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CULTIVATING SUSTAINABILITY:

A DISCRETE CHOICE EXPERIMENT ON DUTCH FARMERS' PREFERENCES FOR CARBON FARMING CONTRACTS UNDER THE QU.A.L.ITY CRITERIA

Msc Thesis

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Abstract

Carbon farming has recently emerged as a new way to combat climate change. The EU has recognised its potential and is exploring ways to incentivise adoption under farmers. Greenwashing has been identified as a significant risk in carbon farming, therefore the EU has proposed a framework under which to validate and certify sequestered carbon, the QU.A.L.ITY criteria. A discrete choice experiment was carried out to analyse Dutch farmers' preferences for carbon farming contracts based on the QU.A.L.ITY criteria. The results were analysed with a mixed logit model and a latent class model. Based on a sample of 94 Dutch farmers, the mixed logit model showed that the average Dutch farmer has a 58.0% predicted probability to accept a carbon farming contract based on the QU.A.L.ITY criteria. When controlling for all variables in the model, the ASC shows that the average Dutch farmer views carbon farming contracts based on the QU.A.L.ITY negatively. The latent class model divided the sample in two classes, one with a predicted probability to accept of 9.9% (labelled as 'risk-averse sceptics') and one with a predicted probability of 81.6% (labelled as 'pragmatic adopters'). Next to higher financial compensation and lower contract lengths, farmers are more likely to accept a carbon farming contract when an option for premature contract termination is included, as well as when farmers receive a 0.5% discount on new loans. Policy makers should focus on finding farmers already applying carbon farming practices, farmers receiving no external funding for these practices, small-scale farms, farmers who view the effect of climate change as negative and farmers in the pragmatic adopter class.

Contents

List of acronyms

AES – Agri-Environment Schemes
ASC – Alternative Specific Constant
B2B – Business-to-Business
CAP – Common Agricultural Policy
CC – Carbon Credits
CF – Carbon Farming
CLM – Conditional Logit Model
CO_2 – Carbon Dioxide
CRCF – Carbon Removal and Certification Framework
DCE – Discrete Choice Experiment
EC – European Commission
EU – European Union
ε – Error Term
FMF – Friese Milieu Federatie
GHG – Greenhouse Gases
ha – Hectare
HBO – Hoger Beroepsonderwijs
IID – Independently and Identically Distributed
IIA – Independence of Irrelevant Alternatives
KM^2 – Square Kilometre
LCM – Latent Class Model
LTO Noord – Land- en Tuinbouw Organisatie Noord
ME – Marginal Effects
MXL – Mixed Logit Model
MRV – Monitoring, Reporting, and Verification
Mt – Mega tonne
N – Nitrogen
N_2O – Dinitrogen Oxide
NFW – Noardlike Fryske Wâlden
PPP – Public-Private Partnership
QU.A.L.ITY – Quantification, Additionality, Long-Term, Sustainability
SNK – Stichting Nationale Koolstofmarkt
SOC – Soil Organic Carbon
SQ – Status Quo
t – Tonne
U – Utility
V – Observed Utility
VCM – Voluntary Carbon Markets
WTA – Willingness to Accept
ZLTO – Zuidelijke Land- en Tuinbouworganisatie

Chapter 1 Introduction

1.1 Background

The Montreal protocol is an often-cited example of successful climate action (see e.g. Gonzalez *et al.*, 2015; Whitesides, 2020). The agreement led to a global reduction in the production, consumption and emission of ozone-depleting substances, ultimately reversing the thinning of the ozone layer (Abbasi and Abassi, 2017). Additionally, the protocol's universal adoption led to climate mitigation, as many ozone-depleting substances are also potent greenhouse gasses (GHG). This represents a twofold success in addressing both ozone depletion and climate change.

The current climate crisis has proven far more difficult to deal with. While there is overwhelming scientific evidence on human-induced climate change (Lynas *et al.*, 2021), decisive worldwide action is lacking. A key distinction between these two climate policy outcomes is the financial cost and the burden of implementation: the transition to non-ozone-depleting substances under the Montreal Protocol was both technologically and economically feasible (Ruhl, 2023), whereas decarbonisation is significantly more complex and costly.

Recognising the climate crisis, the EU has set the ambitious goal of becoming the first climate neutral continent by 2050 (EU Regulation 2021/1119). To overcome the technological and economical barriers hindering decarbonisation, the EU is applying a strategy reminiscent of what made the Montreal Protocol successful—aligning environmental goals with economic feasibility. A key pillar of the European Green Deal is enhancing the financial viability of sustainable practices and driving its' widespread adoption across both public and private sectors. One approach to achieving this is the implementation of market-based mechanisms (EC, 2019). The European Commission (EC) is exploring carbon farming (CF) as a potential avenue for these mechanisms, leveraging its ability to enhance carbon sequestration and reduce emissions by modifying traditional farming practices. By integrating economic incentives, the EU aims to facilitate meaningful climate action while offering farmers a new business model (EU Regulation 2024/3012).

CF leverages the soil's natural ability to store carbon, providing both climate and agricultural benefits. Examples of CF practices include reduced tillage and introducing cover crops. These practices can increase the soil's capacity to capture carbon (McDonald *et al.*, 2021). Soils hold significant potential for removing CO_2 from the atmosphere and securely storing it (Smith, 2004). However, realising this potential has been hindered by intensive agricultural practices, which increase carbon leakage from soils (Gren & Aklilu, 2016). Next to sequestering carbon, CF practices promote soil health (Smith, 2004). Apart from ensuring farm productivity, soil health supplies vital ecological and non-ecological functions (Blum, 2005). Therefore, it is concerning that EU soil health is currently in decline, with over a third of all soils classified as either moderately or highly degraded (Gibbs & Salmon, 2015).

With the 'Carbon Removals and Carbon Farming Regulation', the EU aims to establish a framework, among others, that lays the groundwork for certifiable carbon sequestration. Following from this framework are the QU.A.L.ITY criteria, which ensure carbon sequestration provides meaningful climate action (EU Regulation 2024/3012).

Farmer preferences for environmental contracts have been extensively studied in the literature (see e.g. Ben-Othmen and Ostapchuk, 2023; Broch & Vedel, 2011; Dessart *et al.*, 2019; Lienhoop & Brouwer, 2014), with increasing attention to carbon sequestration contracts in recent years (see e.g. Block *et al.*, 2024; Gramig and Widmar, 2017). At the time of writing, this study is the first to specifically examine farmer preferences for CF contracts based on the EU's QU.A.L.ITY criteria. Data found by Kik (2023) and Matis (2023) allows this research to design contracts that fulfil the QU.A.L.ITY criteria. This research is also the first of its kind studying Dutch famers' preferences for CF contracts.

1.2 Research objective and research questions

The objective of this research is to design and empirically test soil health and CF contracts based on the EU's QU.A.L.ITY criteria. The scheme is voluntary and farmers are renumerated by the contracting party. This study forms a part of the larger NOVASOIL project[1], which is dedicated to promoting innovative business approaches for enhancing soil health. The insights gained from this thesis contribute to NOVASOIL's mission by shedding light on the financial and non-financial incentives that motivate Dutch farmers with regards to soil health and CF (Novasoil, n.d.).

The main research question is:

"Under what conditions are Dutch farmers willing to accept carbon farming contracts that comply with the QU.A.L.ITY criteria?"

The sub-research questions are:

1. *What type of carbon farming practices exist?*
2. *What are the QU.A.L.ITY criteria?*
3. *What is the current state of carbon farming in the Netherlands?*
4. *What drivers are the most important for Dutch farmers' decision to accept carbon farming contracts based on the QU.A.L.ITY criteria?*
5. *Which type of Dutch farmers is the most suitable target groups for carbon farming contracts based on the QU.AL.ITY criteria?*

1.4 Theoretical framework and methodology

Research sub questions 1 to 3 were answered by a literature review. The last two sub questions were answered by analysing the data from a discrete choice experiment (DCE). Sub question 4 was answered by running a mixed logit model, sub question 5 was answered by running a latent class model. A DCE allows for hypothetical contracts and their attributes to be compared, allowing for the analysis of trade-offs between financial and non-financial attributes of contracts (Train, 2009). The sample used consisted of 94 Dutch arable, diary and peatland farmers. The DCE proposed two hypothetical contracts and an opt-out option. The hypothetical contracts vary across attribute levels. Each respondent completed seven decisions. Econometric analysis of the decisions can show us how respondents value different attributes (Mariel *et al.*, 2021).

1.5 Content overview

Chapter 1 introduces the reader to the research topic and its context. Chapter 2 provides an in-depth analysis of what CF entails, including various practices and business models, as well as an explanation of the QU.A.L.ITY criteria. It concludes with the current state of implementation of CF in the Netherlands. In chapter 3 the theoretical framework, the methodology and the design of the DCE are discussed. Chapter 4 presents the results of the DCE. In Chapter 5, the results are discussed in a wider context. Chapter 6 concludes the research.

[1] This research has received support from the Horizon Europe funding programme under grant agreement 10109126.

Chapter 2 Literature review

This chapter delves into the background information relevant for this thesis, aiming to contextualise the central theme of CF. The chapter starts with the broadest aspects of soil and progressively narrows its focus on the valorisation of CF.

