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List of Acronyms

Abbreviation	Full form
ABP	Action-based payment
AECS	Agri-environment-climate schemes
CAP	Common agricultural policy
CH ₄	Methane
CO ₂ e	Carbon dioxide equivalent
DCE	Discrete choice experiment
ETS	Emissions trading system
FFBG	First farm business game
GHG	Greenhouse gas
HP	Hybrid payment
LSU	Livestock unit
RBP	Result-based payment
SFBG	Second farm business game
VCM	Voluntary carbon markets
WTA	Willingness to accept

Executive summary

This report documents findings produced by Task 3.2 “Transition of agri-environmental systems to climate-neutral food systems” within WP3 “Agri-environmental policy experimentation”. The task aims to explore EU farmers’ acceptance of both compulsory measures (such as an agricultural emissions trading scheme) and voluntary carbon markets. It will also examine other economic instruments, including carbon, or CO₂e, taxes and innovative subsidy schemes (such as result-based payments (RBPs) and hybrid payments (HPs)), designed to encourage climate-friendly farming practices. In addition, Task 3.2 has the objective to investigate whether and to what extent behavioural factors affect farmers’ acceptability of such economic policy instruments. To address these objectives, two contextualized experiments involving a total of about 1,100 farmers were conducted, one in Italy and the other in Denmark.

Agricultural activities make a substantial contribution to greenhouse gas (GHG) emissions (IPCC, 2022). In the EU, the agricultural sector alone accounts for more than 10% of the total anthropogenic GHG emissions, with methane (CH₄) and nitrous oxide being the primary sources (European Environment Agency, 2022; FAO, 2024). Livestock farming is the main contributor to methane and nitrous oxide emissions within the agricultural sector (FAO, 2022). Given this, it is imperative to implement measures to reduce GHG emissions from agriculture to meet EU targets on reductions in GHG emissions, particularly within livestock agrifood systems (Matthews, 2023). The agricultural sector holds significant potential for mitigating GHG emissions through the adoption of carbon farming practices (Roe et al., 2019; EU, 2020; Barreiro-Hurle et al., 2021; European Commission, 2025). Carbon farming refers to agricultural practices that promote climate change mitigation at the farm level. These practices focus on managing land, livestock, soil carbon pools, materials, vegetation, and the fluxes of carbon dioxide, methane, and nitrous oxide (COWI, Ecologic Institute and IEEP, 2021).

Under the EU climate policy, GHG emissions from the agriculture sector are regulated by the Effort Sharing Regulation (ESR) and Land Use, Land-Use Change, and Forestry (LULUCF) Regulation (European Union, 2018a; 2018b). Climate action has also been a central element of the EU’s Common Agricultural Policy (CAP), particularly since the previous CAP plan (2014–2020) (European Environmental Bureau, 2019). This contributes to the EU Green Deal’s targets of reducing GHG emissions by 55% by 2030 and achieving climate neutrality by 2050 (European Commission, 2019). However, evaluations of the climate initiatives in agriculture related to the previous CAP plan (2014–2020) showed that the substantial budget allocated for climate action had little impact on curbing GHG emissions (European Court of Auditors, 2021; Hasler et al., 2022). Similarly, the current CAP plan, while greener than its predecessor, still fails to meet the EU’s climate and environmental goals, according to the European Court of Auditors (European Court of Auditors, 2024).

As a result, there are ongoing discussions on supplementing existing policy instruments to reduce GHG emissions from agriculture with additional tools based on the polluter pays principle, such as compulsory (Emissions Trading System - ETS) and voluntary carbon markets, as well as carbon - or CO₂e¹ - taxes (Bognar et al., 2024). For example, New Zealand has considered introducing an agricultural compulsory carbon market for quite some time, while Denmark has already decided to introduce a livestock carbon tax (Blandford, 2024; Spiegel et al., 2024).

Despite the pioneering attempts, policymakers are generally reluctant to implement stricter regulations because of potential public opposition (Bergquist et al., 2022; Douenne and Fabre, 2022; Köppl and Schratzenstaller, 2022). Farmers across Europe have long resisted stricter environmental regulations in the

¹ CO₂e (carbon dioxide equivalent): A standard metric unit used for comparing emissions from various greenhouse gases. It represents the amount of CO₂ that would have the same warming effect as a given mixture of gases.

agricultural sector (Finger et al., 2024). Organized protests by farmers against the introduction of a livestock carbon tax are still ongoing in Denmark (Ipsen, 2025), and the implementation of a compulsory EU carbon market scheme would likely face similar resistance (Bozzola and Cerroni, 2022). A more politically acceptable alternative may be the introduction of voluntary carbon markets that do not rely on a cap-and-trade scheme. A notable example of a publicly administered voluntary carbon market for agriculture is Australia's Carbon Farming Initiative, now known as the Emissions Reduction Fund (McDonald et al., 2021; Raina et al., 2024)

However, the introduction of innovative economic instruments, such as compulsory and voluntary carbon markets, should not be planned in isolation. Rather, these instruments must be carefully integrated with existing policy tools that already support farmers in transitioning toward more sustainable practices, including those related to carbon farming. In the EU, subsidization remains the most common approach to promoting sustainable agricultural production (Bozzola and Cerroni, 2022; Matthews, 2023). While standard Action-based Payments (ABPs) continue to play a central role, new forms of subsidization are emerging, most notably, result-based subsidies, which reward farmers based on the actual environmental benefits achieved through the adoption of sustainable practices (McDonald et al., 2021). To ensure policy coherence and effectiveness, the design of carbon pricing instruments must therefore take into account both the structure and outcomes of existing subsidies, as well as potential future policy developments.

The effectiveness of compulsory and voluntary carbon credit schemes in achieving meaningful and large-scale results largely depends on farmers' acceptance of these instruments (e.g., Piñeiro et al., 2020). However, research on farmers' acceptance of carbon markets and related policy tools is limited. This deliverable aims to contribute to this emerging body of literature by generating new empirical insights into livestock farmers' acceptance of both voluntary and compulsory carbon markets, examined in relation to existing tools such as ABPs and potential innovative instruments, including agricultural RBPs and carbon taxes.

Farmers' acceptability of policy instruments is often mediated by many factors, including behavioural factors. These are defined as social and psychological influences that shape human decision-making. Understanding the influence of these factors on acceptability becomes important to minimize farmers' (negative) reactance to new agricultural policies (Dessart et al., 2019). In this report, we focus on behavioural factors that influence farmers' acceptance of economic instruments aimed at reducing greenhouse gas (GHG) emissions in the livestock sector. Specifically, we examine the role of farmers' prior beliefs about the performance and costs of these policy tools, their risk preferences, pro-environmental attitudes, and perceived behavioural control related to the adoption of sustainable practices.

This report, which constitutes Deliverable 3.3 of the project, contributes to this literature by providing findings from two empirical case studies, one conducted in Italy and one in Denmark. The Italian study investigates dairy farmers' acceptability of a voluntary carbon market scheme as compared to standard ABPs and more innovative RBPs and HPs that reward dairy farmers who engage in a specific carbon farming practice, namely the adoption of essential oils in animal diets to reduce methane emissions from enteric fermentation. Voluntary carbon markets can be considered an alternative way to subsidize farmers and facilitate their transition towards the adoption of more sustainable practices. The study of farmers' preferences for these different forms of subsidization is important to design and implement acceptable subsidy schemes. This study also explores whether acceptability is mediated by farmers' expectations about the methane emission reduction that can be achieved thanks to the introduction of essential oils, their risk preferences, perceived behavioural control (measured as farmers' ability to properly introduce essential oils in animal diets), and their pro-environmental attitudes. The study employs a framed field experiment with 120 dairy farmers to investigate these topics. Results suggest that farmers still prefer standard subsidization schemes (i.e., ABPs) over Voluntary Carbon Markets (VCM) and RBPs. In addition, farmers do not have a strong preference between Voluntary Carbon Markets (VCM) and RBPs. A viable approach to improve the

acceptability towards VCM and RBPs is to pair them in an early stage with more standard ABPs using hybrid solutions. Farmers' response to hybrid solutions appears to be more coherent when ABPs are paired with RBPs than when paired with VCM.

The Danish study examines Danish farmers' acceptability of a carbon tax and an agricultural ETS scheme in Denmark under the provision (or not) of information regarding the economic consequences of the introduction of a carbon tax. Since the introduction of the carbon tax was imminent in Denmark when the study was conducted, the information treatments were framed about the carbon tax rather than the ETS scheme. This design allows to shed light on whether the introduction of a new policy instrument (the carbon tax, in this case) might affect preferences for other tools that could be introduced in the future (such as an agricultural ETS scheme). The two policy tools are complementary, not mutually exclusive. For example, a carbon tax and the EU ETS schemes are currently operating in parallel in Denmark for industry. The study also investigates whether farmers' acceptability of these financial policy tools correlates with intention to adopt a set of possible sustainable practices to be adopted at the farm level, and it investigates whether acceptability varies across different farm types. The Danish study consists of an incentivized survey experiment conducted with 981 farmers. Results suggest that the acceptability of carbon taxes and ETS schemes is undermined by farmers' perceived costs related to these policy instruments, with more stringent taxes being less accepted than milder taxes. Information on the actual costs of these instruments for the agricultural sector appears to slightly reduce farmers' reactance. Interestingly, farmers' reactance to the carbon tax seems to favour support for the implementation of an agricultural ETS scheme in Denmark.

Overall, these two empirical case studies show that farmers' acceptance of such economic tools in agriculture is low. This is particularly true for carbon taxes and cap-and-trade systems but holds true also for voluntary carbon markets and RBPs. Information provision and the use of hybrid solutions seem to facilitate acceptance, but only to some extent. There is heterogeneity in farmers' responses to these policy tools, highlighting the fact that using different approaches for different segments of the farming population could potentially increase acceptability and effectiveness.

The empirical research was accompanied by an online webinar organized by the University of Trento on "Economic Instruments for Innovative and Sustainable Dairy Systems: Insights for Policy and Business" on 30th May 2025. The webinar had the objective of shedding light on innovative economic tools such as carbon taxes, compulsory and voluntary carbon credit markets, and results-based subsidies to promote more sustainable dairy farming systems. It was mainly oriented towards policymakers and agri-food businesses, as well as to other actors involved in dairy value chains.

The report is structured in 4 sections: a general introduction to the examined economic policy tools and the related literature (Section 1), the presentation of the study on farmers' acceptability of voluntary carbon market scheme in Italy (Section 2), the presentation of the study on farmers' acceptability of carbon taxes and compulsory carbon market schemes in Denmark (Section 3), and a presentation of the overall findings from the two studies alongside policy implications (Section 4).

1. Background information on economic policy instruments

1.1 Evidence on examined economic policy instruments

Governments are pursuing various pathways to stimulate farmers' adoption of more sustainable farming practices, including carbon farming. Some countries are considering introducing initiatives such as compulsory carbon markets (e.g., New Zealand) or carbon taxes (e.g., Denmark) (Blandford, 2024; Spiegel et al., 2024). New Zealand is contemplating the idea of including the agricultural sector in its national Emission Trading Scheme or imposing an environmental tax on biogenic methane and nitrous oxide (Spiegel et al., 2024). Denmark recently became the first country in the world to introduce a CO₂e tax on agriculture (Blandford, 2024). This initiative is part of Denmark's ambitious climate strategy to reduce GHG emissions by 70% by 2030, ultimately achieving climate neutrality by 2050, in alignment with broader EU-wide climate goals (Danish Council on Climate Change, 2022). A key component of this strategy is a binding climate target for the agriculture and forestry sectors, which aims to reduce GHG emissions by 55-65% compared to 1990 levels (Ministry of Food Agriculture and Fisheries of Denmark, 2021), as these sectors are projected to account for 46% of Denmark's total GHG emissions by 2030 if no action is taken (Expert Group, 2024).

In general, policymakers are often hesitant to introduce stringent measures, such as CO₂e taxes, because of the risk of strong public opposition (Bergquist et al., 2022; Douenne and Fabre, 2022; Köppl and Schratzenstaller, 2022). European farmers, in particular, have consistently opposed tighter environmental regulations in the agricultural sector (Finger et al., 2024). This opposition has recently intensified, with large-scale protests across the EU prompting the relaxation of existing rules and the withdrawal of certain policy initiatives. For example, in February 2024, the European Union abandoned its proposal to reduce pesticide use by half and eased conditionality requirements in response to farmer demonstrations (Matthews, 2024; Rabesandratana, 2024). These developments mark a considerable obstacle to the EU's goals for cutting greenhouse gas emissions from agriculture.

A proposal to introduce a compulsory EU carbon market scheme could be expected to trigger the same level of farmers' resistance. The agricultural compulsory EU carbon market would most likely look like the cap-and-trade scheme developed under the current EU ETS scheme. Agri-food companies receive or buy emission allowances, which they can trade with each other. If a company emits less than its allowance, it can sell the surplus; if it emits more, it must buy extra allowances. This creates a financial incentive to reduce emissions efficiently and transition to more sustainable production systems (Bozzola and Cerroni, 2022).

The introduction of voluntary carbon markets is expected to be more acceptable to farmers. These markets can be managed by public entities (e.g., governments) or private companies (McDonald et al., 2021; Raina et al., 2024). An example of an existing public-based voluntary market for agricultural carbon credits is Australia's Carbon Farming Initiative, now known as the Emission Reduction Fund. Under this initiative, the government buys carbon credits generated in the agricultural sector via carbon farming actions at a fixed price that is established via a reverse auction (Bozzola and Cerroni, 2022; Raina et al., 2024). Other similar initiatives are the Alberta (Canada) emission offset system, and the California (USA) cap-and-trade program (Bozzola and Cerroni, 2022). Private-based initiatives for the establishment of voluntary carbon markets are also gaining momentum. Private companies that offer technologies related to carbon farming, such as feed additives for animal diets, assist farmers who use their products in monitoring, reporting, and verifying (MRV) GHG emissions reductions, as well as in certifying the associated carbon credits (Agolin, 2024).

Given the agricultural sector's resistance to the economic policy instrument presented above, the most common approach to facilitate a transition towards more sustainable agricultural production remains

subsidization (Bozzola and Cerroni, 2022; Matthews, 2023). The predominant form of subsidization remains ABPs. ABPs are fixed payments that compensate farmers for implementing sustainable farming practices or technologies (McDonald et al., 2021). Numerous examples of Agri-Environment-Climate schemes (AECS) under the Pillar II of the Common Agricultural Policy (CAP) are structured as ABPs and eco-schemes introduced under Pillar I in the 2023 CAP reform also follow an action-based logic. Most of these actions (both AECS and eco-schemes) target biodiversity conservation, water quality enhancement, and organic farming, while fewer consider carbon farming. An exception is the Green Low-Carbon Agri-Environmental Scheme in Ireland, which compensates farmers not only for biodiversity and landscape conservation but also for low-input permanent pasture aimed at reducing emissions (McGurk et al., 2020). ABPs have been criticized for their low cost-effectiveness (Engel, 2016; Pe'er et al., 2019; 2022), which is generally attributed to asymmetric information, adverse selection, and moral hazard (Hanley, 2012; White and Hanley, 2016). These phenomena can reduce additionality and increase windfall effects, thereby undermining the overall cost-effectiveness of ABPs (e.g., Chabé-Ferret and Subervie, 2013; Classen et al., 2018; Wunder et al., 2018; Bertoni et al., 2020; Lichtenberg, 2021; Wuepper and Huber, 2022). Ex post assessments of the CAP's green architecture have also highlighted its limited environmental effectiveness; for example, despite €100 billion being allocated to climate action in 2014–2020 (around 26 % of CAP funds and 50 % of total EU climate action spending), the European Court of Auditors found little measurable impact on agricultural emissions (European Parliamentary Research Service, 2024).

