34–50. <https://doi.org/10.1007/s11119-019-09651-z>.
- Leduc, G., Billaudet, L., Engström, E., Hansson, H., Ryan, M., 2023. Farmers' perceived values in conventional and organic farming: a comparison between French, Irish and Swedish farmers using the Means-end chain approach. *Ecol. Econ.* 207, 107767. <https://doi.org/10.1016/j.ecolecon.2023.107767>.
- Li, J., Ma, W., Zhu, H., 2024. A systematic literature review of factors influencing the adoption of climate-smart agricultural practices. *Mitig. Adapt. Strategies Glob. Change* 29 (1), 2. <https://doi.org/10.1007/s11027-023-10098-x>.
- Lund, T.B., Andersen, L.M., O'Doherty Jensen, K., 2013. Diverse organic consumers in Denmark. *Sociol. Ruralis* 53, 454–478. <https://doi.org/10.1111/soru.12022>.
- Marette, S., Roosen, J., Blanchemanche, S., 2011. The combination of lab and field experiments for benefit-cost analysis. *J. Benefit-Cost Anal.* 2 (3), 1–36. <https://doi.org/10.2202/2152-2812.1073>.
- Meyer-Aurich, A., Karatay, Y.N., Nausediene, A., Kirschke, D., 2020. Effectivity and cost efficiency of a tax on nitrogen fertilizer to reduce GHG emissions from agriculture. *Atmosphere* 11 (6), 607. <https://doi.org/10.3390/atmos11060607>.
- MFAFD, 2023. *Danish action plan for plant-based foods*. Ministry of food. Agriculture and Fisheries of Denmark. <https://en.fvm.dk/Media/638484294982868221/Danish-Action-Plan-for-Plant-based-Foods.pdf>.
- Mkupete, M.J., Davalos, J., 2025. Implications of climate-smart agriculture technology adoption on women's productivity and food security in Tanzania. *Agric. Econ.* 56 (2), 247–267. <https://doi.org/10.1111/agec.12874>.
- Nadeem, F., Nawaz, A., Farooq, M., 2019. Crop rotations, fallowing, and associated environmental benefits. In: Nadeem, F., Nawaz, A., Farooq, M. (Eds.), *Oxford Research Encyclopedia of Environmental Science*. Oxford University Press. <https://doi.org/10.1093/acrefore/9780199389414.013.197>.
- Notz, I., Topp, C.F.E., Schuler, J., Alves, S., Gallardo, L.A., Dauber, J., Haase, T., Hargreaves, P.R., Hennessy, M., Iantcheva, A., Jeanneret, P., Kay, S., Recknagel, J., Rittler, L., Vasiljević, M., Watson, C.A., Reckling, M., 2023. Transition to legume-supported farming in Europe through redesigning cropping systems. *Agron. Sustain. Dev.* 43 (1), 12. <https://doi.org/10.1007/s13593-022-00861-w>.
- Papadopoulos, G., Arduini, S., Uyar, H., Psiroukis, V., Kasimati, A., Fountas, S., 2024. Economic and environmental benefits of digital agricultural technologies in crop production: a review. *Smart Agric. Technol.* 8, 100441. <https://doi.org/10.1016/j.atech.2024.100441>.
- Pedersen, A.B., Nielsen, H.Ø., Daugbjerg, C., 2020. Environmental policy mixes and target group heterogeneity: analysing Danish farmers' responses to the pesticide taxes. *J. Environ. Pol. Plann.* 22 (5), 608–619. <https://doi.org/10.1080/1523908x.2020.1806047>.
- Pedersen, S.M., Erekaló, K.T., Christensen, T., Denver, S., Gemtou, M., Fountas, S., Isakhanyan, G., Rosemarin, A., Ekane, N., Puggaard, L., Nertinger, M., Brinks, H., Pusko, D., Adrián, J.B., 2024. Drivers and barriers to climate-smart agricultural practices and technologies adoption: insights from stakeholders of five European food supply chains. *Smart Agric. Technol.* 8, 100478. <https://doi.org/10.1016/j.atech.2024.100478>.
- Pineiro, V., Arias, J., Elverdin, P., Ibáñez, A.M., Kinengyere, A., Opazo, C.M., Owoo, N., Page, J.R., Prager, S.D., Torero, M., 2020. A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. *Nat. Sustain.* 3 (10), 809–820. <https://doi.org/10.1038/s41893-020-00617-y>.
- Plaza-Bonilla, D., Nolot, J.-M., Raffailac, D., Justes, E., 2015. Cover crops mitigate nitrate leaching in cropping systems including grain legumes: field evidence and model simulations. *Agric. Ecosyst. Environ.* 212, 1–12. <https://doi.org/10.1016/j.agee.2015.06.014>.