2.1 Soil and carbon

Soil is an intricate mix of minerals, organic matter and organisms on the outer layer of the earth (Gregory, 2022; Lehman *et al.*, 2020). It provides vital ecosystem services such as water regulation, nutrient cycling and the provision of habitats. Furthermore, soil provides the basis for many anthropogenic activities such as the provision of housing, industrial processes and cultural activities (Benedetti *et al.*, 2013).

Soil health[2] has become a policy priority for the European Commission (EC) in recent years (EC, 2024, Janzen *et al.*, 2021). Soil health is defined as: 'The capacity of soil to function, within ecosystem boundaries, to sustain crop and animal productivities, maintain or enhance environmental sustainability, and improve human health worldwide' (Yang *et al.*, 2020, p.1).

As soil is a complex concept, measuring its health can be done in many ways. Soil health itself is not quantifiable, necessitating the use of a proxy for measurement purposes. Lehman *et al.* (2020) propose three criteria for soil health proxies: (1) the proxy must be relevant to soil health, (2) the proxy must be quantifiable while not being affected by short-term fluctuations and (3) the proxy must be practical and cost effective. Using soil organic carbon as an indicator fulfils the criteria. First, SOC affects soil health positively as an increase of SOC levels improves the fertility of soils, productivity, drainage, nutrient availability, biodiversity and microbial life (Söderström *et al.*, 2014). Second, changes in SOC can be measured and occur in the long term. Third, measuring SOC is relatively cheap and easy to implement compared to other measures, such as microbial biomass, earthworms and pH levels (Lehmann *et al.*, 2020). SOC is a widely used proxy for measuring soil health, as it reflects multiple functions and ecosystem services of soils (Nunes *et al.*, 2021).

SOC plays an important role in the global carbon cycle. The amount of carbon in soils exceeds that of atmospheric and vegetative carbon combined (Kopittke *et al.*, 2019). Soil carbon pools are affected by three mechanisms: photosynthesis, respiration and decomposition (Ontl and Schulte, 2012). Soil health impacts the capacity of soils to sequester and retain carbon. Soils in good condition act as carbon sinks, soils in poor condition act as carbon sources (Hatano *et al.*, 2024).

Converting natural ecosystems such as forests, meadows, and peatlands into agricultural land substantially reduces the soil's ability to sequester and retain carbon (Bai *et al.*, 2018). Additionally, certain farming techniques exacerbate this issue. Practices such as monoculture cultivation, the application of synthetic fertilisers, and tillage disrupt soil structure and processes, further limiting the capacity of agricultural soils to sequester and retain carbon (Gregorich *et al.*, 2001; Haddaway *et al.*, 2017).

Agricultural soil health practices have the potential to contribute positively to two domains. Agriculture benefits from higher outputs and more efficient use of inputs, leading to increased profits for farmers (Lal, 2011). Additionally, the practices can increase the uptake of atmospheric carbon in soils and increase the capacity to store carbon of soils, leading to mitigation of climate change. Finally, soil health plays a vital role in ecosystem services provision like biodiversity conservation and climate resilience (Amelung *et al.*, 2020).

[2] Soil health and quality are often used synonymously. This thesis uses the term soil health.

2.2 Carbon farming

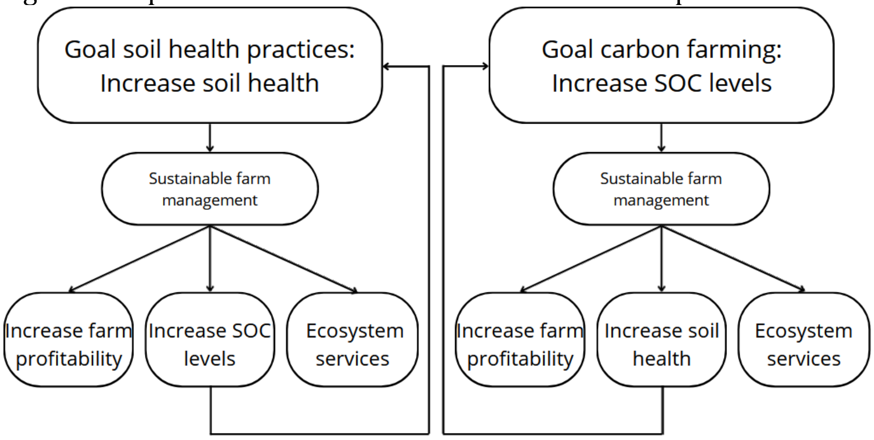
2.2.1 Carbon farming practices

CF leverages the soil's capacity to act as a carbon sink by implementing practices that either enhance SOC levels or prevent SOC leakage. According to McDonald *et al.* (2021, p. 10), CF focuses on "the management of carbon pools, flows and greenhouse gas fluxes at farm level, with the purpose of mitigating climate change."

In contrast to conventional farming, CF broadens its focus beyond food and fibre production to include carbon sequestration through SOC and additional ecosystem services (Matis, 2023). CF is closely related to soil health. CF requires healthy soils to maximise the potential capacity of carbon storage. Like soil health practices, CF brings with it additional benefits in the form of ecosystem services. These benefits are private (e.g. higher farm productivity) and public (e.g. increased biodiversity) (McDonald *et al.*, 2021).

Figure 1 illustrates the relationship between soil health and CF practices. The goals of each approach are juxtaposed with their respective externalities, emphasising the distinctions between them.

Figure 1: Main goals and positive externalities of soil health and CF practices



Source: author's own illustration

The figure shows the close relationship between soil health practices and CF practices, highlighting their overlapping benefits. While soil health practices aim to enhance soil quality, they often involve practices that also contribute to carbon sequestration (McDonald *et al.,* 2021). Similarly, CF's aim focuses on increasing SOC levels but relies on many of the same sustainable farm management practices used to improve soil health (Lal, 2016). Both approaches yield positive externalities, including higher farm profitability, enhanced ecosystem services and the main goal of the other approach. This overlap suggests that policies promoting CF can simultaneously support soil health objectives, reinforcing their mutual benefits.

CF contains a wide array of practices. Table 1 shows the five most prominent categories. A one-size-fits-all solution does not exist. Selecting the best CF practice for an individual farm depends heavily on farm characteristics, soil properties and mitigation goals (McDonald, 2021).

Table 1: CF practice categories and their carbon sequestration potential

	Land use management		**Soil management**	**Livestock, manure and nutrient management**	
Mitigation potential per ha	3.5-29t CO_2-e*/year	0.03-27t CO_2-e³/year	0.5-7t CO_2-e³/year	0.05-1.5t CO_2-e³/year	0-1.5t CO_2-e³/year
Example practices	Peatland rewetting	Planting woody biomass	Conservation tillage, cover crops, improved crop rotations	Improved manure storage, improved feed	Improved nutrient planning and application
Source	McDonald *et al.* (2021)	McDonald *et al.* (2021)	McDonald *et al.* (2021)	McDonald *et al.* (2021), Interreg (2021)	Interreg (2021)

*Notes: CO_2-e *= the CO_2 equivalent of all farm-wide sequestered and prevented GHG.*
Source: Interreg (2021) and McDonald et al. (2021), Moinet et al. (2023)

All CF practices require modifications to conventional farm operations. Some are more intrusive than others. Land use management requires farmers to completely overhaul their operations, with extreme forms such as peatland rewetting leading to soils being unfit for traditional agricultural production. Others are less intrusive, like improved nutrient application. The differences between highly intrusive and less intrusive CF practices are also visible in the mitigation potential. As a rule of thumb, the more intrusive the practice, the higher the mitigation potential (Interreg, 2021, McDonald *et al.*, 2021).

Since CF practices require farmers to adjust their operations, they can also affect farm profitability. Farmers may need to invest in equipment, labour, education or inputs to fulfil the requirements of new practices. Furthermore, CF practices may also influence outputs, either positively or negatively, as the sequestered carbon can increase or decrease productivity, depending on which type of practices are used (McDonald *et al.*, 2021).

In addition to the type of CF practices, soil types play an important role in carbon sequestration potential. Different soil types have different sequestration capacities (Rodrigues *et al.*, 2023). Peatlands have very high carbon sequestration potential due to their intrinsic soil properties (McDonald *et al.*, 2021), while studies by Rougoor *et al.* (2022) and Matis (2023) indicate that sandy soils have higher carbon sequestration potential than clay.

2.2.2 Carbon farming schemes & business models

CF has gained worldwide popularity, with many private initiatives to pay for CF taking off (EC, 2021b). The EC has recognised CF's potential and is aiming to stimulate the adoption of CF schemes in the EU (EU Regulation 2024/3012). CF schemes are defined as a voluntary agreement between a farmer and a contracting partner, where the contracting partner renumerates the farmer for either carbon sequestration in their soils or reduction of farm-wide GHG emissions (Thorsøe *et al.*, 2024).

Different funders offer contracts for CF, leading to different business models due to inherent differences between contracting parties. The business models differ by payment type, funder and funder incentives. Projects such as NOVASOIL differentiate between three business models that are based on the funder: farm payments (e.g. for eco-schemes or agri-environmental schemes), supply chain payments coming from agri-food companies, and payments for certified sequestered carbon achieved on carbon markets.

Table 2 shows the three main business models for CF, their specifications and examples.