RBPs are becoming increasingly attractive to policymakers to overcome these potential issues. Unlike ABPs, RBPs reward farmers based on environmental benefits generated by the adoption of environmentally friendly practices (McDonald et al., 2021). In recent years, the number of RBPs has slowly increased, with a few pilot examples across Europe related to farmland biodiversity improvement (e.g., Herzon et al., 2018; Russi et al., 2021). However, their actual implementation is still limited, especially those related to carbon farming. RBPs related to carbon farming can imply a fixed payment based on the carbon units reduced at the farm level. The main advantage of RBPs is that they mitigate asymmetric information problems as farmers are incentivized to use private information (e.g., cost of implementation and land potential) to maximize their benefits. This can improve the cost-effectiveness of RBPs compared to ABPs (Burton and Schwarz, 2013; White and Hanley, 2016). Indeed, several empirical studies find that, where well-designed, RBPs outperform ABPs in delivering environmental benefits per euro spent (Schaub et al., 2025). However, RBPs also have shortcomings. RBPs are often perceived as less fair and more uncertain by farmers, leading to lower acceptance compared to ABPs (Derissen and Quaas, 2013; Drechsler, 2017; Canessa et al., 2023). Additionally, they are more difficult to implement due to the need for advanced monitoring, reporting, and verification (MRV) processes (Bartowski et al., 2021; Wuepper et al., 2022), a challenge especially relevant in carbon farming (Matthews, 2023; Raina et al., 2024). Here, MRV is particularly critical because accurately quantifying GHG reductions or carbon sequestration requires specialized measurement, modelling, and auditing procedures (COWI, 2021). Empirical evidence shows that MRV and related transaction costs can consume 20–30 percent of total program budgets, eroding much of the expected efficiency gain (Russi et al., 2016; Moran et al., 2021).

A preliminary step toward helping the agricultural sector meet EU climate targets could be the introduction of Hybrid payments (HPs) that can ease farmers into RBPs (Herzon et al., 2018; Piñeiro et al., 2020). HPs combine the strengths of ABPs and RBPs (e.g., Burton and Schwarz, 2013; White and Hanley, 2016; Herzon et al., 2018; Wuepper and Huber, 2022; Kreft et al., 2024). Some examples of HPs related to carbon farming are implemented at the private level by Indigo Ag and Nori (Raina et al., 2024). These HP schemes combine action-based payments, which reward farmers for following specific actions or guidelines, with result-based

payments, which reward them for achieving specific environmental outcomes. In other words, farmers receive a base flat payment (generally based on the number of hectares where the best practice has been adopted) plus a payment tied on the environmental benefit produced by the best practice.

1.2 Farmers' acceptability of examined economic tools

Research on farmers' acceptability of compulsory and voluntary carbon credit schemes is in its infancy. To the best of our knowledge, there is only one study that explores the acceptability of a cap-and-trade system related to the agricultural sector (Bozzola and Cerroni, 2022). Using a small sample of 20 agricultural students, the survey-based study concludes that there is a limited acceptance of an agricultural ETS and that involvement in the scheme facilitates the intended adoption of technologies reducing GHG emissions at the farm level. Despite the limitation regarding the hypothetical nature of the study and the non-representative sample of the farming population, the study represents the very first attempt to investigate responses to an agricultural ETS. The literature on voluntary carbon schemes based on carbon offsetting is equally scant. To the best of our knowledge, Cammarata et al. (2024) offer the sole study on farmers' acceptability of this form of compensation. They elicited Italian farmers' intention to participate in voluntary carbon markets via Likert scales and modelled behavioural intentions using the Theory of Planned Behaviour (TPB). Using a sample of 241 farmers, the study found a lukewarm interest in voluntary carbon markets. Cammarata et al. (2024) also investigate whether and to what extent behavioural factors mediate acceptability. The considered behavioural factors are: perceived consequences, subjective norms, and perceived behavioural control. Results suggest that positive perceived consequences and perceived behavioural control positively affect support, while subjective norms do not affect acceptability.

The literature on the acceptance of carbon taxes in agriculture is very narrow as well. While there is widespread consensus that the general public does not appreciate the introduction of taxes, even carbon taxes (e.g. Maestre-Andrés et al., 2021), there is little evidence regarding the acceptability agriculture-related taxes, mainly suggesting that farmers are not supportive of carbon taxes in agriculture (e.g. Van Wyngaarden et al., 2024). Organized farmers' protest since the publication of CO₂e tax proposals in Denmark by an Expert Group on Tax Reform in February 2024 (Expert Group, 2024) supports this thesis. Despite the broad agreement within the Danish Parliament to introduce the tax in fall 2024, farmers continue to protest demanding the tax's abolishment, citing the potentially severe negative impact of the tax on the sector (Ipsen, 2025). Farmers are particularly concerned about potential disruptions to agricultural production, agricultural employment, and land value. These concerns are not unexpected, as such a tax is predicted to have negative effects in these areas. For example, estimates from the Danish Expert Group on Green Tax Reform indicate that a tax of 750 DKK (approx. 100 EUR) per ton of CO₂e emissions could reduce agricultural production and employment in the primary agriculture sector by 15% and 16% respectively, and land values by 16.8% (Expert Group, 2024).

The literature investigating farmers' acceptability of RBPs and HPs is also limited, but more substantial than the literature on compulsory and voluntary carbon credit schemes. Most studies focus on AECS designed to enhance biodiversity, and only a small fraction focus on AECS that directly promote carbon farming practices. A variety of methods were used to explore farmers' acceptability of RBPs and HPs, from semi-structured interviews (e.g., Birge et al., 2017) and structured interviews (e.g., D'Alberto et al., 2024) to Stated Preference (SP) studies (e.g., Massfeller et al., 2022; Schulze et al, 2024). All SP studies on RBPs and HPs rely on discrete choice experiments (DCEs), except for Massfeller et al. (2022), which uses a Contingent Valuation Method survey. Most analyze biodiversity-focused schemes and generally report that farmers are willing to accept RBP schemes. This finding is rather robust across farming types (arable, grassland, and rice), biodiversity focus

(weed species, plant species, flowering species, and birds), and across countries (Germany, Slovenia, and Japan) (e.g., Massfeller et al., 2022; Šumrada et al., 2022; Tanaka et al., 2022; Canessa et al., 2023). The only exception is Finland, where Niskanen et al. (2021) found that farmers are reluctant to adopt an RBP and prefer more traditional ABPs.

Preferences for HPs were explored by Canessa et al. (2023) and Thiermann et al. (2023). Both studies investigate different subsidization schemes related to biodiversity enhancement and suggest that farmers are willing to accept HPs. The former study focuses on Bavarian grassland (i.e. flowering species), the latter on a meadow bird management scheme in the Netherlands. Results from the former study suggest that farmers in Bavaria prefer RBPs and HPs to ABPs, but they have no strict preferences for HPs over RBPs. Results from the latter show that farmers in the Netherlands prefer HPs over ABPs (RBPs were not an option available to farmers in the DCE study).

A handful of DCE-based studies have focused on RBPs related to the adoption of carbon farming practices. The results are mixed and do not consistently show farmers' support for RBP schemes. Tyllianakis et al. (2023) explored farmers' preferences for RBPs and HPs (over ABPs) geared to increase soil carbon sequestration in the UK, and they found that older and uninformed farmers are indifferent among different subsidization schemes, while younger farmers who are familiar with AECS prefer RBPs over HPs and HPs over ABPs. Contrasting results regarding farmers' acceptability of RBPs and HPs related to carbon sequestration and biodiversity enhancement were found by two recent DCE studies conducted in Spain. In a study focusing on olive groves, Villanueva et al. (2024) reported that RBPs are accepted when applied to carbon sequestration actions, but not when applied to biodiversity enhancement programs. In contrast, in a study focusing on oak savannahs, Granado-Díaz et al. (2024) found that RBPs acceptance is higher for biodiversity enhancement programs than for carbon sequestration ones. Other studies report farmers' reluctance towards RBP schemes. Block et al. (2024) demonstrated that farmers prefer an ABP over an RBP scheme when asked about joining a carbon sequestration scheme in Germany (i.e. the so-called humus programme). Gars et al. (2024) show that Dutch, Finnish, and Swedish farmers' preferences lean towards ABP rather than RBP and HP when asked to implement climate-friendly practices (i.e., use of cover or catch crops).

1.3 Behavioural factors driving farmers' acceptability of economic policy tools

Previous research shows that farmers' behaviour is shaped by many factors. Among these, we find farmer socio-demographics (e.g. age, gender, education, experience), farm characteristics (e.g. farm size, diversification), and behavioural factors (e.g. risk attitudes, descriptive and injunctive norms, etc.). A literature-based mapping that outlines these factors was conducted in Task 2.1 in WP2. Deliverable D2.1. presents the approach used and the findings from this exercise.

In this report, we focus our attention on behavioural factors that can shape farmers' acceptability of economic tools promoting a reduction of GHGs in the livestock sector. These factors are defined as any social and psychological factors that can shape human decision-making. According to Dessart et al. (2019), behavioural factors can be classified into cognitive factors like perceived control, perceived costs, and benefits, knowledge and perceived risks, social factors like descriptive and injunctive norms, and dispositional factors like resistance to change, risk tolerance, personality, and moral and environmental concerns.

Farmers' acceptability of voluntary carbon markets is likely to be affected by behavioural factors related to decision-making under risk and uncertainty, as the amount of the carbon credits is proportional to the reduction of GHG emissions guaranteed by the adoption of a sustainable practice and/or technology, which is, in most cases, rather uncertain. In addition, farmers face another source of uncertainty, which is the price volatility of the carbon credit (Piñero et al., 2020; Bozzola and Cerroni, 2022). Therefore, we anticipate that

expectations regarding the potential GHG emission reductions or the future price of carbon credits can play a role in farmers' acceptability of the financial tools. Similarly, we expect that risk and ambiguity preferences may affect farmers' behaviour. These behavioural factors are likely to affect RBPs and HPs as well. These subsidization schemes, in fact, reward farmers based on the measured environmental benefits produced by the adoption of more sustainable practices. These benefits are often unpredictable and depend on many endogenous and exogenous factors. Farmers' acceptance of compulsory carbon markets (i.e. ETS) can be influenced by the same behavioural factors. After all, farmers involved in compulsory carbon markets also face the volatility of carbon credits' price (Bozzola and Cerroni, 2022).

Stricter economic instruments, such as carbon taxes and compulsory carbon markets, may stimulate a higher level of reactance among farmers. Other behavioural factors can play a crucial role in shaping reactance to these instruments. Previous research suggests that such reactance is often driven by people's economic concerns related to the introduction of such policy instruments. This research shows that perception of the cost of an environmental policy or regulation often differs from its actual or scientifically predicted impact (Carattini et al., 2018; Douenne and Fabre, 2022), and this gap often negatively impacts policy acceptance (Drews and Van den Bergh, 2015). Broad literature on carbon tax acceptance indicates that people often overestimate the costs of taxes (Douenne and Fabre, 2022; Jagers and Hammar, 2009), while they tend to underestimate the environmental benefits of the policy (Carattini et al., 2017). For example, Douenne and Fabre (2022), using a representative survey, find that the French largely reject a carbon tax and dividend policy, overestimating their losses, wrongly viewing it as regressive, and questioning its environmental effectiveness.

More generally, all examined economic instruments are geared to stimulate farmers' adoption of sustainable practices or technologies. Therefore, their acceptability can be directly or indirectly related to the perceived ability of farmers to adopt the carbon framing practice, which is generally related to a latent factor named perceived behavioural control. Perceived behavioural control in this case refers to farmers' perception of their own ability to adopt the practice and reach given environmental performances (Ajzen, 1991; Massfeller et al., 2022). Similarly, pro-environmental attitudes might affect farmers' preferences for examined economic policy instruments (e.g. Dessart et al., 2019). We do not exclude that other behavioural factors could affect farmers' acceptability, but they are not considered in the two studies.

2. The Italian case study

2.1 Background information on the case study

Our empirical application focuses on the introduction of a specific carbon farming practice: The use of essential oils in bovine diets in the dairy sector in the Autonomous Province of Trento (PAT), Italy. Essential oils, categorized as zootechnical feed additives, are derived through the steam distillation of various plant species and function as rumen modifiers, effectively inhibiting the methanogenesis process in ruminants (Glasson, 2022).

The dairy sector holds significant economic importance in Italy, contributing nearly 9.5% of the agri-food industry's total turnover, with a revenue of €18.5 billion in 2023 (ISMEA, 2024). In the PAT, despite a general decline in traditional agriculture, the dairy industry remains vital, with the local sector achieving €65 million in turnover in 2023 (PAT, 2024). It currently supports approximately 18,000 dairy cows and around 638 dairy farms. Moreover, dairy farming contributes important ecosystem services in the PAT, such as preserving the typical alpine landscapes, maintaining farming traditions (e.g., summer grazing in alpine pastures), and enhancing biodiversity (Sturaro et al., 2013).

However, cattle farming also produces negative environmental externalities. Methane accounts for nearly 40 percent of livestock emissions (FAO, 2022), and it was responsible for about 30% of the increase in global temperatures since the Industrial Revolution (IIEA, 2023). To reach the Paris Agreement's goal of limiting warming to 1.5°C above pre-industrial levels, the EU and the US launched the Global Methane Pledge at COP26 in 2021, which requires signatories to take voluntary actions to reduce global methane emissions by at least 30% from 2020 levels by 2030 (Global Methane Pledge, 2021). To meet this ambitious target, the EU developed its EU Methane Strategy (European Commission, 2020). In Italy, the agricultural sector accounts for 7% of the country's total greenhouse gas (GHG) emissions. Within this sector, livestock management represents the largest share, with methane from enteric fermentation accounting for 44.7% of the total GHG emissions in agriculture (ISPRA, 2023). In the PAT, 27% of methane emissions are attributed to agriculture and livestock farming (PAT, 2023).

There are many carbon farming practices available to abate GHG emissions in the dairy sector. Those related to methane emissions from enteric fermentation include dietary and rumen manipulation, ration balancing, production intensification, selection of low-CH₄-producing animals, and extended lactation (Knapp et al., 2014; Lehmann et al., 2019; Beauchemin et al., 2020). Among these, the use of feed additives, and specifically essential oils, may be especially effective in the short term, as these products are already available in the market and can substantially reduce enteric methane emissions (Hristov et al., 2013; Honan et al., 2021; Becker et al., 2023). A recent review by Arndt et al. (2022) concluded that essential oils can reduce enteric methane emission by an average of 8.3%. The extent of this reduction depends on several factors, including the environment, animal diet, and health, among others (Honan et al., 2021; Hristov et al., 2013; Johnson and Johnson, 1995).

Mitigating GHG emissions from agriculture is a priority in the PAT's agenda. Their strategic plan, developed under the rural development programme of the new CAP, emphasizes the need to improve the climate and environmental performance of livestock farms and outlines investments for climate change mitigation in the agricultural sector (PAT, 2022).

2.2 Methods

2.2.1 Sampling and data collection

A total of 120 dairy farmers from the PAT participated in this study. Before the implementation of the study, we ran both focus groups and a pilot with five local livestock farmers in October 2023s. Our sample represents approximately 18% of the total population of dairy farmers, which consists of around 640 individuals. Recruitment was facilitated by the Consortium of Social Dairy Farms of the PAT. All dairy farmers in the Province were contacted either by email or by phone and those who agreed to participate were assigned to experimental sessions contingent on their availability.