- Rey Vicario, D., Kremmydas, D., Baldoni, E., Ciaian, P., Tillie, P., 2025. Do organic farming policies need to be more target-oriented to achieve sustainability? *J. Environ. Manag.* 394, 127342. <https://doi.org/10.1016/j.jenvman.2025.127342>.
- Rezaei, R., Safa, L., Damalas, C.A., Ganjkanloo, M.M., 2019. Drivers of farmers' intention to use integrated pest management: integrating theory of planned behavior and norm activation model. *J. Environ. Manag.* 236, 328–339. <https://doi.org/10.1016/j.jenvman.2019.01.097>.
- Ricart, S., Gandolfi, C., Castelletti, A., 2024. Targeting farmers' heterogeneity to enrich climate change adaptation policy design: findings from northern Italy. *Environ. Res.: Climate* 3 (3), 031001. <https://doi.org/10.1088/2752-5295/ad4580>.
- Riar, A., Goldmann, E., Bautze, D., Rüegg, J., Bhullar, G.S., Adamtey, N., Schneider, M., Huber, B., Armengot, L., 2024. Farm gate profitability of organic and conventional farming systems in the tropics. *Int. J. Agric. Sustain.* 22 (1), 2318933. <https://doi.org/10.1080/14735903.2024.2318933>.
- Ried, L., Eckerdt, S., Kaufmann, L., 2022. Social desirability bias in PSM surveys and behavioral experiments: considerations for design development and data collection. *J. Purch. Supply Manag.* 28 (1), 100743. <https://doi.org/10.1016/j.pursup.2021.100743>.
- Rizzo, G., Migliore, G., Schifani, G., Vecchio, R., 2023. Key factors influencing farmers' adoption of sustainable innovations: A systematic literature review and research agenda. *Organic Agriculture*. <https://doi.org/10.1007/s13165-023-00440-7>.
- Rodd, J.M., 2024. Moving experimental psychology online: how to obtain high quality data when we can't see our participants. *J. Mem. Lang.* 134, 104472. <https://doi.org/10.1016/j.jml.2023.104472>.
- Rogge, K.S., Reichardt, K., 2016. Policy mixes for sustainability transitions: an extended concept and framework. *Res. Pol.* 45 (8), 1620–1635. <https://doi.org/10.1016/j.respol.2016.04.004>.
- Roxburgh, N., Burton, R.J.F., Mittenzwei, K., Polhill, J.G., 2025. Modelling the effect of a carbon tax on the development of a cultivated protein industry: a Norwegian case study. *Clean. Eng. Technol.* 26, 100979. <https://doi.org/10.1016/j.clet.2025.100979>.
- Sain, G., Loboguerrero, A.M., Corner-Dolloff, C., Lizarazo, M., Nowak, A., Martínez-Barón, D., Andrieu, N., 2017. Costs and benefits of climate-smart agriculture: the case of the Dry Corridor in Guatemala. *Agric. Syst.* 151, 163–173. <https://doi.org/10.1016/j.agsy.2016.05.004>.
- Sander, A., Ghazoul, J., Finger, R., Schaub, S., 2024. Participation in individual and collective agri-environmental schemes: a synthesis using the Theory of Planned Behaviour. *J. Rural Stud.* 107, 103255. <https://doi.org/10.1016/j.jrurstud.2024.103255>.
- Sarker, J.R., Roy, S.S., Roy, M., 2025. Evaluating agricultural decision-making: a systematic review of discrete choice experiments and producers' preferences. *World Development Sustainability* 7, 100231. <https://doi.org/10.1016/j.wds.2025.100231>.
- Scherer, L., Verburg, P.H., 2017. Mapping and linking supply- and demand-side measures in climate-smart agriculture. A review. *Agron. Sustain. Dev.* 37 (6), 66. <https://doi.org/10.1007/s13593-017-0475-1>.
- Scotti, F., Flori, A., Crescenzi, R., Pammolli, F., 2025. Demand-pull and technology-push environmental innovation: a policy mix analysis on EU ETS and EU Cohesion Policy. *Clim. Policy* 25 (2), 153–170. <https://doi.org/10.1080/14693062.2024.2366894>.
- SEGES, 2025. Budget calculations for various cereal crops and soil types in 2025. SEGES Farm-Online System. <https://farmtonline.dlbr.dk/>.
- Sheeran, P., Godin, G., Conner, M., Germain, M., 2017. Paradoxical effects of experience: past behavior both strengthens and weakens the intention-behavior relationship. *Journal of the Association for Consumer Research* 2 (3), 309–318. <https://doi.org/10.1086/691216>.
- Sørensen, P.B., Beck, U.R., Berg, A.K., Christiansen, S., Jørgensen, C.L., Kirk, J.S., Stewart, L.B., Stephensen, P.P., 2025. The effects of unilateral climate policy towards

- agriculture: a case study of Denmark. *J. Agric. Econ.* 76 (1), 3–23. <https://doi.org/10.1111/1477-9552.12624>.