Table 2: Business models for CF with real world examples

Business model	Payment type	Funder	Funder incentive	Example
Farm payments	Majority action-based	Public entities or NGOs	Payment for eco-system services	CAP* eco-schemes
Supply chain payments	Majority action-based	Agri-food companies	Higher commodity prices	On the way to Planet Proof
Voluntary carbon markets	Result-based	Private entities	Offsetting emissions	Stichting Nationale Koolstofmarkt

Notes: CAP = EU common agricultural policy*
Source: Hoes & Aramyan (2022), Jongeneel and Gonzalez-Martinez (2023), McDonald et al. (2021), Raina et al. (2024) and Thorsøe et al. (2024)

Payments are additional to farm income benefits (McDonald *et al.*, 2021). The schemes are used to incentivise farmers to start applying CF practices (EC, 2021a). Table 3 presents three different payment types for CF efforts, where payment types differ by how the farmer is compensated, and the strengths and weaknesses of each type.

Table 3: Payment types for CF practices

Payment type	Compensation	Strengths	Weaknesses
Action-based payments	Farmers compensated for action taken	○ Cheap and easy MRV* ○ Certainty of farmer income	○ Low confidence in mitigation results ○ Low farmer flexibility
Result-based payments	Farmers compensated for results achieved	○ High confidence in mitigation results ○ High farmer flexibility	○ Expensive and complex MRV* ○ Uncertainty of farmer income
Hybrid payments	Combined action- and result-based payments	○ High confidence in mitigation results ○ High farmer flexibility ○ Relative certainty of farmer income	○ Expensive and complex MRV*

Notes: MRV = Monitoring, reporting and verification of sequestered carbon*
Source: McDonald et al. (2021), Raina et al. (2024) and Thorsøe et al. (2024).

Farm payments are widely used in the 'common agricultural policy' (CAP) of the EU (McDonald *et al.*, 2021), providing direct compensation for predefined practices. CAP eco-schemes reward farmers who voluntarily carry out climate and environmentally friendly farming practices, in return farmers are compensated by their respective member states (Cortignani *et al.*, 2016). In the Netherlands, farmers have 26 eco-friendly practices they can implement. The amount of money depends on the number of implemented practices, ranging from €60 to €200 per ha per year.

Agri-food companies have seen the possibility to green their supply chains by working directly with farmers (Agnusdei & Coluccia, 2022). Farmers receive higher compensation for their commodities if they implement practices previously agreed upon, while agri-food companies market their products to consumers at a premium. Agri-food companies justify this premium to consumers via labels (McDonald *et al.*, 2021). For example, dairy company FrieslandCampina utilises supply chain payments related to the 'On the way to PlanetProof' label. On the way to PlanetProof is a program that rewards farmers for exceeding legally required minima. Rewards are granted for practices that enhance farm biodiversity, animal welfare or reduce farm-wide GHG emissions. Farmers are audited by On the way to PlanetProof founder 'Stichting Milieukeur'. Farmers who implement the required practices receive an additional two eurocents per litre of milk (Hoes & Aramyan, 2022).

Demand for climate offsetting is not limited to agri-food supply chains. Offset certifications are used to substantiate climate neutrality claims for private and public entities (Kreibich, 2024), driving the development of voluntary carbon markets (VCM) (Trouwloon *et al.*, 2023). On VCMs, offset certifications are sold under the name carbon credits (CC) (Kreibich, 2024). A CC is a certificate that represents 1 tonne of CO_2 equivalent of either sequestered CO_2 or prevented emissions (Klinkert Vadalkar, 2024). CC prices are determined by market powers and are subject to high volatility (Wongpiyabovorn *et al.*, 2021). VCMs work with a verification mechanism. CC are verified by independent auditors. After verification, farmers sell directly to a purchaser or via an intermediary (McDonald, 2021). Stichting Nationale Koolstofmarkt (SNK) is an institution which offers certification services and a platform to sell and buy CC. Farmers go to an independent and approved verifier of CC after which SNK certifies the CC, and the CC are registered in SNK's register. The registered CC are then ready to be sold to any buyer (Stichting Nationale Koolstofmarkt, 2022).

2.2.3 QU.A.L.ITY criteria

Certification is a vital step in for CF business models. To ensure high quality sequestration, the documentation and evaluation of CC needs to be transparent, robust and independently verified (Spilker & Nugent, 2022). For a successful business model, gaining trust of potential buyers is crucial (Nuttavuthisit & Thøgersen, 2015).

Greenwashing is a real concern for CF schemes. Greenwashing refers to poor climatic performance of companies combined with positive communication (De Freitas Netto *et al.*, 2020). Greenwashing undermines climate action in two main ways. First, polluting businesses are rewarded under false pretences by consumers, policy makers and investors. Secondly, climate action is overestimated and GHG emissions underestimated. Low quality CC are at risk of being used for greenwashing (Trouwloon *et al.*, 2023).

Kreibich and Hermwille (2021) state that private companies are losing faith in CC currently sold on VCMs. Current VCMs are not y*et al*igned with the Paris agreement. Kreibich and Hermwille argue for the need of policy support by national or international actors. Standardised rules for CC sold on VCMs are lacking (Valiergue & Ehrenstein, 2022). VCMs are often compared to the wild west of our time (see e.g. Dhanda & Murphy, 2011; Hall, 2022; Valiergue & Ehrenstein, 2022).

To foster legitimacy of CC and to limit the greenwashing risk, the EC has proposed a certification framework for carbon removals (CFCR). Under this proposal, CC are eligible for certification if the removals are independently certified and meet certain criteria, the so-called QU.A.L.ITY criteria (EU Regulation 2024/3012). The QU.A.L.ITY criteria are composed of four key components. Table 4 shows the criteria along with common critiques. This research focuses on CF contracts that fulfil all these criteria.

Table 4: QU.A.L.ITY criteria and their critiques

Attributes	Description	Critique
Quantification	CO_2 sequestration needs to be clear and measurable. Measurement should be based on a comparison to a standardised baseline of regional farm soils.	○ Costly, difficult to measure and labour intensive. ○ Standardised baselines fail to give an accurate view of improvement in sequestration.
Additionality	CO_2 sequestration needs to be additional to EU and member state regulations, and practices need to be additional to regular activities of the farmer.	○ The EU's proposed use of standardised baselines may contradict additionality by including farmers who already implement CF practices.
Longevity	The sequestered carbon needs to be securely stored for several decades. Farmers will be subject to monitoring and measurement during the whole contract period.	○ High risk of SOC levels not being permanent due to intentional or unintentional actions by farmers or natural disturbances.
Sustainability	The practices may not harm overall sustainability on the farm.	○ Practices should seek to create win-win situations, not focus on not harming.

*Sources: EU Regulation 2024/*3012*; McDonald et al., 2023, Scherger and Sharma (2023)*

To comply with the QU.A.L.ITY criteria, farmers submit an application detailing their CF plans, its total projected carbon sequestration potential and long-term storage strategy. These calculations should follow the CRCF methodology. The application is reviewed by a certification body. Each EU member state must accredit at least one certification body. The certification body is either public or private, uses a public registry and publishes annual reports. The certification body gives their verdict to accept or deny the CF plans and, if positive, conducts re-audits throughout the project running time to ensure compliance. Farmers are liable for the full project duration. Buyers of accredited CC minimise their risk of greenwashing (EU Regulation 2024/3012). The technical and methodological details are not specified in the CRCF framework (McDonald *et al.*, 2023).

2.2.4 Carbon farming risks

CF is not without risks. The risks have been divided into three categories. The first category relates to costs, such as the additional investments for farmers to fulfil CF requirements as well as administrative and policy costs. Policy makers need to set up high quality benchmarks and safeguards. Due to the fragmented and heterogeneous nature of the agricultural sector, there are no universally accepted methods. MRV pose significant costs to policy makers (Van Hoof, 2023).

The second category relates to uncertainties. First, the potential to sequester carbon for CF varies heavily depending on soil types, type of farm, CF practices, CF practice application and climate conditions. Additionally, Revenue streams associated with CF are dependent on prices received for sequestered carbon. These prices are subject to strong volatility (Thompson *et al.*, 2022). Furthermore, measuring SOC faces a trade-off between being costly but more precise and cheaper but less accurate. Current prices for measuring SOC levels of the Australian Carbon Farming Initiative are around €14 per hectare. This presents a sizable barrier for farmers and policy makers, while uncertainty about the accuracy of the SOC levels remain (Oldfield *et al.*, 2022). Variations of SOC levels inside singular farm plots are common, due to high spatial and temporal heterogeneity (Paul *et al.*, 2023). Moreover, soils have a natural limit to their capacity to capture carbon (Matus, 2021). There is no consensus on where SOC saturation levels lie (Cotrufo & Lavallee, 2022). As Additionality is one of the QU.A.L.ITY criteria, policy makers and farmers need to take this concept into account. Carbon sequestration can be considered additional if the sequestration would not have occurred without a policy incentive (McDonald *et al.*, 2023). Proving this additionality is difficult, as it needs to be clear what would have happened without the policy (Böttcher *et al.*, 2022). Long-term storage is another QU.A.L.ITY criterium. CF leads to elevated SOC levels due to its practices, however, the achieved higher levels are at risk of being reverted to their original state. CF practices need to be continuously applied, even after the saturation levels have been reached. Failing to do so results in climate change mitigation efforts going to waste (Leifeld, 2023).

The third category consists of negative externalities. Similarly to positive externalities, stakeholders can be faced with unintended consequences stemming from CF. CF practices might lead to higher N_20 emissions from soils (Grados *et al.*, 2022). N_2O is a potent greenhouse gas, which contributes to ozone depletion (IPCC, 2021). In a meta-analysis, Guenet *et al.* (2020) find that some CF practices lead to higher emissions of N_2O, potentially even offsetting increase SOC levels, while some CF practices lead to reduced N_2O emissions.