The experiment was conducted from November 2023 and February 2024 via individual-assisted Zoom sessions. In each session, the same researcher provided an explanation of the experimental instructions and tasks and answered any doubts or questions that the participants had. Each session lasted approximately 40 minutes. The experiment was programmed using oTree (Chen, Schonger, and Wickens, 2016). The experiment received ethical approval from the Ethical Committee at the University of Trento and was pre-registered² at the Open Science Framework (OSF). In our sample, 12% of farmers are women, and 50% are older than 44.5 years old. The majority of respondents (84%) are farm owners, and 74% have received a formal education in agriculture. About 66% of farmers own more than 22 livestock units (LSUs), which is the average for a farm in the Province of Trento. Approximately 85% of our respondents are multi-generational farmers, as dairy farms in the province tend to be family businesses passed down through generations.

Regarding feeding strategies, 74% of farmers continue to use traditional methods, delivering daily rations two or three times a day with individual components (forages, by-products, concentrates, etc.) distributed separately. Conversely, 26% have adopted unifeed systems, a modern approach where all dietary components are mixed into a homogeneous ration. Furthermore, 79% of farmers are also engaged in diversified farming activities. These activities include forage, apples, and grapevine production. Notably, 30% of our farmers have installed solar or photovoltaic panels on their farms. This information was collected via a questionnaire administered at the end of the experimental tasks. Table 1 below provides descriptive statistics for our sample.

² Pre-registration DOI: <https://doi.org/10.17605/OSF.IO/NPJCV>

Table 1 Descriptive Statistics

Variable	Description	Mean	SD
Female	= 1 if farmer is female (= 0 otherwise)	0.12	0.33
Older_farmer	= 1 if farmer is older than 45.5 ^a (= 0 otherwise)	0.50	0.50
Farm_owner	= 1 if farmer is farm business owner (= 0 otherwise)	0.84	0.36
First_generation	= 1 if farmer is first generation farmer (= 0 otherwise)	0.15	0.36
Ag_education	= 1 if farmer has formal education in agriculture, at least a high school diploma (= 0 otherwise)	0.74	0.43
Large_farm	= 1 if LSU > 22 (= 0 otherwise)	0.66	0.47
Unifeed	= 1 if farmer uses Unifeed as feeding strategy (= 0 otherwise)	0.26	0.44
Premix	= 1 if farmers use premix as feeding strategy (= 0 otherwise)	0.05	0.21
Traditional_feed	= 1 if farmers use traditional feeding strategy (= 0 otherwise)	0.69	0.46
Farm_diversification	= 1 if other farming activity (either apple, grapevine, forages, or other activity) (= 0 otherwise)	0.79	0.40
Photovoltaic/ solar_panels	= 1 if farm has solar or photovoltaic panels (= 0 otherwise)	0.30	0.47
Perceived_control ^b	= 1 if farmer has high perceived control on feeding strategy (= 0 otherwise)	0.84	0.36
CH ₄ _reduction ^b	= 1 if farmer believes reducing CH ₄ is necessary (= 0 otherwise)	0.76	0.42
Risk averse ^c	= if farmer is risk averse (= 0 otherwise)	0.62	0.48
Ambiguity averse ^b	= if farmer is ambiguity averse (= 0 otherwise)	0.35	0.39
Pro-env attitudes ^b	= if farmer has pro-environmental attitudes (= 0 otherwise)	0.73	0.44

^a The median of farmers' age in our sample; ^bData collected using a 5-point Likert scale from on a scale from 1 ("Strongly disagree") to 5 ("Strongly agree") and then transformed into a dummy using a median split (1 if value above or equal to median); ^cData collected using an 11-point Likert scale ranging from 0 ("very unlikely to take risk") to 10 ("very likely to take risk") and then transformed into a dummy using a median split (1 if value above or equal to median).

2.2.2 Experimental design and treatments

Our experiment is structured in four phases. In the first phase, farmers participate in a farm business game (e.g., Peth et al., 2020; Angioloni and Cerroni, 2025) designed to elicit their preferences for an RBP scheme or a voluntary carbon offsetting scheme compared to an ABP scheme. This game will be referred to as the *First Farm Business Game* (FFBG). In the second phase, they engage in a similar business game to assess their preferences for an HP versus an ABP (referred to as the *Second Farm Business Game*, or SFBG). In the third phase, farmers play a belief elicitation game that reveals their subjective probability distributions about the effectiveness of essential oils in reducing methane emissions using the interval method (Charness et al., 2021;

Cerroni and Rippo, 2023). In the fourth and final phase, farmers complete a questionnaire designed to collect data on their personal, farm characteristics, and behavioural factors.

The experiment follows a between-subject design, with participants randomly assigned to one of two main treatment groups: RBP or VCM. In the FFBG, farmers in the RBP group are offered a result-based payment of 6€ for each unit of methane emission reduction achieved using essential oils. In contrast, those in the VCM group are presented with a voluntary carbon market mechanism, where they receive one carbon credit per unit of methane reduced through the same essential oil intervention. Each credit can be sold for a fixed price of 6€ to a public body managing the voluntary market. This mechanism simulates a forward contract in which the payment per unit of methane reduction is known in advance, eliminating price uncertainty. As a result, the only source of uncertainty that farmers face is related to the actual effectiveness of essential oils in reducing emissions. This framing ensures that the two treatments are equivalent in terms of payoff structure and allows for a direct comparison of farmers’ preferences between RBP and VCM. One commonly debated issue with RBP schemes is the reliability of MRV systems. To address this concern, farmers are informed that a farm advisor will visit their farm to measure actual methane emission reductions achieved by essential oils.

In the SFBG game, participants from each main treatment group (RBP or VCM) are then randomly assigned into one of three subgroups in order to explore how they respond to different designs of the HP scheme. These designs differ in the proportion of ABP, RBP, or VCM components. Specifically, the HP(10%-90%) variant offers 10% of the payment based on ABP and 90% on RBP(VCM); HP(30%-70%) offers 30% ABP and 70% RBP(VCM); and HP(50%-50%) provides an equal split between ABP and RBP(VCM). The overall experimental design and subgroup allocation are summarized in Table 2.

Table 2 Experimental Design and Sample Sizes

Treatment Group	Sub-Groups	Sample Size
RBP	HP-RBP (10%-90%)	20
	HP-RBP (30%-70%)	20
	HP-RBP (50%-50%)	19
VCM	HP-VCM (10%-90%)	20
	HP-VCM (30%-70%)	21
	HP-VCM (50%-50%)	20

In the third phase, in each treatment group (RBP or VCM), farmers were asked to provide their subjective probability distributions about the efficacy of essential oil in reducing methane emissions using the interval method (Charness et al., 2021; Cerroni and Rippo, 2023). More details will be provided in the next section.

In the fourth phase, farmers were asked to fill a questionnaire on sociodemographic characteristics (sex, age, education), farm characteristics (farm owner, farmer generation, work experience, farm dimensions, other farming activities, photovoltaic or solar panel adoption), environmental attitudes using the New Environmental Paradigm (NEP) scale (Dunlap et al., 2000), domain-specific self-reported risk attitudes (Finger et al., 2023), ambiguity aversion regarding experts’ opinions on agricultural innovations (adapted from Han

et al., 2018), and perceived control over the implementation of the novel strategy (adapted from Ajzen, 1991). All behavioural questionnaires contained 5-point Likert scales with answer options ranging from 0 (“Strongly disagree”) to 5 (“Strongly agree”), except for the self-reported risk attitudes, which were expressed on a scale ranging from 0 (“very unlikely to take risk”) to 10 (“very likely to take risk”).

2.2.3 Experimental tasks

2.2.3.1 The first farm business game (FFBG)

In the FFBG, farmers expressed their preferences for acquiring essential oils under alternative subsidization schemes. Either an ABP or an RBP in the RBP group, either an ABP or a VCM scheme in the VCM group. A certainty-equivalent multiple price list (CE-MPL) format was used (e.g., Abdellaoui et al., 2011; Cerroni, 2020; Di Falco and Vieider, 2022). The CE-MPL format consists of seven decision tasks involving three alternatives in each: i) purchase and use of essential oils while receiving an ABP, ii) purchase and use of essential oils while receiving an RBP, or iii) no purchase of essential oils (see Figure 1 for an example).

Participants were asked to assume they own a dairy farm of an average size in the PAT (i.e., a farm that owns 22 LSU) and to consider purchasing methane-reducing essential oils (1g/LSU/day) to include in bovine diets for a period of one year. The annual cost for the purchase and use of essential oils per LSU is €59,76. This makes the annual total costs of purchasing and using essential oils for a 22-LSU farm equal €1.315. Farmers begin with a reference net farm income of €20.000 and their decisions in the farm business game can alter it.

The ABP option covers a specified percentage x of the total incurred costs which ranges from 75% to 120%. It is increasing over each decision task, with $x = [75\%, 80\%, 85\%, 90\%, 95\%, 100\%, 120\%]$. For example, in Figure 1 (left-hand side), the ABP option covers 85% of the costs (i.e., 1.1118€), and the net income at the end of the period is equal to 19.803€ (20.000€ - 1.315€ + 1.118€). The decision to include an ABP that covers 120% of the costs was motivated by the new CAP Strategic Plan regulation for ecosystem services. Under this regulation, remuneration can be based either on opportunity costs or on the value of the ecosystem services provided. If remuneration is based on the value of the services, there is no strict limit on the ratio between costs and payments.

The RBP or VCM option (either in the RBP or the VCM group), instead, implies a payment of 6€ for each ton of methane reduced thanks to the introduction of essential oils. The RBP or VCM option is the same across decision tasks, and it is characterized by some degree of uncertainty about the level of methane emission reductions that the use of essential oils will generate and hence about the final RBP or VCM. Numerous studies have demonstrated that methane emissions reductions due to essential oils can be rather heterogeneous due to several factors: the environment where the cattle live, health conditions, diet management, etc. (Honan et al., 2021; Hristov et al., 2013; Johnson and Johnson, 1995). Farmers were informed that introducing essential oils into animal diets could lead to y percentage intervals of emission reductions, where $y = [(6.6\%, 7\%), (7.1\%, 7.5\%), (7.6\%, 8\%), (8.1\%, 8.5\%), (8.6\%, 9\%), (9.1\%, 9.5\%), (9.6\%, 10\%)]$. These intervals were identified based on previous literature (Arndt et al., 2022), and using midpoints, this yields seven different levels of compensation under the RBP or VCM ($z = [1.077\text{€}, 1.156\text{€}, 1.236\text{€}, 1.315\text{€}, 1.394\text{€}, 1.473\text{€}, 1.552\text{€}]$), (see the central part of Figure 1). The actual realization of emission reduction is unknown to farmers when making choices. The “no buy” option means that farmers do not want to purchase and use essential oils and hence keeps the farm income constant and equal to 20.000€ (see right-hand side of Figure 1).

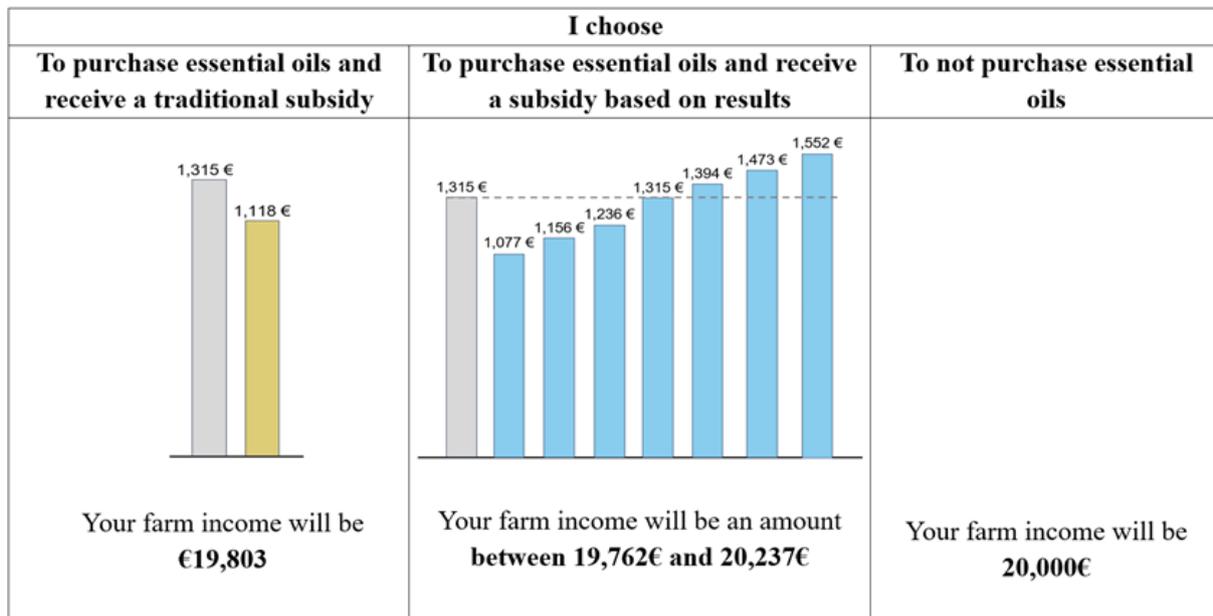


Fig. 1 Example of a choice card in the RBP game

2.2.3.2 The second farm business game (SFBG)

The SFBG replicates the first one with the key difference being the replacement of the RBP or VCM with an HP. The HP consists of two components: a given percentage (10%, 30%, or 50%) of the total HP comes from a fixed payment based on the ABP, while the remaining part (90%, 70%, and 50%) comes from the variable payment based on the RBP or VCM (see Figure 2). Specifically, the fixed payments in the HP are calculated as percentages of an ABP that covers 70% of the cost of buying and using essential oils.³ The variable payments, instead, are calculated as a percentage of an RBP or VCM, assuming 6€ for each unit of methane emission reduced. This strategy helped to ensure that the total compensation remained realistic without excessively inflating the payments. Moreover, we intentionally avoided schemes with higher ABP shares, as the rationale is to use hybrid schemes as a gradual transition from ABP to RBP or VCM. As in the first farm business game, the HP remains constant throughout the seven decision phases, while the ABP gradually increases from 75% to 120%.

³The fixed payments are calculated based on a 70% ABP (= 920€). These are equal to 460€ in the HP (50%-50%), 276€ in the HP(30%-70%) and 92€ in the HP(10%-90%).