- Späti, K., Huber, R., Logar, I., Finger, R., 2022. Incentivizing the adoption of precision agricultural technologies in small-scaled farming systems: a choice experiment approach. *Journal of the Agricultural and Applied Economics Association* 1 (3), 236–253. <https://doi.org/10.1002/jaa2.22>.
- Spiegel, A., Heidecke, C., Osterburg, B., 2025. Distance to climate targets in agriculture in the EU. *Q Open* 5 (1). <https://doi.org/10.1093/qopen/qoae018>.
- Stagnari, F., Maggio, A., Gallieni, A., Pisante, M., 2017. Multiple benefits of legumes for agriculture sustainability: an overview. *Chem. Biol. Technol. Agric.* 4 (1), 2. <https://doi.org/10.1186/s40538-016-0085-1>.
- Stephane, C., 2020. Pwr: Basic Functions for Power Analysis. <https://CRAN.R-project.org/package=pwr>.
- Stetter, C., Buser, V., Finger, R., 2026. Policy mixes and major emission reductions in European agriculture. *Food Policy* 140, 103084. <https://doi.org/10.1016/j.foodpol.2025.103084>.
- Takács-György, K., Takács, I., 2022. Towards climate smart agriculture: How does innovation meet sustainability? *Ecocycles* 8 (1), 61–72. <https://doi.org/10.19040/ecocycles.v8i1.220>.
- Thomas, F., Midler, E., Lefebvre, M., Engel, S., 2019. Greening the common agricultural policy: a behavioural perspective and lab-in-the-field experiment in Germany. *Eur. Rev. Agric. Econ.* 46 (3), 367–392. <https://doi.org/10.1093/erae/jbz014>.
- Thompson, B., Barnes, A.P., Toma, L., 2022. Increasing the adoption intensity of sustainable agricultural practices in Europe: farm and practice level insights. *J. Environ. Manag.* 320, 115663. <https://doi.org/10.1016/j.jenvman.2022.115663>.
- Turna, D., 2025. Taxation of agricultural emissions in combating climate change: the case of Denmark. *J. Life Econ.* 12 (1), e2713. <https://doi.org/10.15637/jlecon.2713>.
- Vatn, A., Kvakkestad, V., Steiro, Å.L., Hodge, I., 2020. Pesticide taxes or voluntary action? An analysis of responses among Norwegian grain farmers. *J. Environ. Manag.* 276, 111074. <https://doi.org/10.1016/j.jenvman.2020.111074>.
- Verdi, L., Dalla Marta, A., Falconi, F., Orlandini, S., Mancini, M., 2022. Comparison between organic and conventional farming systems using life cycle assessment (LCA): a case study with an ancient wheat variety. *Eur. J. Agron.* 141, 126638. <https://doi.org/10.1016/j.eja.2022.126638>.
- Vos, J.L., Leach, A.M., Galloway, J.N., Dalgaard, T., Graversgaard, M., 2025. The Danish nitrogen footprint: balancing regulation with individual environmental responsibility. *Environ. Res. Lett.* 20 (5), 054026. <https://doi.org/10.1088/1748-9326/adc0b2>.
- Was, A., Malak-Rawlikowska, A., Zavalloni, M., Viaggi, D., Kobus, P., Sulewski, P., 2021. In search of factors determining the participation of farmers in agri-environmental schemes – does only money matter in Poland? *Land Use Policy* 101, 105190. <https://doi.org/10.1016/j.landusepol.2020.105190>.
- Yang, Y., Zheng, T., Wu, J., 2024. Green taxation, regional green development and innovation: mechanisms of influence and policy optimization. *Hum. Soc. Sci. Commun.* 11 (1), 810. <https://doi.org/10.1057/s41599-024-03335-4>.
- Zimmermann, B., Claß-Mahler, I., Von Cossel, M., Lewandowski, I., Weik, J., Spiller, A., Nitzko, S., Lippert, C., Krimly, T., Pergner, I., Zörb, C., Wimmer, M.A., Dier, M., Schurr, F.M., Pagel, J., Riemenschneider, A., Kehlenbeck, H., Feike, T., Klocke, B., et al., 2021. Mineral-Ecological cropping Systems-A new approach to improve ecosystem services by farming without chemical synthetic plant protection. *Agronomy* 11 (9), 1710. <https://doi.org/10.3390/agronomy11091710>.
- Degieter, M., Gellynck, X., Goyal, S., Mattelin, M., De Wulf, J., Ott, D., & De Steur, H., 2023. A mixed-methods approach to examine farmers' willingness to adopt protein crops. *Outlook on Agriculture*, 00307270231205924.
- Wreford, A., A. Ignaciuk and G. Grùère. 2017. "Overcoming barriers to the adoption of climate-friendly practices in agriculture", *OECD Food, Agriculture and Fisheries Papers*, No. 101, OECD Publishing, Paris, <https://doi.org/10.1787/97767de8-en>.