2.3 Carbon Farming in the Netherlands

As part of its commitment to reduce GHG emissions under EU regulations and the Paris agreement, the government of the Netherlands is exploring CF as a strategy to meet climate goals (Klinkert Vadalkar, 2024). The goal of the Dutch government is to sequester an additional 0.4-0.6 Mt CO_2 per year in agricultural soils by 2030 (Lesschen *et al.*, 2021).

2.3.1 Dutch carbon farming potential

The Netherlands has a surface area of 30.000 km^2, of which 54% is classified as agricultural soils (CBS, 2020). Dutch soils can be broadly divided in four main categories peat, clay, sand and loam. The distinction is made based on mineral and structural characteristics (RIVM, 2012). The agricultural sector currently emits 18 Mt of CO_2-e per year (RIVM, 2024).

By applying CF practices to all its agricultural land, the Netherlands has a technical sequestration potential of around 1 Mt of CO_2-e per year, representing a 5,6% decrease in yearly agricultural emissions. Agroforestry and peatland rewetting were excluded from this calculation (Lesschen *et al.*, 2012; Lesschen *et al.*, 2021).

Lesschen *et al.* (2021) modelled CF practices (excluding agroforestry and peatland rewetting) and their potential on typical Dutch soils. The three practices with the highest potential are: permanent grassland (0.3 Mt CO_2-e/year), catch crops (0.2Mt CO_2-e/year) and cover crops (0.2 Mt CO_2-e/year). All these practices fall under the soil management category (table 1).

2.3.2 Dutch carbon farming projects

Currently, 13 CF projects providing incentives to farmers for CF are running or have finished in the Netherlands. Most projects are exploratory and are in the pilot phase (Thorsøe *et al.*, 2024). Table 5 highlights characteristics of three exemplary projects. Projects are grouped by business models and payment type. Project specific characteristics can differ inside groups.

The 13 projects have been categorised into three main types based on available online information. All three business models are represented in the project groups. Each group involves multiple stakeholders. The supply chain and voluntary carbon market projects follow a business-to-business (B2B) model, while the Windpark Krammer project is a public-private partnership (PPP). All three payment types are represented. Hybrid payments are the most prevalent with nine projects in total.

The supply chain group is the only one not in the pilot phase, the program has been implemented widely across the Netherlands. Important to note is that increasing SOC levels is not the main goal of this group. In contrast, the other projects are in the development phase, aiming to both mitigate sector emissions and to validate business models and methodologies. Certification criteria differ between groups: the supply chain projects strive to going beyond legally required minima, whereas the groups using VCMs follow the QU.A.L.ITY criteria.

CF practices vary across the projects. The supply chain group, focused on dairy production, employs CF practices tailored to this sector. Valuta voor Veen is focused solely on peatland rewetting. The Windpark Krammer group demonstrates greater diversity in CF practices, allowing farmers flexibility in selecting practices suitable for their soils.

CF in the Netherlands is in an early phase. Supply chain payments are the most developed business model. Methodologies are continuously evolving and adapting. Given the ambitious carbon sequestration goals of the Dutch government, broader adoption of CF by farmers is needed. For this to occur, CF schemes must be supported by a viable and trusted business model. The following chapters of this thesis provide a quantitative analysis of Dutch farmers' preferences for CF contracts, while also identifying key factors that influence acceptance rates.

Table 5: Three CF projects and their characteristics

Projects	**PlanetProof**	**Valuta voor Veen**	**Windpark Krammer**
Business model	Supply chain payments	Voluntary carbon markets	Voluntary carbon markets, farm payments
Payment type	Action-based	Result-based	Hybrid
Partners	Stichting Milieukeur, agri-food sector, SNK	LTO Noord[3], NFW[5], FMF[5], Provincie Fryslân, SNK	ZLTO[5], Intterreg, EU
Partnership type	B2B	B2B	PPP
Payments to farmers	Higher commodity price for agreed upon practices	Payment based on measured increase in SOC levels	70% payment for agreed upon practices, 30% measured increase in SOC
Certification criteria	Improvement on legal minima	QU.A.L.ITY criteria	QU.A.L.ITY criteria
Area	89.000 ha	172 ha	670 ha
Goal of project	Greening supply chain and mitigating GHG emissions	Mitigating GHG emissions and validating business model	Mitigating sector emissions and validating business model
CF practices	Permanent grassland, herb-rich grassland	Peatland rewetting	Choice of 2 CF practice and 1 ecological practice
# similar projects	1 (Duurzame zuivelketen)	1(NLgroen)	8 (4 ZLTO projects, Carbon Farmers, Bionext, Carbon Farming in de Praktijk, Carbon Farming)

Sources: Rougoor et al. (2022), PlanetProof (2023), Valuta voor Veen (2023), ZLTO (n.d.), Hoogeveen et al. (2023), NLgroen (2024), Carbon Farmers (2024), Bionext (n.d.), WUR (n.d.), Carbon Farming Netherlands (n.d.)

[3] LTO Noord: Land- en Tuinbouw Organisatie Noord, NFW: Noardlike Fryske Wâlden, FMF: Friese Milieu Federatie, ZLTO: Zuidelijke Land- en Tuinbouworganisatie

Chapter 3 Methodology

Eliciting farmers' preferences for CF contracts and soil health enhancing practices requires a methodology designed to address hypothetical decision-making scenarios. Discrete choice experiments have emerged as a widely used approach for analysing decision-making scenarios in environmental contract selection (see e.g. Block *et al.*, 2024; Broch and Vedel, 2011; Niskanen *et al.*, 2021). Discrete choice experiments are a form of stated-choice methods based on the random utility theory of McFadden (1973). A DCE presents a respondent with a choice between a set of alternatives, after which the respondent indicates their preference. Alternatives are characterised by several attributes, which each varying across different levels. The choices reveal respondent's trade-off between attributes.

3.1 Survey design and sampling

The survey conducted for this experiment consists of three distinct parts. The first part is a filter, leading all respondents to the version of the survey most applicable to their soil. Afterwards, respondents were supplied with information on CF and requirements for CF tailored to their specific soil and farming operation types. The second part is the DCE. The survey concluded with questions regarding characteristics and attitudes of the farmer and their farm. The subsequent section provides a detailed overview of the survey design choices, including the required practices per soil and farm type, as well as the selection of attributes incorporated into the DCE. The survey can be found in appendix A.

3.1.1 Filter design

Chapter 2 has shown that the potential to sequester carbon varies widely due to farm and soil characteristics. The survey was therefore adjusted for each soil type. After a short introduction to the topic, the survey asked the farmers which soil and farm type most applied to their operations. The survey made a distinction between arable, dairy and peatland farmers (McDonald *et al.*, 2021; Niskanen *et al.*, 2021). Within the group arable farmers, a distinction was made between peat, clay, sand, loam and loess soils(Lesschen, 2021). These groups were again split into extensive and intensive farming operations (Johnston *et al.*, 2017; Matis, 2023). After farmers were assigned to the most relevant survey, they were presented with information on CF, requirements for CF practices and sequestration potential for their specific soil type. Table 6 shows all the required practices to be fulfilled by farmers if they opted to accept a CF contract in the DCE, based on soils and farm operation type.

Incorporating different practices for each farm type and subsequently conducting a DCE focused solely on contract attributes is a common approach. Niskanen *et al.* (2021) provide an example of using varied practices depending on farm type. Anastassia *et al.* (2013) adopt a contractual features-as-attributes approach to DCE, while Ščasný *et al.* (2016) apply a contractual practices-as-attributes approach. Broch and Vedel (2011) employ a combination of both approaches. This thesis employs a combination of approaches as well. Providing a set of contract attributes suitable for all farm types allows including more farmers in the sampling procedure.

Table 6: Required practices when accepting a CF contract

Farm type	Required practices	Extensive	Intensive	Soils	Potential ha/year	Sources
Arable	○ Enhanced crop rotation ○ Cover crops ○ 100 Kg N/ha from cattle manure or compost	Rotations min. 50% cereals	Rotations min. 25% cereals	Clay	0.27 t CO_2	[1],[2], [3], [4]
				Sand	0.7 t CO_2	[1],[2], [3], [4]
				Loam	0.5 t CO_2	[1],[2], [5]
				Loess	0.5 t CO_2	[1], [2], [5]
Peatland	○ Water level is raised by 20 cm ○ Land is available for grazing or mowing	-	-	Peat	8 t CO_2	[1], [6]
Dairy	○ Minimum of 0.3 animals per ha ○ Resting period until 21.05 ○ Organic manure ○ During grass renewal, no tilling is allowed	-	-	Clay	0.27 t CO_2	[1], [3], [4]
				Sand	0.7 t CO_2	[1], [3], [4]

Sources: [1] = Interreg (2020), [2] = Avasiloaiei *et al.* (2023), [3] = Kik (2023), [4] = Matis (2023), [5] = Huang *et al* (2022), [6] =McDonald (2021)

The requirements set for arable farmers are based on the articles of Kik (2023) and Matis (2023). Kik (2023) determined arable farm management practices that reach certain soil health objectives while at the same time maximise profitability of the arable production branch of the farm. Matis (2023) calculated the resulting carbon sequestration for a typical Dutch arable farm applying the optimised strategies identified by Kik (2023). Using the optimized management requirements (enhanced crop rotations with minimum grain shares, the planting of cover crops whenever there are at least six weeks between harvesting a crop and seeding another) found by Kik (2023) allowed to set up contracts meeting the QU.A.L.ITY criteria.