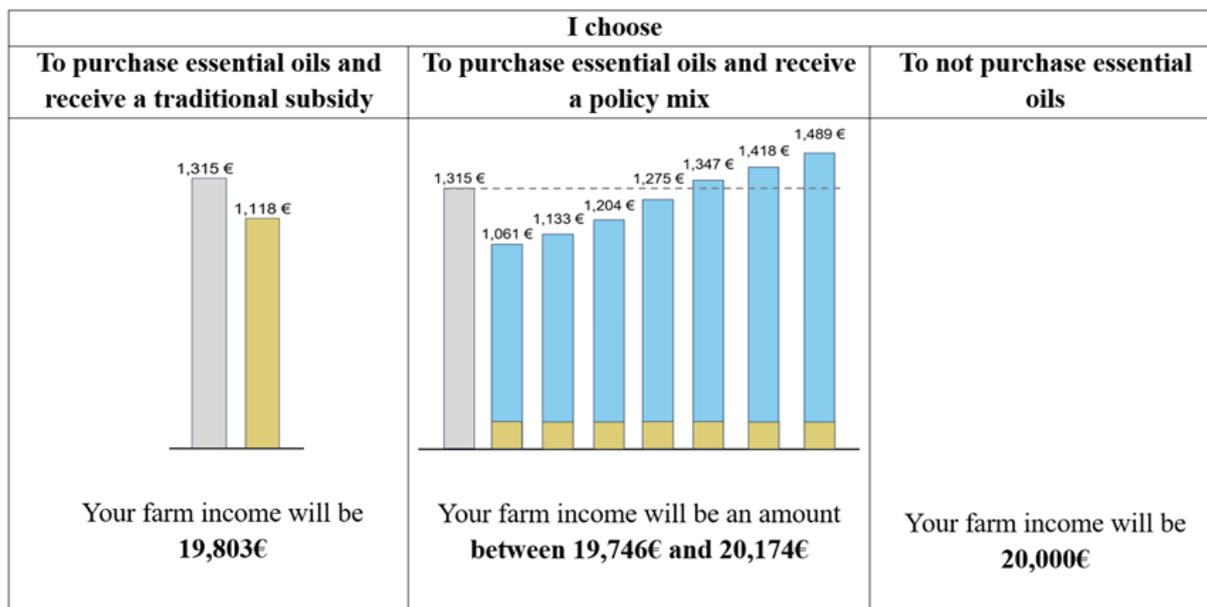


Fig. 2 Example of a decision card in the HP(10%-90%) game

The three variations of the HP reflect different possible HP designs. It is important to note that designs can be ranked in terms of their expected value (EV); the HP(10%-90%) provides higher compensation than the HP(30%-70%) design that, in turn, provides higher compensation than the HP(50%-50%) (see Figure 3). Therefore, in principle, rational farmers should prefer the RBP or VCM to the HP schemes (as they have higher EV compared to HP schemes), and they should prefer the HP(10%-90%) over the HP(30%-70%) over the HP(50%-50%). From a policy perspective, the HP was designed according to the rationale of minimising public expenditures with respect to the RBP and VCM schemes.

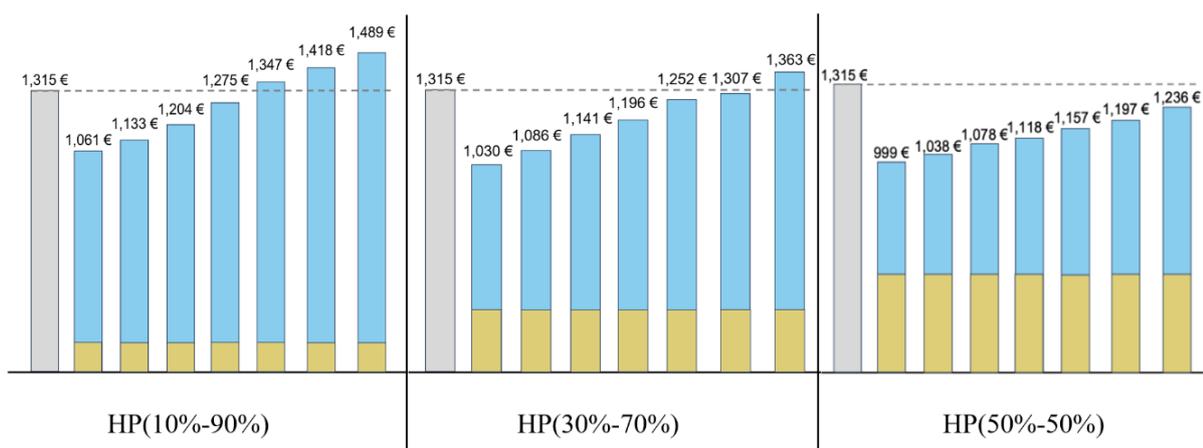


Fig. 3 The three variations of the HPs in the SFBG game

2.2.3.3 The subjective probability distribution elicitation game

In the subjective probability distribution game, farmers were asked to provide their subjective probability distributions about the efficacy of essential oil in reducing methane emissions. The interval method was used (Charness et al., 2021; Cerroni and Rippo, 2023). Farmers were tasked with distributing 70 tokens across 7 possible intervals of reduction in methane emissions; so that the more tokens were assigned to a specific interval, the more they believed that reduction would happen. A screenshot of the token distribution device is provided in Figure 4. Farmers could be rewarded with the additional bonus for this phase (equal to 15€) if and only if their guesses about the token allocation that represents their subjective probability distribution (of the reduction in methane using essential oils in bovine diets) matched the underlying probability distribution with an error margin of 10%. The true distribution was designed considering information provided in Arndt et al. (2022) and experts' opinions and was unknown to farmers before they participated in the third task. This phase was implemented to check, in an incentivised way, whether farmers believe in the efficacy of the essential oils. It was in the best interest of the participant to report the truthful beliefs in probability distribution as this maximizes the likelihood to win the bonus, allowing us to control whether belief in essential oil efficacy was affecting the willingness to adopt essential oils in FFBG and SFBG.

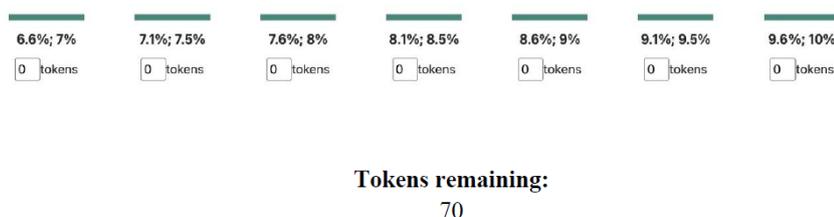


Fig. 4 Visual representation of the token distribution device

2.2.3.4 Monetary incentives

To ensure incentive compatibility, participants were informed that their monetary reward at the end of the experiment would be based on their decisions in one of the two farm business games or the subjective probability distribution game. After completing the study, one of the three games was selected at random.

If the FFBG or the SFBG was selected, then one of the seven decision rounds was randomly chosen as binding. The payoff in that round determined each participant's monetary rewards, calculated as

$$Payoff = 15 \times \left(\frac{Final\ net\ farm\ income - 19.605,5}{631,8} \right)$$

where *Final net farm income* is equal to the initial farm income (20.000€) minus any cost of essential oils plus any payment earned for their use. After subtracting the minimum available income in the farm business games (19.605,6€) and scaling down (dividing by the largest positive difference (631,8€)), the outcome is multiplied by 15, which gives a reward between €0 and €15. It is then added to the €10 flat-rate participation fee.

For those who chose the RBP or VCM or HP option in the binding task, we next drew a random methane-reduction outcome. We simulated the probability distribution of the seven possible reduction scenarios—

based on Arndt et al. (2022) and expert elicitations—then used that draw to determine the realized farm income (and thus the final payoff) under uncertainty.⁴

If the subjective probability distribution game was selected, the rewards were provided as explained in section 2.2.3.3.

2.3 Results

2.3.1 The first farm business game

The FFBG elicits dairy farmers' willingness to accept (WTA) an ABP to adopt essential oils. WTA is calculated based on each participant's switching point, which represents the point at which a participant shifts their preferences from the RBP (or VCM, depending on the between subject-treatment group) to the ABP. Specifically, we use the midpoint method, meaning that we calculate the WTA by taking the midpoint between the value of the row at which the participant switches from RBP (or VCM) to ABP and the value of the previous row. For example, if the switch happens at 1.052€, the corresponding WTA is 1.019€, that is the midpoint between 1.052€ and 986€ (i.e. the value presented before 1.052€).

WTA an ABP is an indirect measure of preferences for the RBP or VCM option. In fact, a high WTA an ABP indicates a strong positive preference for the RBP or VCM.⁵ Specifically, a high WTA an ABP means that the participant is willing to accept a high sum (and that it is the minimum he/she is willing to accept) to give up the RBP or VCM option, hence the participant attaches a high value to the RBP or VCM option. For example, a participant *i* who chooses RBP or VCM option until round four, and then switches to ABP in the next round, will be willing to accept 1.216,5€ to give up the RBP or VCM option. A participant *j* $\neq i$ who chooses the RBP or VCM option until round two and then switches to ABP in the next round will be willing to accept 1.019€ to give up the RBP or VCM option. It follows that participant *i* values the RBP or VCM option more than participant *j*, hence participant *i* is more willing to accept an RBP or VCM than participant *j*.

Switching from RBP (or VCM) to ABP is not the only option. An alternative decision-making pattern would be to consistently choose the RBP or VCM option. In this instance, farmers would then be asked for their maximum WTA for switching from the RBP or VCM to the ABP using an open question. Another possible decision-making pattern would be to consistently choose the ABP option. If that was the case, farmers were asked an additional question to ascertain their minimum WTA for an ABP. Farmers choosing any other behavioural pattern are considered irrational and are excluded from our analyses.

In the FFBG, 97.5% of farmers chose to buy essential oils, with their WTA values ranging between a minimum value of 0€ and a maximum value of 1.578€.⁶ On average, pooling the data from the RBP and the VCM treatments, farmers were willing to accept an ABP of 1.134,05€ (SD = 289.07), which covers 86.2% of the yearly cost of buying and using essential oils. This result provides two insights. First, farmers were generally willing to adopt essential oils in bovine diets if payment schemes were available (only 4 farmers consistently chose not to adopt essential oils). Second, farmers who opted in were willing to accept an ABP that covers less than the full cost of adoption to avoid the RBP or VCM. This signals that, on average, farmers are not particularly keen about RBP and VCM schemes.

⁴The 10 experts involved in the preparatory stage were animal nutrition and production scientists, vets, animal feed, dairy and meat company representatives.

⁵To avoid confusion, we emphasize that WTA in this context does not imply aversion for ABPs per se but serves as an indirect measure of the farmer's preference for more result-oriented payment schemes.

⁶Two farmers who consistently choose the ABP option, reported a WTA equal to 0€. The rationale behind this decision were discussed in the one-to-one sessions: either the cost was not considered to be substantial, or the farmer viewed essential oils as a beneficial investment for animal welfare and the environment.

We now proceed to compare WTA across treatment groups. The mean WTA an ABP is 1.139,73€ (SD = 295.43) in the RBP group and 1.127,66€ (SD = 284.72) in the VCM group.⁷ The difference in WTA between groups was tested by estimating two different econometric models. In all models, the dependent variable is the WTA for the ABP. Model 1 only includes the dummy variable RBP, which indicates whether the WTA for the ABP option was elicited under the RBP treatment (rather than under the VCM treatment). Model 2 adds control variables such as i) socio-demographic variables describing the farmer, ii) farm characteristics, iii) farmers' perceived control about using essential oils and iv) general attitudes towards methane reductions in agriculture (see Table 1 for a description of these variables)⁸. Given the nature of the dependent variable, an ordinary least squares (OLS) estimator was used to estimate the models. The results from these models are presented in Table 3.

⁷ Differences in WTA across groups were tested using non-parametric Kolmogorov-Smirnov test. No statistical difference was detected.

⁸ Remaining behavioural variables were tested to consistently not be significant predictors and were therefore removed from the final model.

Table 3 OLS regressions for FFBG

	Dependent Variable: WTA	
	(1)	(2)
RBP	12.065 (57.618)	13.335 (57.486)
Female		35.798 (92.297)
Older_farner		-113.560* (63.278)
Farm_owner		-79.672 (83.345)
First_generation		77.290 (81.100)
Ag_education		-3.685 (68.910)
Large_farm		-103.160 (71.256)
Unifeed		116.120 (75.317)
Pre-mix		-60.581 (135.396)
Farm_diversification		-41.803 (72.821)
Photovoltaic/Solar_panels		148.713** (68.212)
Perceived_control		-48.211 (83.216)
Reduction_necessary		170.928** (72.110)
Constant	1,127.667*** (41.923)	1,122.397*** (135.614)
Observations	102	102
R2	0.0004	0.199

Note: *p<0.1; **p<0.05; ***p<0.01

Both Model 1 and 2 do not detect any statistical difference in WTA between the two treatments, confirming that farmers have no real preferences between a payment associated with an RBP or a VCM scheme.

Estimation results from Model 2 highlight some heterogeneity in farmers' responses. Older farmers are willing to accept a lower ABP than the others (around €115 lower, $p < 0.1$), suggesting that the former are less willing to accept RBP or VCM. Results from Model 2 also indicate that farmers with a pro-environmental sensibility are generally willing to accept a higher WTA an ABP than the others, suggesting that they have stronger preferences for RBP or VCM. Farmers who installed photovoltaic or solar panels on their farm structures also exhibit a higher WTA an ABP (approximately €170 higher, $p < 0.05$) than others. Similar results were found by Canessa et al. (2023), who observed that farmers with a better general environmental performance tend to accept RBP schemes more frequently. In addition, farmers who believe that reducing emissions of enteric methane is a necessary step to be taken by dairy systems also show a higher WTA an ABP than others (approximately €168 higher, $p < 0.05$), indicating a higher acceptability of RBP and VCM schemes. This suggests that farmers who are convinced about the necessity of reducing GHG emissions at the farm level are more willing to accept innovative payment schemes.

2.3.2 The second farm business game

In the SFBG, 96% of farmers chose to purchase essential oils, with only 4 out of 106 farmers consistently opting out. Notably, these farmers were the same as in the FFBG, except for one who had, instead, previously decided to purchase essential oils. The average WTA an ABP was 1.098,39€ (SD = 261.20), which covers 83.52% of the annual cost of adopting essential oils. Interestingly, the majority of farmers (around 85%) indicated that they would be willing to accept a payment that is lower than the full cost of adoption of this feeding strategy. This proportion is higher than the one of the FFBG, where 69% of farmers were willing to accept a payment below the full cost. Again, this signals that, on average, farmers are not particularly keen about HPs. Figure 5 shows means and standard errors for WTA an ABP for each proposed HP scheme.

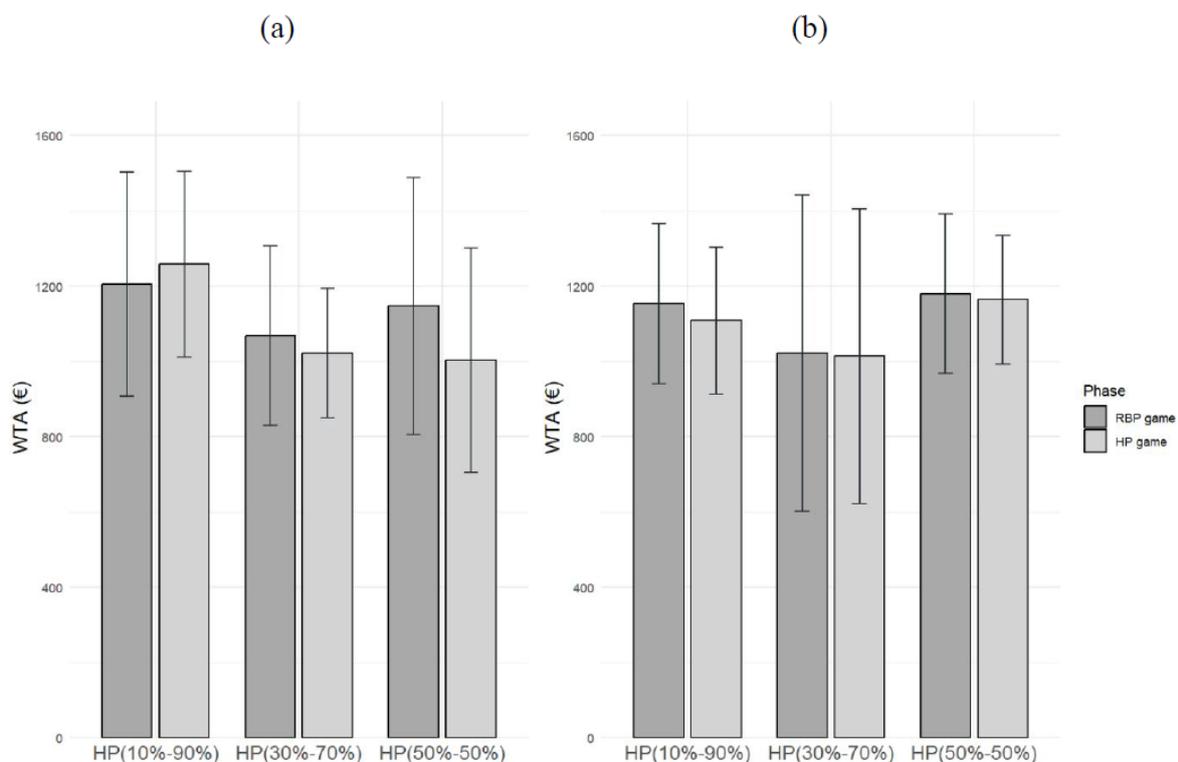


Fig. 5 WTA comparison across HP-RBP (a) and HP-VCM (b) treatments

Differences in WTA across HP groups and treatments were investigated by estimating two OLS models. In these models, WTA for an ABP elicited in the SFBG is the dependent variable. Model 1 only includes the following covariates: HP-RBP(10%-90%), HP-RBP(30%-70%), HP-VCM(10%-90%), and HP-VCM(30%-70%), while the variables HP-RBP(50%-50%) and HP-VCM(50%-50%) serve as reference categories. Model 2 controls for farmers' sociodemographic and attitudinal variables as well as farm characteristics (see Table 1 for a description of these variables). The results from these models are presented in Table 4.

Table 4 OLS regressions for SFBG

	Dependent Variable: WTA	
	(1)	(2)
HP-RBP(10%-90%)	174.819**	174.633**
	(73.114)	(72.188)
HP-RBP(30%-70%)	-61.931	-28.021
	(73.114)	(75.775)
HP-VCM(10%-90%)	24.819	78.674
	(74.533)	(78.843)
HP-VCM(30%-70%)	-69.411	-27.097
	(81.953)	(84.195)
Female		113.407
		(80.738)
Older_farmer		-16.687
		(56.983)
Farm_owner		-56.259
		(74.206)
First_generation		72.053
		(72.857)
Ag_education		-10.622
		(60.741)
Large_farm		-84.587
		(64.220)
Unifeed		144.147**
		(67.700)
Pre-mix		233.506*
		(121.084)
Farm_diversification		-134.757**
		(67.092)
Photovoltaic/Solar_panels		100.749
		(63.117)
Perceived_control		-133.893*
		(73.948)
Reduction_necessary		130.893**
		(73.948)

Constant	1,083.181*** (42.212)	1,157.576*** (121.220)
Observations	102	102
R2	0.097	0.263

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

First, we compared WTA within each treatment group (either RBP or VCM) across the three HP schemes (HP(50%-50%), HP(30%-70%), and HP(10%-90%)). Results from the estimation of both Model 1 and 2 suggest that the design of HPs has some influence on farmers' decisions. In the HP-RBP group, farmers exhibit a higher WTA a HP(10%-90%) compared to the other HP options. Specifically, farmers' WTA a HP(10%-90%) option is higher by, approximately, €175 compared to the WTA for a HP(50%-50%) ($p < 0.05$). A post-estimation test further indicates that WTA a HP(10%-90%) option is significantly higher than the WTA a HP(30%-70%) ($p < 0.01$), by €220 on average. These results indicate that, as the proportion of the RBP decreases in the HP, farmers' WTA the HP scheme decreases as well. This means that they prefer HP with higher RBP proportions, consistent with what we expected by design. However, results also show that farmers are indifferent between the HP(50%-50%) option and the HP(30%-70%), suggesting some form of insensitivity to changes in the RBP proportion when the more incentivizing scenario (HP(10%-90%)) is not considered. Economic agents' insensitivity to probability changes, including farmers, is not a novelty, and it is often attributed to probability weighting (e.g., Finger et al., 2023; Čop et al., 2023; Angioloni and Cerroni, 2025).

Contrary to our expectations, no significant differences in WTA were observed within the sub-groups in the HP-VCM treatment. This signals that farmers are indifferent between the HP(10%-90%) and the HP(50%-50%) option, as well as between the HP(30%-70%) and the HP(50%-50%). A post-estimation test confirms that they are also indifferent between HP(10%-90%) and HP(30%-70%).⁹ These findings highlight a divergence in behavior within the two groups (HP-RBP and HP-VCM), likely driven by differing levels of familiarity and trust in the schemes. Specifically, the stronger preference for higher RBP proportions in the HP-RBP group may reflect greater confidence in the RBP framework, which is more familiar to European farmers. Conversely, the lack of significant differences in the HP-VCM group might be attributed to the novelty of the carbon credit system and the associated uncertainties, as discussed earlier.

Next, we performed post-estimation tests to compare the WTA across treatment groups (HP-RBP and HP-VCM) within each HP scheme (HP(30%-70%), and HP(10%-90%)). Specifically, no statistically significant difference is found between HP-RBP and HP-VCM for the group HP(30%-70%) and HP(10%-90%). In summary, farmers do not show clear preferences between groups (HP-RBP and HP-VCM) with the same proportion of ABP and result-dependent payments, regardless of whether these hybrid schemes are associated with an RBP or a VCM, as expected given that HP-RBP and HP-VCM are equivalent by design. Estimation results from Model 2 provide some insightful findings regarding farmers' heterogeneous responses to HP schemes. Dairy farmers who adopt more innovative feeding strategies (unifeed and pre-mix) demonstrate a higher willingness to accept HP schemes than those using a more traditional strategy, respectively €144 higher ($p < 0.05$) and €234 higher ($p < 0.1$). This might suggest that innovation-oriented farmers are more open and receptive to HP schemes.

Again, as per Model 1 for FFBG, farmers with pro-environmental beliefs show stronger preferences for HPs. Specifically, farmers who believe that the dairy system should reduce the emission of methane from enteric

⁹p-values from the post-estimation tests are 0.31 and 0.27 respectively in Model 1 and 2.

fermentation show higher WTA for an ABP (€130 higher, $p < 0.05$) and hence stronger preferences for an HP than their counterparts. This result consistently strengthens the link between pro-environmental beliefs and openness to innovation. Conversely, farmers engaged in diversified farming activities tend to have a lower WTA for ABP (€135 lower, $p < 0.05$), suggesting that these farmers have a lower preference for HP compared to those specialized in dairy farming.

Finally, perceived control over the implementation of essential oils has a significant negative effect (€134 lower, $p < 0.10$) on the WTA for an ABP. This implies that farmers who perceive greater confidence in their ability to adopt and manage this new practice are less willing to accept HPs than ABP. One potential explanation is that farmers with higher perceived control might exhibit a lower preference for HPs because they anticipate better outcomes, and thus higher payment levels under a pure RBP or VCM scheme. However, the evidence supporting this latter interpretation is insufficient, and further research is needed in this direction.

2.3.3 The impact of other behavioural factors on farmers' acceptability

We also tested whether other behavioural factors elicited in the final questionnaire were correlated with farmers' acceptability of RBP and VCM in the FFBG and in the SFBG. The behavioural factors were the subjective probability distributions elicited in the third phase as well as environmental attitudes elicited using the New Environmental Paradigm (NEP) scale (Dunlap et al., 2000), self-reported risk attitudes (Finger et al., 2023), and ambiguity aversion regarding experts' opinions on agricultural innovations (adapted from Han et al., 2018) elicited in the final questionnaire using multi-item Likert scales. Concerning the subjective probability distributions about the efficacy of essential oil in reducing methane emissions, we used different indicator specifications: i) the expected value of the elicited individual distributions, ii) a dummy variable indicating those farmers who had an individual expected value below (i.e. pessimistic) or above (i.e. optimistic) the sample median, and iii) a dummy variable indicating those farmers who had an individual expected value below (i.e. pessimistic) or above (i.e. optimistic) the expected value of the distributions used to resolve the uncertainty in the FBG, SBG and the subjective probability distribution game. Regarding the other behavioural factors, we use two variable specifications: i) the average score of each multi-item Likert Scale and ii) a dummy variable indicating those farmers who had an individual average score below or above the sample median. These models were estimated again using the OLS estimator. We did not find any statistical correlation using extended versions of the models that were presented above.

2.4 Conclusions of the Italian case study

Overall, our results provide some interesting findings that can have important policy implications. Almost all farmers (97%) chose to buy and adopt essential oils in the experiment, suggesting that this carbon farming practice could be a viable option to reduce GHG emissions in the dairy sector in terms of acceptability. This is mainly due to the fact that essential oils are readily available in the market, they are relatively cheap, and their introduction does not require skills or substantial extra work for farmers. These considerations stem from the focus groups and the piloting phases of the experiment that were informed by one-to-one interviews with stakeholders involved in the local dairy supply chain (WP 5 – Task 5.3) and from the foresight exercises conducted during our Science-policy Interface workshops (WP 6 – Task 6.3).

Regarding farmers' preferences for different subsidization schemes, results suggest that our sample of farmers still prefers the status quo, meaning that they prefer ABP over more innovative solutions such as RBP and HP schemes, and the participation in VCM. This suggests that farmers are reluctant to innovative schemes that can be more financially rewarding but more uncertain in the final level of compensation (as RBP, HP, and VCM). However, our results suggest that farmers' preferences are highly heterogeneous, and they are mediated by farmers' and farms' characteristics. For example, we found that while pro-environmental *attitudes* do not influence farmers' acceptability, pro-environmental *behaviour* is a strong

determinant. Farmers who engage in environmental practices like installing solar panels are more willing to accept innovative economic policy tools such as RBPs and VCMs. Similarly, farmers who believe that a reduction of methane emissions from the dairy sector is necessary are more willing to accept these innovative tools. In addition, our findings suggest that farmers who have adopted more innovative feeding solutions are also more likely to adopt innovative schemes, suggesting a reinforcing behavioural mechanism. On the other hand, older farmers and more diversified businesses are less likely to adopt RBPs and VCMs. Literature on innovation adoption suggests that age negatively influences the transition process towards more innovative solutions (Brown et al, 2019; Dhraief et al, 2019; Rodríguez-Barillas et al., 2024). While it seems logical that more diversified farms are generally less interested in these new economic policy tools, as livestock farming may not be the core business. Overall, these results indicate that a shift from ABP to RBP and VCM, even when mediated by HP schemes, may encounter some resistance from farmers, especially those who are older, less sensitive to environmental externalities generated by agriculture, and, more generally, less inclined to innovation. Our results are not surprising considering the farmer protests that took place across Europe in 2023 and 2024 and led EU and national governments to retract some key initiatives for transitioning to more sustainable agri-food systems (Finger et al., 2024).

Interestingly, our results suggest that farmers' acceptability of VCM and RBPs is equivalent. This suggests that experiences like Australia's Carbon Farming Initiative, which rewards farmers involved in carbon farming initiatives via voluntary carbon markets, may also be replicable in Europe. However, results from the SFBG indicate that farmers' response to the different HP designs is contingent on the mechanism used to operationalize the compensation, VCM or RBP. By design, farmers should prefer HP schemes with a higher proportion of result-based payments as these are more financially rewarding to farmers. Hence, farmers should prefer HP where the result-based component is 90% than those where the result-based component is 70% and 50%. Interestingly, our results indicate some degree of insensitivity to probabilities among farmers. When exposed to an RBP, farmers' decisions align with this rational pattern, while they do not when they face a VCM. A possible explanation is farmers' unfamiliarity with the ideas of carbon credits and voluntary carbon credit markets. In addition, during the individual-assisted sessions, some farmers expressed concerns about the complexity of implementing and monitoring carbon credit systems, citing the increased auditing requirements on their farms. While these findings provide valuable insights, we should also interpret them with caution. The study relied on a hypothetical scenario (though implemented in an incentivized design) and a regionally focused sample, which cautions against easy generalization to a broader population. Future research with larger and more diverse samples and real-world pilots would help extend these findings.

Overall, our results indicate that there is some room for public institutions to gradually transition towards innovative schemes that reward farmers who adopt carbon-friendly initiatives. Although some farmers are not ready yet to embrace the idea of trading carbon credits in voluntary carbon markets, they may be more inclined to accept result-based reward systems. Carbon markets are still perceived as complex or distant from their daily operations, whereas RBPs could offer more familiar benefits. Initiatives at the EU, national and local level should be developed to make farmers more aware and ready to accept the fact that agriculture contributes to the climate crisis. They should also be reassured that there are actions, including innovative subsidization systems, that can compensate for the possible loss in production due to the adoption of carbon farming initiatives, while strengthening the resilience of farms and the entire agri-food system. Results from this study can stimulate several policy-related research questions on how to better design result-based subsidies and hybrid schemes related to pro-environmental actions at the farm level. For example, future research could address aspects like the uncertainty related to the value of carbon credits to be traded in carbon markets, alternative designs of hybrid payment schemes, and the public or private nature of carbon markets.

3. The Danish case study

3.1 Background information on the case study

As an EU member state, Denmark abides by EU climate commitments and aims to achieve a 70% GHG emission reduction by 2030 and climate neutrality by 2050 (Danish Council on Climate Change, 2022). As part of this commitment, a 55-65% GHG emission reduction is expected from agriculture by 2030 compared to 1990. In 2030, Danish agriculture will contribute disproportionately to GHG emissions (46%) if climate policy remains unchanged, despite making up only 2% of the prosperity (gross value added) and 3% of employment. Within the sector, animal production accounts for 52% of emissions, crop production for 29%, and land use (mainly from drained carbon-rich soil) for 19% (Expert Group, 2024). In order to address GHG emissions from agriculture and meet the national and EU's plan to reduce the GHG emissions by 70%, a broad agreement on Green Tax Reform was reached in the Danish parliament in 2020. The Green Tax Reform agreement identified a uniform CO₂e tax as a key policy instrument. Following the agreement, the Danish government established an Expert Group that consists of six members to develop various CO₂e tax models based on scientifically rigorous methods and evaluate the impacts on both industry and agricultural sectors, as well as their environmental effects (Danish Ministry of Finance, 2020).

In February 2024, the Expert Group published a report on green tax reform for the agricultural sector that contains three tax models that vary in stringency (Expert Group, 2024). It used an economy-wide computable general equilibrium model called the GreenREFORM model (Expert Group, 2024; Sørensen et al., 2025). The model assesses the environmental and climate effects of economic activity, as well as the economic effects of environmental and climate policy initiatives.

The regulatory basis for the GHG emissions from agriculture relies on data reported by farmers through fertilizer accounts, used in the national emission inventory for agriculture and LULUCF, covering emissions from livestock, fertilizer and liming, and carbon-rich soils, with total emissions calculated using farm-specific data and standardized emission factors. The proposed taxes include a tax on livestock, a tax on fertilizer use on fields, a tax on agricultural lime fields, and a tax on CO₂e emissions from carbon-rich lands. The Expert Group provided detailed documentation on the impact of each tax model on production and employment in the primary agricultural sector (crop, cattle, and pig) and land value when it is implemented in 2030. Below a brief description of the tax models is provided.

- Model 1 (high CO₂e tax): a uniform tax rate of 750 DKK¹⁰ per ton of all CO₂e emissions. In this tax model, agriculture is equated with other industries outside of the EU ETS that are also subject to a tax rate of 750 DKK. This tax model involves a significant reduction in agricultural production.
- Model 2 (moderate CO₂e tax): an effective tax rate of DKK 375 per ton of CO₂e emissions in 2030, by including a 50% deduction in the tax base (750 DKK per ton). The emphasis is on replacing CO₂e emission reductions achieved through production decline with reductions from measures of a more technological nature that reduce carbon leakage but are costlier in socioeconomic terms compared to Model 1.
- Model 3 (low CO₂e tax): an effective rate of 375 and 125 DKK per ton of CO₂e emissions from crop cultivation (resulting from N₂O) and livestock, respectively. Marginal tax rate of 750 DKK per ton on CO₂e emissions from crop cultivation and 350 DKK per ton of CO₂e emissions from livestock. The effective rates result from a 50% deduction in the tax base. The emphasis in this model is on

¹⁰ 750 DKK \cong 100 Euro (2024)

minimizing the decline in production through additional technical effects, but it involves an even higher socio-economic cost, a significant annual burden on government finances, and greater uncertainty about the achievability of technological reductions.