The data of Matis (2023) fulfils the quantification criterium by modelling SOC levels on a farm which is applying the optimized management practices. Matis (2023) then models a farm operating with business-as-usual practices, this serves as the baseline measurement. This way, extra sequestered SOC is calculated.

The additionality criterium is fulfilled by including minimum grain shares or minimum requirements for organic fertilisation, which are not found in the CAP and therefore ensure that measures are additional.

Finally, the sustainability criterium is fulfilled by Kik's (2023) management requirements. These ensure that certain soil health indicators are reached, leading to more sustainable soil management.

The requirements for peatland farmers reflect that peatlands can only sequester carbon when rewetted (Günther *et al.*, 2020; McDonald *et al.*, 2021). The requirements for grassland farmers reflect measures described by McDonald *et al.* (2021), the resting periods are included to achieve sustainability objectives on grassland, in this case the protection of meadow birds. The carbon amount that is expected to be sequestered is based on calculations by Matis (2023) for arable land and depends on soil type (clay and sand). Averages are presented for loam and loess. The amounts presented for grassland are the same as for arable land. The long-term component of the QU.AL.ITY criteria is fulfilled by a contract attribute in the following section.

3.1.2 Contract attributes

The DCE in this survey proposed hypothetical CF contracts that varied along five attributes. These attributes are outlined in Table 7, they are contract attributes that are commonly described to hold potential to promote farmers' uptake of, for example, agri-environmental schemes (Schaub *et al.*, 2023; Schulze *et al.*, 2023).

Table 7: Attributes of the proposed CF contracts

Attribute	**Levels**
Compensation of costs	100%, 75%, 50%, 25%, **0% (SQ)**
Carbon credit (CC) price	€50, €40, €30, €20, €10, **€0 (SQ)** per tonne of CO_2 sequestered.
Contract length	30 years, 20 years, 10 years, **0 years (SQ)**
Option premature termination contract	yes, **no (SQ)**
Support for sustainable soil management	free yearly training on sustainable management, 0,5% discount on all new farm loans, **none (SQ)**

Notes: **SQ** = status quo – the status quo level was exclusively expressed in the third alternative, representing no participation (no carbon farming contract).

The number of attributes included in the experiment is determined by balancing between accurately reflecting real-world conditions and maintaining a manageable level of complexity for the farmers (Adamowicz *et al.*, 1998; Swait & Adamowicz, 2001). Mariel *et al.* (2021) argue that researchers often underestimate how many attributes can be included in a choice experiment before the complexity becomes overwhelming for participants. Therefore, this research uses only five attributes.

Compensation of costs is a proxy for risk sharing and uncertainty (Hudson and Lusk, 2004). Its inclusion serves to reduce the perceived risk associated with entering a CF contract. In DCEs, it is crucial to balance alternatives with the SQ in such a way that actors are equally likely to choose any option (Louviere *et al.*, 2008). Costs of CF practices implementation vary per farm type, therefore *compensation of costs* was expressed in relative terms.

The attribute *CC price* is centred around the current CC price set by Stichting Nationale Koolstofmarkt (2022) at €25 per tonne of sequestered CO_2. This attribute serves as the price attribute which is used to estimate the WTA in section 3.3.5.

CF requires time to take effect. IPCC (2003) estimates that it takes 20 years to reach a new carbon equilibrium. The European Commission (EC) (2021a) aims for long-term carbon storage to be 35 years, for carbon farming on arable land it is indicated that the storage should at least be a decade (EU Regulation 2024/3012). Longer contracts, however, go against the preferences of farmers (see e.g. Greiner, 2015; Ruto and Garrod, 2009; Bougherara & Ducos, 2006). Contract length has been centred around 20 years. This attribute ensures that the long-term storage requirement set by the QU.A.L.ITY criteria is reached.

The *option premature termination contract* in the event of a sale or retirement is considered an important factor in the decision-making process, especially for long-term contracts. Broch and Vedel (2011) highlight the significance of this option in ensuring flexibility for farmers, particularly in situations where they are unable to continue managing the farm.

Free educational training or better access to credit are commonly described to hold the potential to promote the uptake of contracts among farmers (Schaub *et al.*, 2023; Schulze *et al.*, 2023). For example, Rabobank offers carbon farming contracts to Dutch farmers (Rabobank, n.d.) and could easily promote contract acceptance by offering discounts on loans. FrieslandCampina organises trainings (FrieslandCampina, n.d.), and could similarly promote contract acceptance by offering free trainings.

3.1.3 Choice card design

Using a full factorial design, the total number of possible choice sets is $(5^2*3^2*2)*(5^2*3^2*2)$=202.500 (Block *et al.*, 2024). It would be infeasible for farmers to evaluate such a large number of choices. Therefore, a D-efficient design was created using Stata based on Hole (2016). This resulted in a design featuring 21 choice cards. Upon reviewing the design for dominant alternatives, one was identified and removed, reducing the D-efficiency to 95.45%. This level is considered acceptable (Johnson *et al.*, 2013). Each farmer was randomly assigned seven of the remaining 20 choice cards.

Each choice card presented two alternative contracts alongside an opt-out option (status quo). Including the opt-out option is essential to prevent farmers from feeling compelled to choose a contract, ensuring a more realistic and voluntary decision-making process (Hanley *et al.*, 2001). Table 8 shows an example choice card.

Table 8: Example of a choice card (translated from Dutch to English)

Attributes	Alternative 1	Alternative 2	Alternative 3
% compensation of costs	75%	50%	No participation (status quo)
CC price	€20	€10	
Contract length	20 years	10 years	
Option premature termination contract	No	Yes	
Support sustainable soil management	None	Free yearly soil health training	

Source: Author’s own illustration

For coding purposes, the attributes *Cost Compensation*, *CC Price*, and *Contract Length* were linearly coded, while *Option End* and *support for sustainable soil management* were dummy coded. To analyse *Support for sustainable soil management* the variable is split in two separate dummies. The model also includes an alternative-specific constant (ASC), which captures the utility associated with accepting a contract that is not explained by its specific attributes (Soliño and Farizo, 2014). The ASC is coded as a dummy variable, taking the value of one if a contract is chosen and zero if not. To prevent correlation with the ASC, the status quo level for all non-linear attributes varied across the alternatives.

3.1.4 Characteristics and attitudes

Concluding the DCE, farmers were asked to provide information about themselves and their farm. Questions included age, education, acreage and views on climate change and risk. The questions are grounded in scientific literature.

Several factors influence farmers' willingness to accept environmental contracts, as highlighted by Lastra-Bravo et al. (2015) and Sapbamrer & Thammachai (2021). These factors can be grouped into four main categories: demographic and socio-economic characteristics, agricultural and operational conditions, behavioural dispositions, and external support and resources.

The meta-analyses conducted by these two studies examined the factors that increase the likelihood of farmers accepting organic or agri-environmental scheme (AES) contracts. Common positive influences include off-farm employment, pro-environmental attitudes, land ownership, and farm size relative to national averages.

Additionally, Lastra-Bravo et al. (2015) found that education and access to training significantly affect contract acceptance. Meanwhile, Sapbamrer & Thammachai (2021) highlighted the importance of having a successor and prior experience with AES as key factors.

3.1.5 Data collection

Data collection was carried out via an online survey with the software Qualtrics. The survey was distributed by a contracted market research company. When the initial response rate proved insufficient, additional farmers were recruited through alternatives methods, namely articles in agricultural magazines, approaching farmers at agricultural events and door-to-door visits to farms. Farmers were assured of their privacy, and to incentivise participation, a €500 voucher was randomly awarded to one participating farmer. To elicit realistic responses, the survey incorporates the use of cheap talk scripts (Schaak and Mußhoff, 2019).

The survey was initially distributed to 5.000 farmers, resulting in 75 completed responses. The remaining respondents were recruited through the aforementioned methods. Door-to-door farm visits proved to be the most effective approach, resulting in 16 completed interviews. This thesis is based on a preliminary dataset consisting of 94 respondents. The full data set consists of 100 respondents.

3.2 Estimation

This section explores methods for estimating preferences in DCEs, starting with random utility theory (RUT) and progressing through the conditional logit model (CLM), the mixed logit model (MXL), and the latent class model (LCM), highlighting their interconnections and differences.

3.2.1 Random utility theory

The models employed in this thesis are all grounded in RUT, initially proposed by Thurstone (1927). According to RUT, a respondent knows their exact utility, while a researcher is not able to observe this. RUT further assumes that respondents act to maximise their utility by rationally weighing all available options. Preferences that are not directly observable by researchers are captured by the model's stochastic error term.

Respondent utility is dependent on how a respondent values a good or a contract. In the context of this thesis, RUT assumes that a respondent can rationally rank all attributes of a contract, leading to a choice that is optimal for utility maximisation (McFadden, 1973).