After the Expert Group's report was released, a tripartite forum was established to negotiate a broad agreement on the implementation of the Green Tax Reform. The forum consisted of the government, Danish Agriculture and Food Council, Danish Nature Conservation Association, Danish Food Association, and the representatives of the Danish Labour Unions. The forum reached an agreement on June 24, 2024. In the autumn of 2024, the agreement was further negotiated in Parliament, leading to a broad consensus that included, among other measures, the introduction of a 120 DKK per ton CO₂e emission tax on the livestock sector starting in 2030.

3.2 Methods

3.2.1 Sampling and data collection

Our survey started in May 2024 with the aim of collecting data from a representative sample of 1,000 Danish farmers. However, data collection was stopped before reaching this target following the public release of the tripartite agreement on June 24, 2024. Until the announcement, the outcome of the negotiations was unknown to both farmers and the general public. In the end, we collected data from 981 Danish farmers during May and June 2024. We collected the data in collaboration with a survey company called Aspecto A/S, which has a representative panel of more than 6000 farmers. The survey was programmed in an online survey tool called SurveyXact and took respondents on average 20 minutes to complete. We used a stratified sampling approach to ensure the sample represents Danish farmers by geography and age. To focus on farm groups likely most affected by the proposed CO₂e tax, we intentionally included a higher share of participants from specific subgroups based on farm size and type. Specifically, we targeted farms of 20 hectares or more to limit the inclusion of very small-scale or hobby farms, and we also included a higher proportion of livestock farms (pig and dairy) due to their anticipated relevance under the expert's tax proposals. The ethical approval has been documented in the visionary Milestone 5.

3.2.2 Experimental design and treatments

Our experimental design can be described as a 2x2 between-subject design. Farmers were randomly allocated to two information groups, respectively exposed to the high and the low CO₂e tax scenarios proposed by the Expert Group on Tax Reform (Expert Group, 2024). In both treatment groups, a sub-sample of the respondents was exposed to information of the impact of the specific CO₂e tax (high or low) on production, employment, and land value based on expert estimates.

3.2.3 Experimental tasks

The survey experiment includes the following main stages, as depicted in Figure 6:

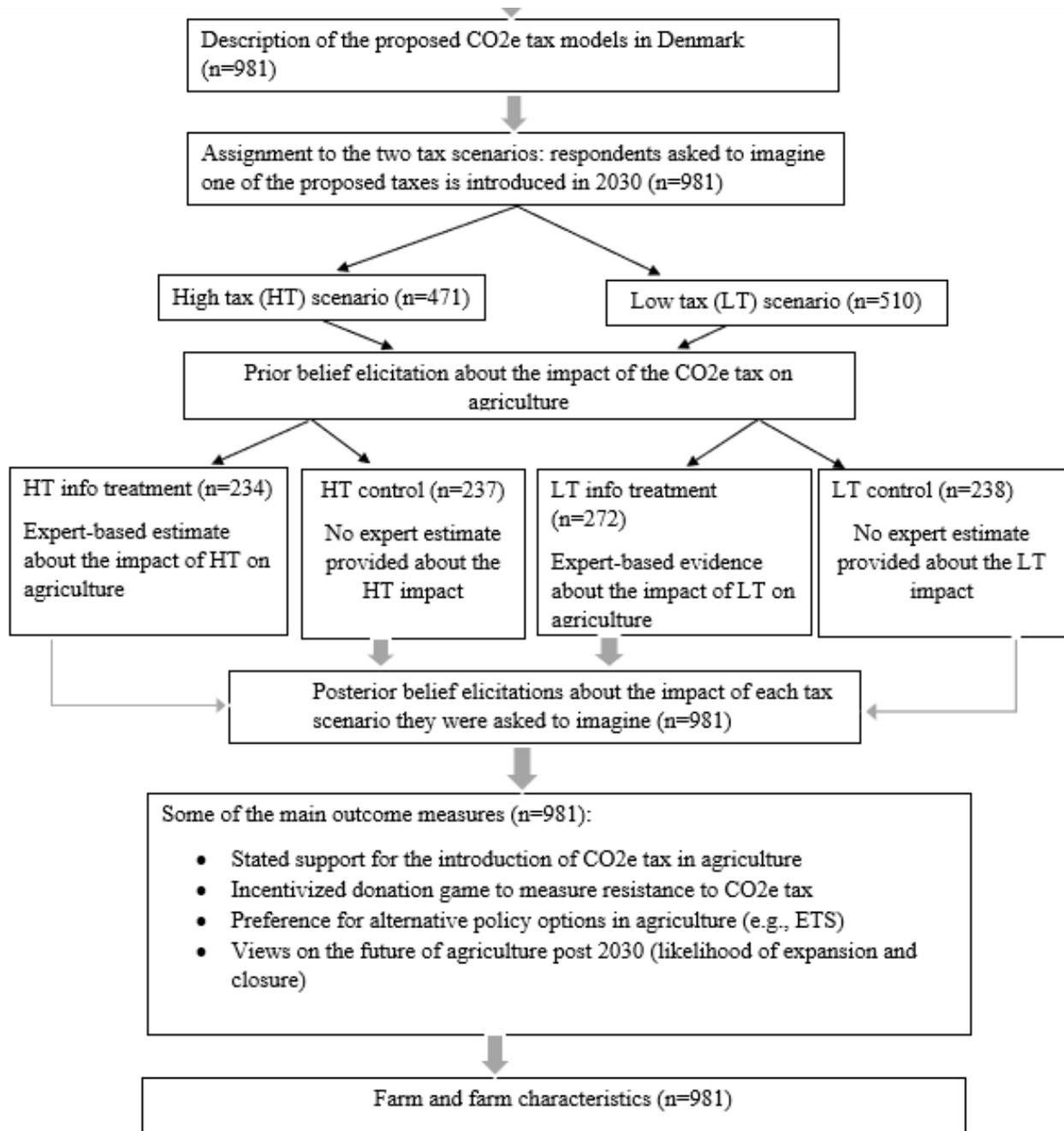


Fig. 6 Structure of the survey experiment

Stage 1: Assignment to CO₂e tax scenarios

We used two of the CO₂e tax models proposed by the Expert Group for Green Tax Reform; the high and the low tax scenario. We randomly assign respondents to high and low CO₂e tax scenarios and ask respondents in each group to envision that a high CO₂e tax or a low CO₂e tax is introduced in 2030.

Stage 2: Belief elicitation about CO₂e tax impact

We used a quantitative belief elicitation technique to elicit the respondents' beliefs about the impact of CO₂e tax on agriculture. The elicitation technique is suitable for interpersonal comparability and is relatively easy to understand by respondents (Haaland et al, 2023). Before asking respondents their beliefs about the impact of CO₂e tax on agriculture, we presented them with relevant details about Denmark's climate targets, political agreements on GHG reduction from agriculture, and the proposed tax models by the Expert Groups in order for the respondents to have the same familiarity with the subject matter.

We then explicitly told respondents to imagine a specific tax scenario, either the high CO₂e tax or the low CO₂e tax after explaining the corresponding tax levels for each tax model. This was followed by questions about the tax's perceived impact on agricultural production, employment, and land values. The specific question, for the production impact, for example, was phrased as: "agricultural production today amounts to 100 units, how many units will be lost by 2030 due to the introduction of the CO₂e tax?".

To make the questions easier to understand, we asked respondents to answer in specific units rather than percentages, based on insights from a pilot test of the survey .

Stage 3: Information provision about the CO₂e tax impact

In this stage, a sub-sample of respondents in each of the two tax scenarios (high and low CO₂e tax) were provided with information about the impact of the specific CO₂e tax scenario they were assigned to (high or low) on agricultural production and employment in the primary agriculture sector, and land value based on estimates by the Expert Group.

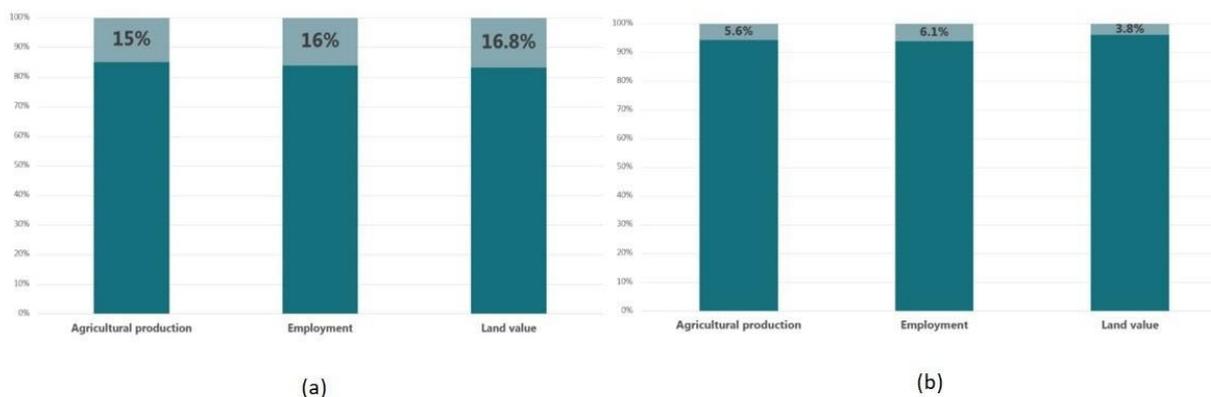
In the high tax scenario, respondents in this treatment were told that introducing the high CO₂e tax rate of DKK 750 per ton of CO₂e emissions reduces production and employment in the primary agricultural sector by 15% and 16% respectively, and land value by 16.8%. To ensure respondents paid attention to the information, we informed them beforehand that the next page would present the experts' estimates of the impacts. On the next page, we provided the information both in text and visually, making it easy to understand (Figure 7, Panel A).

In the low tax scenario, respondents in this treatment were told that introducing the low CO₂e tax scenario reduces production and employment in the primary agricultural sector by 5.6% and 6.1% respectively, and land value by 3.8% (Figure 7, Panel B).

In the control groups, respondents did not receive information about the impact of CO₂e tax.

Balancing tests between the treatment and control groups were performed indicating no significant differences in average characteristics, confirming that our random assignment to the different groups worked

Fig. 7 Expert Group’s estimates of the CO₂e tax impacts on the primary agriculture sector



Stage 4: CO₂e tax impact re-elicitation

In this stage, we re-elicited respondents’ beliefs about the impact of the CO₂e tax to measure whether respondents updated their beliefs in response to the information provided based on the Expert Group’s estimates. To mitigate consistency bias when measuring prior and posterior beliefs (Haaland et al., 2023), we re-elicited impact beliefs by disaggregating questions on production and employment across crops, cattle, and pigs. For land value, we repeated the original question, as disaggregation was not practical. Respondents were reminded to assume the high (or low) CO₂e tax would take effect in 2030, after which we asked specific, disaggregated questions to re-elicite their beliefs, such as the following on employment impacts:

Out of 100 employees in the cattle sector, how many can be expected to lose their jobs?

Out of 100 employees in the pig sector, how many can be expected to lose their jobs?

Out of 100 employees in the crop production sector, how many can be expected to lose their jobs?

Stage 5: Measuring carbon tax and ETS acceptance, climate measure preferences and climate policy views

Self-reported measure of acceptance for CO₂e tax: Farmers were asked their degree of support for the introduction of (high/low) CO₂e tax on agriculture in 2030 on five-point Likert scale (strongly oppose, oppose, neither...nor, support, strongly support).

Behavioural measure of acceptance: An incentivized donation experiment to measure farmers’ resistance against the introduction of CO₂e tax on agriculture was conducted. Farmers were asked to divide 2000 DKK between themselves and an organization of their choice that they believe would best defend the interests of the agriculture sector in the tripartite negotiations on a CO₂e tax. We first asked respondents to either select or specify an organization they would like to donate to, or to choose the option "I do not wish to donate." For those who opted to donate, we then asked about the amount, up to 2000 DKK, that they would be willing to donate. The assumption underlying the donation experiment is that: the higher the amount of money a respondent is willing to donate, the higher their resistance against the introduction of a CO₂e tax on agriculture. We also included an additional question asking respondents to explain why they chose not to donate. This allowed us to gain a deeper understanding and better qualify their responses.

Preference for EU ETS: We asked respondents to express their preference for the introduction of an ETS for agriculture by indicating the likelihood of choosing to introduce this policy tool if participants were in the policy makers’ position on a five-point scale (very unlikely, unlikely, neither...nor, likely, very likely).

Views on the future of agriculture: We asked respondents about their views on the prospects of agriculture post-2030 if the (high/low) CO₂e tax on agriculture is introduced. More specifically, we asked respondents the likelihood of expanding and shutting down their farms.

Measuring adoption of climate measures: We asked respondents about their likelihood to adopt six different climate measures, which include: methane-reducing feed additives such as Bovaer¹¹, setting aside carbon-rich soils, slurry acidification, carbon storage via biochar, biogas production, and reduced fertilizer use when the (high/low) CO₂e tax was implemented. The climate measures were assessed using a five-point Likert scale (very unlikely, unlikely, neither...nor, likely, very likely).

Stage 6: Farmer and farm characteristics

We also collected background information on farmers' participation in agri-environmental practices, as well as farm characteristics (e.g., type, size) and farmer demographics (e.g., age, experience, location).

3.3 Results

3.3.1 Carbon tax and ETS acceptance, climate measure preferences, and climate policy views

We used the following specification to analyze the effect of stringency of the carbon tax and the information treatments on farmers' carbon tax acceptance, the preferences over an agricultural ETS scheme, and different climate measures that could be adopted at the farm level, and their climate policy views.

$$y_i = \beta_0 + \beta_1 S_i + \beta_2 T_i + \beta_3 S_i \times T_i + \beta_4 O_i + \beta_5 O_i \times T_i + \beta_6 S_i \times T_i \times O_i + \beta_7 X_i + \varepsilon_i$$

Five different models were estimated using the OLS estimator. The five different models are equivalent, except for the dependent variable, which varies across models. In the first model, the dependent variable captures the self-reported measure of acceptance for CO₂e tax, in the second, the actual donations made by farmers in the behavioural donation game, in the third, farmers' preferences for the agricultural ETS scheme, in the fourth, farmers' views on the future of agriculture, and in the fifth, their preference for the adoption of various climate measures. The latter is the average score given by the farmers to each of the considered climate measures, namely methane-reducing feed additives such as Bovaer, setting aside carbon-rich soils, slurry acidification, carbon storage via biochar, biogas production, and reduced fertilizer use. The estimation for all the models were conducted on Stata 17.

S_i is the stringency of the CO₂e tax, it is 1 if it is a high CO₂e tax, while T_i is an indicator for the information treatment whether the respondent received (or not) information about the impact of CO₂e tax based on expert estimates (1= receiving the information, =0 otherwise). O_i is an indicator for overestimation or lack of downward revision in beliefs. We first calculated the average prior and posterior beliefs regarding the CO₂e tax impact across three factors, agricultural production, employment, and land value, and then created an indicator that equals 1 if a respondent does not revise their beliefs downward (i.e., if the prior belief exceeds the posterior belief) and 0 otherwise. X_i is the vector of control variables such as farm and farmer characteristics, which include region, age, experience, financial state, full-time farmer, and carbon content of farmland.

Results suggest that respondents' self-reported acceptance of the introduction of a CO₂e tax on agriculture is contingent on the stringency of the tax and the provision of information costs related to the CO₂e tax. Column 1 of Table 5 shows that support for CO₂e tax is negatively associated with the stringency of the CO₂e tax. Respondents in the high CO₂e tax scenario are less likely to support the introduction of CO₂e tax

¹¹ Bovaer is the commercial name for the feed additive 3-Nitrooxypropanol (3-NOP), which is incorporated into cattle feed to lower methane emissions by blocking the enzymes in the animals' stomachs responsible for methane production

compared to those in the low CO₂e tax scenario. It is also important to highlight that we employed an incentivized donation game as an alternative approach to assess farmers' resistance to the CO₂e tax. Results show that donations to an organization of their choice that they believe would best defend the interest of the agriculture sector in the tripartite negotiations on a CO₂e tax are positively correlated with the stringency of the CO₂e tax (Column 2 of Table 5). However, reactance to tax is stronger when considering the self-reported measure of acceptance than when considering the donations from the behavioural donation game. The discrepancy in results can be due to many factors, among others, the intention-action gap (Conner and Norman, 2022). The self-reported acceptance measures intended behavior, while donations are related to real behavior, among others. This might lead to different preference formation patterns.

Interestingly, a decrease in farmers' acceptance of the CO₂e tax due to the stringency of the tax leads to an increase in the acceptance of an agricultural ETS scheme (see Column 3 of Table 5) and an increase in the likelihood of adopting climate measures (Column 5 of Table 5). The ETS scheme might be perceived as the lesser of two evils, considering also the heated debate occurring in Denmark when the study was administered. While CO₂e tax and ETS could theoretically have similar effects, the trading aspect of ETS may introduce flexibility, making it a more appealing option for respondents. This is also in line with the literature in the general public's acceptance of carbon tax, which documents that taxes are less popular compared to other policy instruments (Carattini et al., 2018; Lucas Jr, 2017). Similarly, the adoption of climate change measures can be seen as a strategy to avoid the CO₂e tax. This is in line with the theoretical literature that indicates that a higher tax incentivizes investment and innovation in GHG emission-reducing technologies (Acemoglu et al., 2012). This result also aligns with previous empirical research suggesting that carbon prices must be sufficiently high to drive innovation (Aghion et al., 2016; Laing et al., 2013). In addition, Column 4 of Table 5 indicates that the stringency of the tax increases the perception that the CO₂e tax could contribute to the end of business for the farmers.

Our results also suggest that information about the extent of the CO₂e tax's impact on agriculture is positively associated with support for the introduction of the tax. This may appear to be a counterintuitive result at first glance, but it might be explained by the good news-bad news effect, a heuristic that predicts good news to be accepted by people more than bad news (Eil and Rao, 2011). Evidence in support of the good-bad news effect is reported in several papers (e.g. Cerroni et al., 2019; Coutts 2019) As farmers in both tax scenarios (high and low) substantially overestimate the negative impacts of the CO₂e tax on agriculture as compared to experts, information from experts might be perceived as good news and it might be used by farmers to positively update their beliefs. This will explain why information - that is endogenously good news - in our study boosts farmers' acceptance of the tax. In our sample, under the high tax scenario, farmers' perceived impact of the tax is 1.26 to 1.88 times higher than experts' estimates, while in the low tax scenario, the perceived impacts are exaggerated by a factor of 2 to 3 (see Figure 8) Notably, respondents particularly overestimated the impact on agricultural production, which is sensible given that it directly affects their operations and profitability, making it a more personally significant issue. Our speculation is supported by the fact that farmers seem to update their beliefs towards experts' estimates when information is provided, however it is important to note that updating is very modest. Moreover, our findings show, on average, the information treatment significantly increases stated support for the introduction of the tax. In contrast, the effect of information by experts does not carry over to preferences for an agricultural ETS scheme, and preferences for the adoption of climate measures, and perceptions about the future of agriculture. This variable only marginally influences perceptions about the future of agriculture. This lack of correlation might be due to the fact that this variable captures whether farmers revise or not their prior beliefs, rather than to what extent they revise their beliefs. All interaction terms are not statistically significant, except one, indicating that there is not a consistent and robust effect of these variables on the outcome variables.

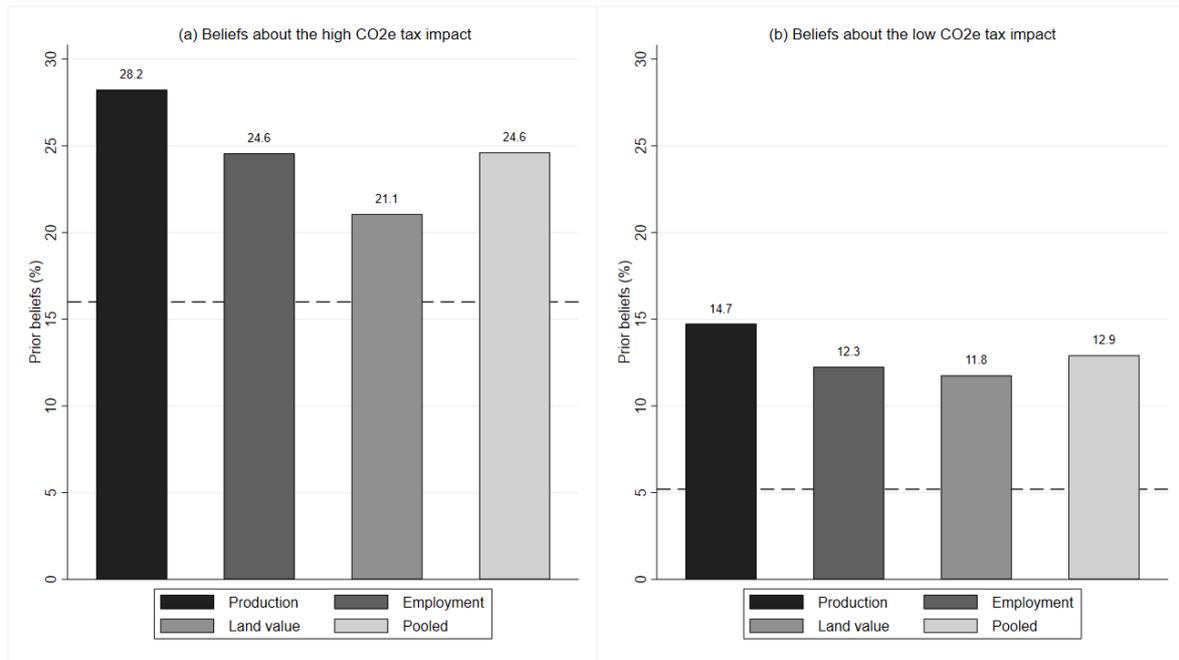


Fig. 8 Average beliefs about CO₂e tax impact on agriculture by stringency. Note: the dashed horizontal lines are expert estimates about the CO₂e tax impact on agriculture.

Table 5 Stringency and information on acceptance of climate polices, potential for farm closure, and adoption of climate measures

	Self-reported support for CO ₂ e tax	Donation	Preference for ETS	Farm closure	Adoption of Climate measures
Information	0.198^{***} (0.0686)	0.0234 (0.0341)	0.0648 (0.0749)	0.0547 (0.0787)	0.0921 (0.0780)
Stringency(High)	-0.248^{***} (0.0541)	0.0726^{**} (0.0344)	0.259^{***} (0.0675)	0.571^{***} (0.0763)	0.281^{***} (0.0680)
Overestimate	0.0115 (0.0582)	-0.0399 (0.0352)	-0.0959 (0.0727)	0.156[*] (0.0840)	0.0231 (0.0697)
Stringency x info	-0.0775 (0.0953)	-0.0712 (0.0518)	-0.215[*] (0.113)	-0.0856 (0.111)	-0.0131 (0.102)
Overestimate x info	-0.188 (0.121)	0.0215 (0.0596)	0.193 (0.129)	-0.107 (0.144)	0.0879 (0.120)
Stringency x info x overestimate	0.0797 (0.143)	-0.0651 (0.0673)	-0.0252 (0.164)	-0.0217 (0.166)	-0.170 (0.138)
Control	Yes	Yes	Yes	Yes	Yes
Constant	1.983 ^{***} (0.179)	0.217 ^{**} (0.0915)	2.698 ^{***} (0.204)	1.847 ^{***} (0.193)	4.110 ^{***} (0.186)
N	981	981	981	981	981
R2	0.0735	0.0743	0.114	0.173	0.165

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.3.2 Heterogeneity analysis by farm size and type

In this subsection, we conduct a heterogeneity analysis to explore how the provision of information and the stringency of the CO₂e tax influence the outcome variables presented in subsection 3.3.1. We specifically examine how these effects vary across different farm sizes and types, providing a more nuanced understanding of how they shape responses to the provided information and stringency.

Columns 2-5 of Table 6 show that the impact of the stringency of tax on farmers' self-reported acceptance of CO₂e tax varies by farm size and type. Larger farms are about twice as negatively responsive to stringency as smaller farms, while crop and livestock farms show a similar degree of responsiveness to stringency. Considering data from the behavioural donation game (Columns 6-9 of Table 6), we observe a similar pattern regarding the impact of stringency on acceptance of larger or smaller farms. Interestingly, we find that stringency boosts support (i.e. donations) of livestock farms but not that of crop farms.

Preferences for the agricultural ETS scheme follow the same pattern as in section 3.3.1; exposure to a more stringent tax increases farmers' preference for the ETS scheme. Larger farms have more intense positive

preferences for the ETS scheme than smaller farms. Interestingly, livestock farms show a positive preference for the ETS scheme, while crop farms do not (Columns 2-5 of Table 7). Preferences for the adoption of climate measures follow a different pattern. While larger farms are more likely to adopt climate measures than small farms when exposed to a more stringent tax, crop farms are more likely to adopt climate measures than livestock farms.

Finally, farmers' perception regarding the future of agriculture is affected by the stringency of the tax by farm size and type. Larger and livestock farmers believe that the tax would imply farms' closure to be more likely than smaller and crop farms, respectively (Columns 2-5 of Table 8).

The impact of the information by experts on farmers' self-reported acceptance of CO₂e is mediated by farm size and farm type. When considering self-reported measures of acceptance, we observe that smaller farms are more responsive to information than larger farms, while livestock farms are more responsive than crop farms (Columns 2-5 of Table 6). When considering the real donations, we only observe that livestock farms are more responsive than crop farms (Columns 6-9 of Table 6). We did not find any robust and consistent behavioural pattern for all other variables included in the models.

Farmers' preferences over the agricultural ETS scheme are mediated by farm type but not farm size. Livestock farms are more responsive than crop farms, while no difference is detected in preference patterns for small vs large farms (Columns 2-5 of Table 7). No robust effect of information is detected on farmers' preferences for the adoption of climate measures (Columns 6-9 of Table 7), and their expectations about the future of agriculture (Columns 2-5 of Table 8). Most of the included interaction terms are not statistically significant, and no robust behavioural pattern can be identified by interpreting the coefficients of the variables.

Table 6 Treatment effect heterogeneity: self-reported acceptance of the CO₂e tax and donation

	Support for CO ₂ e tax				Donation			
	Smaller farms	Larger farms	Crop farms	Livestock farm	Smaller farms	Larger farms	Crop farms	Livestock farm
Information	0.241^{***}	0.131	0.150*	0.244*	0.00112	0.168	-0.107	0.240*
	(0.0893)	(0.108)	(0.0817)	(0.126)	(0.0946)	(0.118)	(0.0946)	(0.126)
Stringency(High)	-0.170^{**}	-0.364^{***}	-0.220^{***}	-0.248^{***}	0.194^{**}	0.388^{***}	-0.0292	0.531^{***}
	(0.0737)	(0.0766)	(0.0662)	(0.0902)	(0.0839)	(0.112)	(0.0926)	(0.0987)
Overestimate	-0.0009	0.0405	-0.0729	0.0901	-0.0837	-0.135	-0.183*	0.00988
	(0.0808)	(0.0839)	(0.0659)	(0.0992)	(0.0932)	(0.115)	(0.0972)	(0.102)
Stringency x info	-0.115	-0.0644	-0.116	-0.145	-0.224	-0.207	0.213	-0.706^{***}
	(0.132)	(0.131)	(0.116)	(0.164)	(0.148)	(0.175)	(0.140)	(0.199)
Overestimate x info	-0.229	-0.188	-0.169	-0.186	0.166	0.245	0.229	0.233
	(0.159)	(0.187)	(0.122)	(0.250)	(0.162)	(0.203)	(0.149)	(0.244)
Stringency x info x overestimate	0.0326	0.186	0.268	-0.0491	0.0324	-0.0978	-0.260	0.129
	(0.189)	(0.209)	(0.167)	(0.266)	(0.210)	(0.251)	(0.213)	(0.288)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.945 ^{***}	1.853 ^{***}	1.642 ^{***}	2.615 ^{***}	2.938 ^{***}	2.953 ^{***}	2.894 ^{***}	3.135 ^{***}
	(0.261)	(0.246)	(0.219)	(0.314)	(0.257)	(0.380)	(0.276)	(0.344)
Observations	588	393	572	399	588	393	572	399
r2	0.0746	0.118	0.0995	0.125	0.0591	0.112	0.107	0.211

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7 Treatment effect heterogeneity: ETS scheme and adoption of climate measures

	ETS Scheme				Adoption of climate measures			
	Smaller farms	Larger farms	Crop farms	Livestock farm	Smaller farms	Larger farms	Crop farms	Livestock farm
Information	0.00112 (0.0946)	0.168 (0.118)	-0.107 (0.0946)	0.240* (0.126)	0.0226 (0.0950)	0.154 (0.125)	0.0760 (0.0914)	0.0315 (0.0939)
Stringency	0.194** (0.0839)	0.388*** (0.112)	-0.0292 (0.0926)	0.531*** (0.0987)	0.146* (0.0870)	0.428*** (0.103)	0.348*** (0.0875)	0.0178 (0.0714)
Overestimate	-0.0837 (0.0932)	-0.135 (0.115)	-0.183* (0.0972)	0.00988 (0.102)	-0.0185 (0.0930)	0.0738 (0.110)	0.00228 (0.0945)	-0.0153 (0.0729)
Stringency x info	-0.224 (0.148)	-0.207 (0.175)	0.213 (0.140)	-0.706*** (0.199)	0.217* (0.128)	-0.381** (0.160)	0.102 (0.123)	0.138 (0.114)
Overestimate x info	0.166 (0.162)	0.245 (0.203)	0.229 (0.149)	0.233 (0.244)	0.140 (0.161)	-0.0440 (0.180)	0.202 (0.150)	0.0644 (0.133)
Stringency x info x overestimate	0.0324 (0.210)	-0.0978 (0.251)	-0.260 (0.213)	0.129 (0.288)	-0.238 (0.169)	-0.102 (0.229)	-0.311* (0.180)	-0.173 (0.141)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.938*** (0.257)	2.953*** (0.380)	2.894*** (0.276)	3.135*** (0.344)	3.941*** (0.240)	4.349*** (0.319)	3.203*** (0.249)	4.038*** (0.217)
Observations	588	393	572	399	588	393	572	399
r2	0.0591	0.112	0.107	0.211	0.222	0.183	0.109	0.0581

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8 Treatment effect heterogeneity: farm closure

	Farm closure			
	Smaller farms	Larger farms	Crop farms	Livestock farm
Information	0.0246 (0.104)	0.0446 (0.118)	-0.0597 (0.105)	0.138 (0.121)
Stringency	0.461^{***} (0.103)	0.715^{***} (0.112)	0.498^{***} (0.106)	0.668^{***} (0.108)
Overestimate	0.179 (0.113)	0.158 (0.123)	0.000277 (0.116)	0.345^{***} (0.112)
Stringency x info	-0.0674 (0.149)	-0.0178 (0.164)	0.0368 (0.149)	-0.0947 (0.176)
Overestimate x info	-0.107 (0.176)	-0.0883 (0.241)	0.0642 (0.189)	-0.327 (0.211)
Stringency x info x overestimate	0.0499 (0.210)	-0.276 (0.250)	-0.135 (0.215)	0.0432 (0.252)
Control	Yes	Yes	Yes	Yes
Constant	1.739 ^{***} (0.269)	2.423 ^{***} (0.331)	1.381 ^{***} (0.277)	2.384 ^{***} (0.324)
Observations	588	393	572	399
r2	0.193	0.184	0.155	0.190

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.4 Conclusions of the Danish case study

Despite being one of the largest contributors to GHG emissions, the agricultural sector has largely been exempted from strict climate regulations such as carbon taxation and a compulsory carbon market (cap-and-trade, ETS scheme). Policymakers have hesitated to implement strict policy measures due to anticipated pushback from farmers and agricultural interest groups. Farmers' reactance to strict climate regulations can be mediated by their perceptions about the costs of these policies. Public perception of climate policy costs often diverges from reality, with support or opposition driven more by what people believe policies will cost them than by actual economic effects. Individuals commonly overestimate the personal financial burden of measures like carbon taxes while underestimating their environmental benefits. The gap between perceived and actual costs could be one of the reasons that triggered organized protests by farmers in Denmark against the CO₂e tax. Although there is broad political consensus in the Danish parliament to implement the tax in the fall of 2024, farmers remain opposed, calling for its withdrawal and warning of the potentially serious consequences it could have on the agricultural sector. Given this policy context, the study explores whether farmers' concerns and negative expectations about the costs of introducing the tax hinder farmers' acceptance of the carbon tax and related policy instruments, such as an agricultural ETS scheme, and whether perceptions gaps could be mediated by the provision of information about experts' opinions regarding such costs.