RUT assumes that the utility *(U)* is unobservable and consists of an observable part *(V)* and an unobservable error term *(ε)*. For respondent *i*, presented with alternative *j*, utility is modelled as:

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

Where i=1, 2, ..., I, j=1, 2, ..., J and ε_{ij} represents the error term which captures unobserved utility which is not included in V_{ij} (McFadden, 1973). This can be rewritten to:

$$U_{ij} = x_{ij}\beta' + \varepsilon_{ij} \tag{1}$$

Where x_{ij} represents the vector of observable characteristics for alternative *j* presented to actor *i*, and β' represents the parameter estimates quantifying the effects of x_{ij} on utility.

The probability that the actor *i* chooses alternative *j* instead of the alternative *x* is denoted as:

$$
\begin{aligned}
P_{ij} &= P\left(U_{ij} > U_{ix} \; \forall \; x \neq j\right); \qquad \forall \; x \in C \\
P_{ij} &= P\left(V_{ij} + \varepsilon_{ij} > V_{ix} + \varepsilon_{ix} \; \forall \; x \neq j\right); \qquad \forall \; x \in C \\
P_{ij} &= P\left(\varepsilon_{ix} - \varepsilon_{ij} < V_{ij} - V_{ix} \; \forall \; x \neq j\right); \qquad \forall \; x \in C
\end{aligned} \tag{2}
$$

P_{ij} represents the probability that individual *i* chooses alternative *j* from the choice set C. The formulas indicate that the predicted probability of choosing alternative *j* reflects the probability that alternative *j* offers the highest utility among all options in *C* (Train, 2009).

3.2.2 Conditional logit model

The CLM, introduced by McFadden (1974), is widely used in discrete choice analysis. Initially applied to allocation problems, it has since become a standard in socio-economic research (Train, 2009), owing to its relative ease of interpretation (Holmes *et al.*, 2017).

The CLM assumes preference homogeneity, meaning that all error terms ε_{ij} are independently and identically distributed (IID) following a type 1 extreme value distribution. This assumption requires the β-coefficients to be fixed across the entire population (Willis, 2013). This allows for direct calculation of predicted probabilities. Additionally, the CLM assumes independence of irrelevant alternatives (IIA), which implies that the relative probability of choosing between two alternatives remains unaffected by the presence or absence of other alternatives in the choice set (Dougherty, 2016).

The choice probability for actor *i* choosing alternative *j* from choice set C containing *K* alternatives is calculated by the CLM as:

$$
P_{ij} = \frac{\exp\,(V_{ij})}{\Sigma_{x \,\in\, C}\,\exp(V_{ix})}
$$

$$
P_{ij} = \frac{\exp\left(X_{ij}\;\beta'\right)}{\Sigma_{x \,\in\, C}\exp(X_{ix}\;\beta')} \tag{3}
$$

The sum of probabilities in choice set C is equal to 1, reflecting that a respondent must always choose an alternative. Therefore, an increase in utility (V_{ij}) increases the probability (P_{ij}) of choosing alternative *j* (Train, 2009).

3.2.3 Mixed logit model

The MXL addresses a key limitation of the CLM by relaxing the assumption of preference homogeneity (Willis, 2013). Unlike the CLM, the MXL allows for preference heterogeneity by permitting the β-parameters to vary across actors. This flexibility enables the MXL to account for respondent-specific preferences, with each respondent having unique parameter values.

Due to its adaptability, the MXL is highly versatile and capable of accounting for various underlying distributions of preferences within the population (McFadden & Train, 2000). It is solved through simulation and integrates the standard logit probabilities of the CLM over a density of parameters. The MXL probability for respondent *i* choosing alternative *j* is:

$$P_{ij} = \int \frac{\exp(X_{ij}\ \beta')}{\Sigma_{x \in C}\exp(X_{ij}\ \beta')} f(\beta|\theta) d\beta \tag{4}$$

Where $f(\beta|\theta)$ represents the probability density function of the random coefficients β, with θ representing the parameters of this distribution. The integral accounts for the random nature of the coefficients, integrating over the distribution of β, which reflects individual heterogeneity in preferences (Train, 2009). However, it does not allow for identifying homogenous groups within the heterogeneous sample. This limitation is addressed by the second model used in the analysis, the latent class model.

3.2.4 Latent class model

The LCM assumes that the population can be divided into M subgroups, with each subgroup exhibiting homogeneous preferences but differing preferences between the subgroups.

In this context, we modify the CLM to account for these subgroups. It is assumed that a subset of parameters exists, β_m , where β_m represents the specific β-parameter for subgroup m. This modification causes the model to revert to the CLM within each subgroup, as there is no preference heterogeneity within each subgroup. The LCM model can be rewritten as:

$$P_{ij} = \sum_{m=1}^{M} s_m \left(\frac{\exp(X_{ij}\ \beta_m)}{\Sigma_{x \in C}\exp(X_{ix}\ \beta_m)} \right) \tag{5}$$

The β-parameters can take M possible values, denoted β_1, β_2, ..., β_M and the probability that a respondent belongs to subgroup m is given by s_m (Anastassiadis & Mußhoff, 2013).

The LCM also allows for estimation of class membership probabilities based on independent variables, linking actor characteristics to the likelihood of belonging to a specific class m (Eshima, 2022). The class membership probability for actor i belonging to class m follows:

$$P_{im}(\alpha) = \frac{\exp(\alpha'_m\ z_i)}{\Sigma_m \exp(\alpha'_m\ z_i)} \tag{6}$$

Where $P_{im}(\alpha)$ represents the probability that respondent i belongs to class m, α_m represents the vector of parameters associated with class membership for class m, z_i denotes respondent-specific characteristics (Anastassiadis & Mußhoff, 2013).

The appropriate number of subgroups M must be determined exogenously. Various selection methods are suitable. A common approach is to rely on information criteria, which help identify the model that best balances fit and complexity (Zhou *et al.*, 2017). The CAIC and the BIC are widely used for this purpose (see e.g., Anastassiadis & Mußhoff, 2013; Niskanen *et al.*, 2021; Schaak & Mußhoff, 2020). The optimal number of classes is determined by minimising these criteria.

The CAIC is calculated by the following formula:

$$CAIC = 2 \times log(maximized\ liklihood) - K \times \log(N) + K \times \log(\log(N)) \tag{7}$$

Where K is the number of parameters and N is the number of observations (Dean & Raftery, 2009).

The BIC is calculated by the following formula:

$$BIC = 2 \times log(maximized\ liklihood) - K\ \times \log(N) \quad (8)$$

Where K is the number of parameters and N is the number of observations (Dean & Raftery, 2009).

3.2.5 Marginal effect and willingness to accept

The coefficients from the MXL and LCM cannot be directly interpreted in an economic sense (Train, 2009). ME and WTA offer economic interpretations.

ME focuses on the sensitivity of choice probabilities linked to attribute changes. It shows how a one-unit change in an attribute affects the likelihood of choosing a contract, ceteris paribus. The formula for ME is:

$$ME_{ik} = \frac{\delta P_j}{\delta x_k} \quad (9)$$

where ME_{jk} represents the marginal effect of a one-unit change in attribute *k* on the probability of choosing alternative *j*, P_j is the probability of selecting alternative *j*, and x_k denotes the value of attribute *k* for alternative *j* (Friedel *et al.*, 2022).

WTA measures the amount of compensation an actor requires to be indifferent to a change in an attribute level, i.e. no change in overall utility. WTA requires a price attribute to be included in the DCE (Nieboer *et al.*, 2010). WTA in this context refers to the amount of money an actor is willing to accept in exchange for agreeing to changes in specific contract attributes, ceteris paribus.

WTA is calculated by the following formula:

$$WTA_{ik} = \frac{\beta_k}{\beta_{\text{CC price}}} \quad (10)$$

Where β_i represents the estimated coefficient of attribute *i* and $\beta_{\text{CC price}}$ represents the estimated coefficient of the price attribute *carbon credit price* (Louviere & Islam, 2007).

Chapter 4 Results

This chapter discusses the results of the methodology. It starts with an overview of the sample's descriptive statistics, followed by the results of the MXL and LCM.

4.1 Descriptive statistics

Table 9 presents the descriptive statistics of the sampled farmers, comparing them to Dutch national averages.

Table 9: Descriptive statistics of the sample and Dutch population

	Sample average	*Dutch average*
Socioeconomic data		
Number of respondents	94	-
Age	55	58[1]
Higher education	55.3%	14.0%[2]
North Netherlands	12.8%	18.2%[3]
East Netherlands	21.3%	32.8%[3]
West Netherlands	36.2%	24.4%[3]
South Netherlands	29.8%	24.6%[3]
Full-time	81.9%	66.6%[4]
Acceptance CF contract	40.9%	-
Farm characteristics		
Size	90 ha	60 ha[5]
Arable farmers	71.0%	22.6%[6]
(In transition to) organic	6.0%	4.9%[7]
Already implementing CF	56.4%	-
No external funding	17.0%	-
Attitudes		
Climate positive	51.1%	-
Risk seeking	21.3%	-
Soil importance	91.5%	-

Source: Author's own calculations, [1] = AgriDirect (2024), [2] = Energy Shift (2018), [3] = CBS (2024c), [4] = CBS (2020b), [5] = Van Der Meulen (2024), [6] = CBS (2024a), [7] = CBS. (2024b)

The survey was completed 94 times. The average age of respondents is 55, closely aligning with the national average of 58. A significant proportion of the sample has completed higher education (HBO or university), nearly four times the national average. Geographically, the north and south of the Netherlands are reasonably well represented, while the west is overrepresented and the east is underrepresented. The proportion of full-time farmers in the sample is relatively high. Across all respondents, a contract was chosen 40.9% of the time.

The sample includes relatively large farms, with an average size of 90 hectares—50% larger than the national average. The proportion of arable farmers is also significantly higher than the Dutch average, comprising 71% of the sample compared to 22.6% nationally. The share of farms that are classified as organic or in transition to being classified as organic is comparable to the national average, with 6% in the sample versus 4.9% in the general population. 56.4% of the sample is already implementing at least three CF practices on their farm. 17.0% of farmers do not receive any external funding any of the CF practices they are already implementing (funding from, for instance, eco-schemes from the CAP can be applied to some CF practices).

Farmers rated their attitudes using a 5-point Likert scale. A response of 4 or 5 was considered as agreement. Over half (51.1%) of the surveyed farmers agree that climate change is negatively impacting their farm. There is strong consensus (91.5%) on the importance of soil health, with the vast majority agreeing that it is one of the most critical factors in maximising farm profits. In contrast, only 21.3% of farmers classify themselves as risk-seeking.

4.2 Mixed logit model

Table 10 depicts how the average Dutch farmer from our sample perceives accepting a CF contract and how contract attributes and sociodemographic factors influence this decision. The variables have been selected by starting with all possible variables and running this in a CLM. Insignificant variables were dropped from the model systematically. The variables are added to the model as interactions with the ASC. likelihood ratio test showed that this simpler model holds as much predictive power as the full model. The results are based on 658 completed choice sets.

Table 10: MXL results including interactions between variables and ASC

	Coefficient	Std. Error	P-value
Mean			
Compensation of costs	0. 075	0.022	0.001***
Carbon credit price	0.098	0. 031	0.002***
Contract length	-0. 222	0.0612	0.003***
Option premature termination contract[1]	4.778	1.597	<0.001***
0.5% cheaper loans[1]	3.064	1.132	0.007***
Free soil health training[1]	0.671	0.615	0.275
ASC[1]	-14.823	5.727	0.010**
Full-time[1]	-2.021	1.550	0.192
Arable[1]	-0.711	3.326	0.831
Already implementing CF[1]	4.246	1.575	0.007***
No external funding[1]	6.161	2.294	0.007***
Negative impact climate change[1]	6.711	2.644	0.011**
Farm size	-0.040	0.013	0.003***
Standard deviation			
ASC	8.956	3.080	0.004***
Compensation of costs	0.069	0.022	0.002***
Carbon credit price	0.051	0. 024	0.034**
Contract length	-0.241	0.088	0.006***
Option premature termination contract	-1.847	0.578	0.001***
0.5% cheaper loans	3.999	1.330	0.003***
Free soil health training	2.481	1.050	0.018**
Predicted probability	**Prob.**		**Std. Dev.**
Contract acceptance	58.0%		16.7%
Goodness of fit			
McFadden's R-squared	0.320		

*Source: Au*thor's own calculations
Notes: *= significant at 10% level, **=significant at 5% level, ***=significant at 1%, [1] = dummy variable

The MXL does not allow for direct interpretation of the coefficients, only the signs are interpretable (Mariel *et al.*, 2021). The predicted probability of accepting a CF contract for an average farmer in this sample is 58.0%. McFadden's R-squared for this model is 0.320, this signifies a good fit (Louviere *et al.*, 2000).

The estimated *ASC* is negative, which is statistically significant at a 5% level. All, but one, contract attributes included in the DCE have a significant effect on contract acceptance. *Compensation of* *costs*, *CC price*, and the *option for premature termination* all have a positive significant effect at the 1% level. Additionally, the attribute *0.5% cheaper loans* has a positive significant effect at the 5% level. *Free soil health training* has a positive effect but is the only attribute which is not significant. *Contract length* is the only contract attribute which reduces the likelihood of acceptance and is significant at the 5% level.

Farmers *already implementing* at least 3 CF practices, farmers receiving *no external funding* for CF-related practices and farmers who perceive *negative effects of climate change* are more likely to accept a CF contract, all these effects are significant. *Full-time* farmers, *arable* farmers and farmers with a larger *farm size* are less likely to accept a CF contract. Only *farm size* is significant out of the three.

Table 11 shows the ME and WTA based on the MXL model with their standard deviations and variable type.

Table 11: Marginal effects and willingness to accept based on MXL.

Attributes	ME	Std dev	WTA	Variable type (range)
ASC	-	-	€151,94	Dummy (0-1)
Compensation of costs	0.0009	0.0007	-€0,77	Linear (0-100 %)
CC price	0.0012	0.0008	-	Linear (0-50 €)
Contract length	-0.0034	0.0023	€2,27	Linear (10-30 years)
Option premature termination contract	0.0633	0.0424	-€48,57	Dummy (0-1)
0.5% cheaper loans	0.0386	0.0288	-€31,40	Dummy (0-1)
Free soil health training	0.0093	0.0007	-€6,88	Dummy (0-1)

*Source: Au*thor's own calculations

MEs were calculated at mean values of the contract attributes, based on a one-unit increase ceteris paribus. A one percent increase in *compensation of costs* leads to an increased probability of accepting a contract of 0.09%. A €1 increase of *CC price* leads to an increased probability of accepting a contract of 0.12%. A one-year increase of *contract length* leads to a decreased probability of accepting a contract of 0.34%. Including the *option premature termination contract* in the contract leads to an increased probability of accepting a contract of 6.33%. Including *0.5% cheaper loans* increases the probability of accepting a contract with 3.86%. Including *free soil health training* in a contract leads to an increased probability of accepting a contract of 0.93%.

The WTA has been calculated relative to the variable *CC price,* ceteris paribus*.* The *ASC* shows that a farmer would demand an €151,94 higher *CC price* to overcome the negative effects associated with accepting a CF contract by farmers when controlling for the attributes and sociodemographic factors. A farmer would be willing to accept a €0,77 lower *CC price* for a one percent increase in the *compensation of costs* and would demand a €2,27 higher *CC price* for a one-year increase of *contract length*. A farmer would be willing accept a €48,57 lower *CC price* if the *option of premature ending of a contract* is included in the contract. A famer would be willing to accept a €31,40 lower *CC price* if *0.5% cheaper loans* is included in the contract. A farmer would be willing to accept a €6.88 *CC price* if *free soil health training* is included in the contract.

4.3 Latent class analysis

A crucial step in an LCM is selecting the appropriate number of classes. This is typically guided by information criteria, which help identify the model that best balances fit and complexity. The CAIC and the BIC are widely used for this purpose (e.g., Anastassiadis & Mußhoff, 2013; Niskanen *et al.*, 2021; Schaak & Mußhoff, 2020). The optimal number of classes is determined by minimising these criteria. Table 12 presents the CAIC and BIC values for models with two, three, and four latent classes:

Table 12: CAIC and BIC values for three different latent classes.

Information criterion	2 latent classes	3 latent classes	4 latent classes
CAIC	903.14*	941.58	958.75
BIC	885.25*	912.58	918.75

*Source: Au*thor's own calculations
*= significant at 10% level, **=significant at 5% level, ***=significant at 1%

Both the CAIC and BIC indicate that a two-class model is optimal, as it yields the lowest values for both criteria. Beyond two classes, the model fit does not improve sufficiently to justify the added complexity.

Table 13 presents the LCM results with two classes. The model structure and variable selection are identical to those in the MXL model.

Table 13: LCM with two latent classes

	Class 1		Class 2	
Attributes	**Mean (SE)**	**P-value**	**Mean (SE)**	**P-value**
ASC	-7.861 (1.562)	<0.001***	-1.091 (0.446)	0.015**
Compensation of costs	0.043 (0.008)	<0.001***	0.018 (0.003)	<0.001***
CC price	0.033 (0.020)	0.103	0.031 (0.007)	<0.001***
Contract length	-0.055 (0.032)	0.087*	-0.059 (0.012)	<0.001***
Option premature termination contract	2.667 (0.691)	<0.001***	1.232 (0.180)	<0.001***
0.5% cheaper loans	0.475 (0.658)	0.471	0.905 (0.257)	<0.001***
Free soil health training	0.090(0.679)	0.895	0.414(0.234)	0.077*
Class membership	**Mean (SE)**	**P-value**	**Mean (SE)**	**P-value**
Full-time	1.034 (0.617)	0.094*	0.000	0.000
Arable	-11.990 (209.743)	0.954	0.000	0.000
Already implementing CF	-1.284 (0.573)	0.025**	0.000	0.000
No external funding	-1.690 (0.788)	0.032**	0.000	0.000
Negative impact climate change	-0.733 (0.493)	0.137	0.000	0.000
Farm size	.0054 (0.004)	0.212	0.000	0.000
Class shares	**Class 1**		**Class 2**	
Share in %	57%		43%	
Predicted probability	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
Contract acceptance	9.9%	10.9%	81.6%	8.5%

*Source: Au*thor's own calculations
Notes: *= significant at 10% level, **=significant at 5% level, ***=significant at 1%

For the LCM model, the focus is on differences between classes. For class 1, the predicted probability for accepting a contract is 9.9%. 57% of our sample belongs to this group. The *ASC* and *contract length* have a negative effect on contract acceptance, *compensation of costs, CC price, premature termination, 0.5% cheaper loans* and *free soil health training* have a positive effect on contract acceptance. The contract attributes *ASC*, *compensation of costs* and *option of premature termination* are significant at the 1% level. *Contract length* is only significant at the 10% level, while *CC price, 0.5% cheaper loans* and *free soil health training* are not significant.