The main findings of the study are reported here. First, the overwhelming majority of farmers (94%–97%) overestimate the impact of CO₂e tax on agriculture. CO₂e tax stringency is one of the key factors shaping farmers' beliefs. Perceived impacts are higher under the high-tax than the low-tax scenario; however, in relative terms, overestimation is more pronounced in the low-tax scenario. While perceived impacts exceed experts' estimates by 53%–88% under the high-tax scenario, they overestimate experts' predictions by 100%–210% under the low-tax scenario. These results align with previous literature on carbon tax acceptance, which suggests that individuals tend to overestimate the personal costs of such taxes (Douenne and Fabre, 2022; Jagers and Hammar, 2009). This tendency could be intensified by the organized anti-tax campaigns that followed the release of the Danish Expert Group on Green Tax Reform's report. The report sparked intense public debate, with lobbying groups, farm organizations, and some political actors portraying the CO₂e tax as a major threat to Danish agriculture. One parliamentary party, in particular, led farmer protests across the country with slogans such as "No, thank you to a CO₂e tax" and "Preserve Danish Agriculture". Such messaging may have reinforced fears that the tax would devastate the sector, exacerbating belief distortions. Additionally, the overestimation may reflect a broader psychological aversion to the word "tax" itself, which has been shown to provoke negative reactions regardless of the policy content (Hardisty et al., 2010; Kallbekken et al., 2011).

Second, the perception gaps regarding the impacts of the CO₂e tax on agriculture may be corrected. Farmers seem to update their beliefs towards experts' estimates, but updating is very modest. This may be attributed to a significant disconnect between farmers and both scientific evidence and scientists. For instance, Rust et al. (2022) and Burbi et al. (2016) both found that farmers tend to place more trust in the practices and experiences of their peers rather than in experts from academic or government institutions. Similarly, Maas et al. (2021) further support this by showing that farmers assign low importance to scientific evidence, often viewing research and academic articles as less relevant for making agricultural and environmental decisions.

Third, the stringency of the tax affects both farmers' self-reported acceptance of the CO_{2e} tax and their actual donations towards an organization of their choice that they believe would best defend the interest of the agriculture sector in the tripartite negotiations on a CO_{2e} tax (which is an indirect but incentivized measure of acceptance). A more stringent tax reduces farmers' acceptance of the tax as expected.

Fourth, the decline in farmers' acceptance of the CO_{2e} tax is accompanied by a rise in support for an agricultural ETS and an increased probability of implementing climate-related practices by farmers. The ETS may be viewed as the more acceptable alternative, especially in light of the intense public discourse in Denmark at the time of the survey. In addition, although both the CO_{2e} tax and the ETS could, in theory, yield comparable environmental outcomes, the flexibility offered by the trading mechanism in the ETS likely enhances its appeal. Furthermore, farmers may perceive adopting climate measures as a strategy to avoid the burden of the CO_{2e} tax. This aligns with theoretical frameworks suggesting that higher carbon prices encourage investment in low-emission technologies (Acemoglu et al., 2012), and with empirical findings that emphasize the need for sufficiently high carbon prices to stimulate innovation (Aghion et al., 2016; Laing et al., 2013). Additionally, an increased tax severity amplifies the concern that such a tax could threaten farmers' business viability.

Fifth, information on the impact of the CO_{2e} tax predicted by experts increases support for the tax itself, but only when measured using self-reported acceptance (not using real donations). This might be due to the fact that farmers are overall pessimistic about the expected impact of the tax in terms of additional costs for the agricultural sector as compared to experts. When given access to experts' predictions, they revised these accordingly, boosting support for the CO_{2e} tax. However, information has no impact on support for an agricultural Emissions Trading Scheme (ETS) and an increased probability of implementing climate-related practices by farmers.

Sixth, farmers' response to stringency of the tax and information from experts is heterogeneous across farm sizes and farm types. More stringent CO_{2e} taxes affect acceptance of the tax itself and preferences for an agricultural ETS scheme more substantially for larger than smaller farms, and for livestock than crop farms. The impact of information follows a similar preference pattern.

This report offers valuable insights into how agricultural climate policy can be more effectively designed by considering the complex interactions between different policy instruments and farmers' behavioural responses. A key takeaway is the need for a more holistic and integrated approach to policy design, where instruments are not viewed in isolation but in terms of how they influence the acceptability and effectiveness of each other. Our findings show that while a stringent CO_{2e} tax is generally less acceptable to farmers, it may paradoxically increase support for complementary instruments, such as an agricultural Emissions Trading Scheme (ETS). Even more significantly, stronger carbon pricing appears to incentivize the adoption of farm-level climate measures, which can enhance environmental outcomes and support the long-term economic resilience of farms. This effect is particularly pronounced among larger farms, which tend to respond more to robust economic signals than to softer interventions such as information campaigns.

In parallel, communication strategies play a vital supportive role in the success of climate policy. While information provision alone has limited influence, especially on larger farms, it can nonetheless be a cost-effective complement to more stringent measures. Targeted information campaigns can be especially effective for smaller farms, which are more responsive to expert-based information. These efforts can help bridge misperception gaps about the impacts of climate policies, such as the CO_{2e} tax,

thereby increasing their legitimacy and acceptance. However, the effects of information may diminish over time, underlining the importance of repeated and consistent communication efforts.

In sum, a well-designed climate policy package for agriculture should combine economic instruments like carbon taxes and/or ETS with targeted and sustained communication, tailored to farm size and characteristics. Such an approach can enhance both the environmental effectiveness and social acceptability of climate action in the agricultural sector, supporting the EU's broader sustainability and climate goals.

4. Overall findings and policy implications

Agriculture remains a cornerstone of European food security, yet it is simultaneously a significant contributor to climate change. As documented in recent international reports, including those by the IPCC and the European Environment Agency, agricultural activities are responsible for over 10% of anthropogenic greenhouse gas emissions in the EU, with methane and nitrous oxide from livestock systems standing out as major sources. These emissions not only challenge the EU's broader climate goals under the Green Deal and Farm to Fork Strategy but also highlight the urgent need to innovate and diversify the portfolio of policy instruments designed to promote sustainability in food production.

Despite the implementation of several climate-related measures under the CAP, including agri-environmental schemes and eco-schemes aimed at incentivizing carbon farming, current policy efforts remain insufficient. At the same time, the agricultural sector retains untapped potential for climate change mitigation, particularly through carbon farming practices, and the urgency to identify effective and socially acceptable pathways has never been greater.

This report contributes to the ongoing policy debate by presenting the findings from two empirical case studies conducted in Italy and Denmark. These case studies offer a unique lens into farmers' acceptability of a range of economic policy instruments designed to reduce GHG emissions from livestock systems, including traditional subsidies, voluntary carbon markets, result-based payments, carbon taxes, and emissions trading schemes. Importantly, they explore how different instrument designs affect farmer support and acceptability.

The Italian study, centered on the dairy sector, focused on farmers' willingness to engage in a VCM as well as more innovative RBPs. They were all framed around a specific carbon farming practice: The use of essential oils in animal feed to reduce enteric methane emissions. A key insight from this study is that, while farmers still show a preference for traditional ABPs, they are not strongly opposed to innovative instruments like VCMs or RBPs. In fact, acceptance improves when these novel tools are introduced in hybrid formats alongside standard subsidies. This suggests that hybridization, using ABPs to anchor more innovative elements like VCMs and RBPs, can serve as a transition strategy to build trust and familiarity.

The Danish study complements these findings by examining livestock farmers' reactions to more stringent economic instruments, specifically a carbon tax and an ETS. Denmark provides a particularly relevant context, as the introduction of a carbon tax was already under political consideration during the study's execution. The results show that farmers are generally skeptical of carbon taxes and ETS schemes, especially when perceived economic costs are high. However, the study also reveals that providing credible information on actual economic impacts can reduce resistance, albeit modestly, and that opposition to carbon taxes may paradoxically enhance support for ETS schemes. This suggests a spillover effect, where aversion to one instrument increases openness to another, particularly when the latter is framed as a more flexible or fair alternative.

Together, these findings show that economic instruments such as taxes, carbon markets, and RBPs are vital for incentivizing sustainable behavior and internalizing environmental externalities; their success hinges on political feasibility and social acceptability. In other words, even the most economically efficient policy design will fail if it lacks legitimacy among those expected to implement it. This underscores the need to place farmers' perspectives and behavioural responses at the center of climate policy design for agriculture.

The evidence from both studies supports a series of key conclusions and policy recommendations for the EU and its Member States. First, there is strong potential for the gradual integration of innovative economic instruments into existing agricultural policy frameworks. Rather than replacing traditional subsidies outright, these innovative tools should be introduced incrementally and strategically, leveraging the familiarity and relative safety of ABPs to ease farmers into more performance-oriented or market-based mechanisms. For example, result-based payments can be integrated into CAP measures in hybrid formats that combine fixed payments with outcome-linked bonuses. Such designs can reduce perceived income risk while simultaneously building capacity for more advanced mechanisms, such as participation in VCMs.

Indeed, VCMs themselves may benefit from this gradualist logic. Currently, many farmers view them as opaque, complex, or administratively burdensome. These concerns are amplified by limited familiarity with carbon credit systems and insufficient technical support. However, when paired with simpler, more familiar ABPs or RBPs, VCMs can gain legitimacy and encourage early participation. Over time, greater engagement with VCMs may also pave the way for acceptance of stricter regulatory instruments, such as cap-and-trade systems or carbon taxation. In this respect, hybrid policies can serve both as transitional mechanisms and as confidence-building tools in the broader transformation of agri-environmental systems.

Second, policy instruments should not be designed or introduced in isolation. The Danish study provides a clear example of how policy interactions can influence perceptions and preferences. While farmers initially resisted a proposed carbon tax, this resistance did not translate into blank rejection of all climate tools. On the contrary, some farmers viewed the ETS more favourably, particularly when informed of the relative costs and flexibilities involved. This suggests that an intelligent mix of instruments (such as hybrid payments investigated in the Italian case study) can create positive synergies and mitigate opposition. Taxes, ETS schemes, VCMs, and subsidies can coexist—each fulfilling different roles in a broader policy architecture tailored to reduce emissions while maintaining economic viability for farmers.

Third, the findings underscore the importance of accounting for behavioural and structural heterogeneity among farmers. Acceptability is far from uniform and varies by farm size, sectoral specialization, previous experience with sustainability initiatives, and individual values. For instance, farmers already engaged in environmental practices or equipped with renewable energy systems tend to be more open to new instruments. By contrast, older farmers or those in diversified farms may exhibit greater reactance, especially when instruments are perceived as complex or risky. Therefore, differentiated policy strategies are essential. Tailoring instruments to specific segments of the farming population, not only in terms of economic design but also in communication and support, can increase both effectiveness and legitimacy.

Information provision is one area where tailoring is particularly important. While the Danish study found that information on economic impacts had only a modest effect in reducing opposition to carbon taxes, the manner in which information is delivered matters significantly. Farmers are more likely to trust and act upon information disseminated by credible intermediaries, such as agricultural cooperatives, peer farmers, or trusted advisors. Consequently, communication strategies should prioritize transparency, trust-building, and contextual relevance. Additionally, advisory services and training initiatives should be expanded to help farmers navigate new tools, understand potential benefits, and comply with technical or administrative requirements.

At the same time, it is important to acknowledge the limitations of the empirical case studies on which these conclusions are based. The two case studies were conducted in different countries, under different political and institutional conditions, and employed different methodological approaches. In Italy, it was not feasible to study more contentious instruments such as ETS schemes due to high levels of political resistance. Conversely, in Denmark, the salience of a pending carbon tax provided an opportunity to examine real-time reactions to an imminent policy change. These contextual differences limit the direct comparability of findings and caution against overly broad generalizations.

Additionally, the instruments tested were necessarily context-specific. For example, the voluntary carbon market scheme studied in Italy relied on a particular feed additive (essential oils) and a relatively advanced institutional framework for carbon accounting. These conditions may not be replicable in all EU regions. Similarly, farmers' responses in both countries were shaped by national policy debates, media coverage, and stakeholder mobilization at the time of data collection. Finally, while the studies incorporated some behavioural determinants of policy acceptance, such as risk preferences, attitudes, and perceived behavioural control, they did not systematically investigate other factors that are also likely to influence farmer decision-making.

Nevertheless, the findings from Task 3.2 offer valuable lessons for EU policymakers. Policy innovation must go hand in hand with democratic engagement. Resistance to carbon taxes or ETS schemes can be overcome by involving farmers in the co-design of new instruments—through consultations, pilots, or participatory governance structures—public authorities can build trust and legitimacy while enhancing policy responsiveness. This participatory approach can help ensure that instruments reflect the lived realities of farming communities and are better adapted to local contexts.

In sum, the conclusions drawn from the Italian and Danish case studies highlight that no single instrument will suffice to decarbonize European agriculture. Rather, what is needed is a flexible, multi-layered policy approach that reflects the diversity of European farming systems and aligns environmental goals with farmer motivations. Hybrid schemes that blend traditional subsidies with performance-based rewards can serve as stepping stones toward more ambitious instruments. Voluntary carbon markets, if properly regulated and supported, can generate new opportunities for climate-smart farming. Carbon taxes and ETS schemes, while currently unpopular among farmers, may gain traction if framed transparently and introduced gradually in combination with other tools.

Achieving the EU's climate targets for 2030 and 2050 will demand such pragmatism and creativity. But more than that, it will require a transformation in how agricultural climate policies are imagined, designed, and implemented. With thoughtful planning, inclusive governance, and strategic investment, public authorities—together with researchers, farmer organizations, and market actors—can co-create policy frameworks that are not only effective, but also fair and resilient. This is not just a technical challenge, but a societal one, and its success will ultimately depend on the trust, participation, and commitment of Europe's farmers.

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