For class 2, the predicted probability for accepting a contract is 81.6%. 43% of our sample belongs to this group. The *ASC* and *contract length* have a negative effect on contract acceptance, *compensation of costs, CC price, premature termination, 0.5% cheaper loans* and *free soil health training* have a positive effect on contract acceptance. All contract attributes are significant at the 1% level except the *ASC* and *free soil health training*, which are significant at the 5% level and 10% level, respectively.

The class membership categorises farmers into distinct groups based on their sociodemographic characteristics. Class 2 serves as the reference group for comparison to class 1. *Full-time* farmers and farmers with larger *farm size* are more likely to belong to class 1. *Arable* farmers, farmers *already implementing* at least three CF practices, farmers receiving no *external funding* and farmers who perceive *negative effects of climate change* are less likely to belong to class 1. Only farmers *already implementing* at least three CF practices and farmers receiving *no external funding* are significant at the 5% level.

Table 14 shows the WTA for the two classes. The LCM model does not allow for calculations of ME, but it does allow for testing the significance of the WTA estimates.

Table 14: LCM WTA estimates for class 1 and class 2

Attributes	WTA Class 1	P-value	WTA Class 2	P-value
ASC	€235,55	0.045**	€35,06	0.004***
Compensation of costs	-€1,28	0.080*	-€0,59	<0.001***
Contract length	€1,65	0.162	€1,89	<0.001***
Option premature termination contract[1]	-€79,95	0.125	-€39,60	<0.001***
0.5% cheaper loans	-€14,23	0.333	-€29,09	0.002***
Free soil health training	-€2,68	0.889	-€13,06	0.088*

*Source: Au*thor's own calculations
Notes: *= significant at 10% level, **=significant at 5% level, ***=significant at 1%

The WTA of the *ASC* for class 1 is €235,55, whereas class 2 is significantly lower with a WTA of €35,06. Both effects are significant at a 5% level, and class 2 even at a 1% level. Farmers in class 1 are willing to give up double the *CC price* for an increase in the compensation by one percentage point (-€1,28 vs. -€0,59). Furthermore, farmers in class 1 prefer a 1% increase of *compensation of costs* over a €1 increase in *CC price*, while class 2 does not. Class 1's effect, however, is only significant at the 10% level. Both classes prefer shorter contracts, as indicated by the positive WTA values (€1,65 vs €1,89). However, the strength of this preference differs. For class 2, *contract length* is at the 1% level. For class 1, the effect is only significant at the 10% level. The *option premature termination contract* is valued much more highly by class 1 compared to class 2 (-€79,95 vs. -€39,60), class 1 would accept almost a twice as big decrease in *CC price* compared to class 2 to keep the option. Again, however, this evidence holds only at the 10% while the effect for class 2 is significant at the 1% level. Class 1 assigns a much lower value to *0.5% cheaper loans* compared to class 2 (-€14,23 vs. -€29,09). Only the effect of class 2 is significant. Framers in class 2 values are willing to give up almost five times as much *CC price* to include *free soil health training.* This effect is only significant for class 2 at the 10% level.

Chapter 5 Discussion

5.1 Results

This thesis aimed to gain insight into farmers' preferences related to CF contracts that fulfil the QU.A.L.ITY criteria. This was achieved by estimating an MXL, an LCM and their respective predicted probabilities, ME and WTA.

5.1.1 MXL

The predicted probability calculated by the MXL for the average Dutch farmer is 58.0%. On average, a farmer in our sample accepts a CF contract. This is an indication that farmers view the combination of the requirements of the QU.A.L.ITY criteria together with the contract attributes cautiously positive. This is somewhat in line with Thiermann *et al.* (2023). The authors find a predicted probability to join a result-based AES scheme of 75%. Thiermann *et al.* (2023) use a maximum contract length of 10 years and payments per ha per year which with a maximum of €1200, excluding bonusses. 10 years is the minimum contract length used in this research and payments per ha per year do not get close to reaching €1200. Shorter contract lengths and higher payments lead to higher acceptance rates in this research. The 27% gap in predicted probabilities could be explained by the more attractive contract attribute levels.

The MXL attributes show that all, but one, contract attributes have a significant effect on CF contract acceptance. Only *free soil health training* does not have a significant effect.

First, the estimated *ASC* is negative and significant at a 5% level, with a WTA of -€151,94. This indicates that, on average, farmers in this sample have a negative perception of accepting a CF contract when controlling for contract attributes and sociodemographic factors. This is in line with the literature, environmental contracts are generally perceived negatively, as indicated by the negative *ASCs* reported in previous studies (see e.g. Block *et al.*, 2024; Lienhoop and Brouwer, 2015; Greiner, 2015). Compared to the literature, the WTA of the *ASC* is very high. This could be because farmers judge the QU.A.L.ITY criteria as too restrictive.

Second, farmers value financial security. Both financial attributes *compensation of costs* and *CC price* are highly significant at the 1% level. The ME of *compensation of costs* is 0.09% and the ME of *CC price* is 0.12%. This seems low, however if we extrapolate to the whole range (0%-100% and €10-€50), the MEs are 9.0% and 4.8%, respectively. This is higher than all dummy contract attributes. The literature consistently emphasises that farmers prioritise financial security (see e.g. Lienhoop and Brouwer, 2014; Christensen *et al.*, 2011). A possible explanation for the smaller effects of *CC price* is the low amounts of CC a farmer would be expected to sequester, between 0.27 CC per ha and 0.7 CC per ha, excluding peatland farmers. The difference between a €25 *CC price* and €50 *CC price* is €6,75 per ha and €17,50 per year per ha. The average added value per ha per year for Dutch farm lays between €1.700 and €2000 (Silvis & Voskuilen, 2021). Increasing *CC price* does not make a significant contribution to this. Farmers commented on the comparatively small effects of CC during in-person interviews.

Third, contractual flexibility is highly valued. *Contract length* has a significant and negative effect on contract acceptance, indicating that farmers prefer shorter contracts. The ME and WTA are -0.34% and €2,27, respectively. Mamine *et al.* (2020) show in their meta-analysis that contract duration is mostly viewed negatively in the literature. The *option for premature termination* is positive and significant, with ME and WTA values of 6.3% and -€48,57, respectively. The option is the most appreciated of all the dummy contract attributes. Broch and Vedel (2011) find a high appreciation of a termination clause as well.

Finally, for the *support for sustainable soil management* contract attribute, only the *0.5% cheaper loans* option is significant. The ME and WTA are 3.9% and -€31,40, respectively. In their meta-analysis, Schulze *et al.* (2023) show that supplying cheaper credit has a positive effect on agri-environmental contract acceptance. It must be noted that all studies used for this finding are conducted in countries not as technologically advanced as the Netherlands. *Free soil health training* did not have a significant effect, while Schulze *et al.* (2023) show that training and technical assistance are viewed positively in their analysis. Again, these results are found in countries less technologically advanced countries. A possible explanation is that farmers in the sample see themselves as experts on soil health. 92% of our sample viewed soil health as (very) important to their farming operations. In the in-person interviews, many farmers indicated that they consider themselves knowledgeable about soil and that they did not find the option attractive.

As the WTA values are calculated from the ratio of the coefficients, it allows for comparisons between the strength of the contract attributes. To illustrate the highly negative perception of CF contract acceptance (indicated by the negative *ASC*), a 100% increase in *compensation of costs* would lead to farmers accepting a decrease of €77 in *CC price*. Overcoming the negative perception (€151,94) of farmers is very costly, as it requires an increase of twice the maximum range of *compensation of costs*.

The WTA of *compensation of costs* is -€0,77. This means that the average farmer prefers a 1% increase *compensation of costs* over a €1 increase in *CC price*. The literature shows that farmers are often risk-averse (see e.g. Woods et al., 2017; Dessart et al., 2019). This is in line with the findings of this study.

A 20-year increase in *contract length* would lead to farmers demanding an increase of €45,40 in *CC price*. This is comparable with the WTA of *option premature termination contract*. By including this option, contracting parties can stimulate longer contracts and save money while doing so.

Including the option *0.5% cheaper loans* is attractive for contracting parties. A farmer would be willing to accept a contract with a lower *CC price* of €31,40. Average planned investment for European farmers is €170.000 (Marianne *et al.*, 2014). If we take a hypothetical interest rate of 5% and apply the discount of 0.5%, this will leave a farmer with €850 lower interest fees per year. If an average farmer sequesters 27 tonnes of CO_2 per year, this will save contracting parties €847,80. In this example, including the option *0.5% cheaper loans* will save contracting parties money and stimulate contract acceptance, if a farmer sequesters more than 27 CC.

The MXL show that the following farm and farmer characteristics significantly affect CF contract acceptance. If a farmer is *already implementing* at least three CF practices, if they receive *no external funding* for these CF practices and if a farmer perceives that *climate change has a negative impact* on farm operations, they are more likely to accept a CF contract. These effects follow logically and are confirmed in the meta-analysis of Schulze *et al.* (2023).

Full-time farmers as well as *farm size* decreases contract acceptance significantly. *Full-time* farmers and farmers with a larger *farm size* are more likely to be intensive in the Netherlands (Bos *et al.*, 2013). CF signifies a shift to more extensive farm operations (Lal, 2016). *Full-time* farmers as well as farms with a larger *farm size* are thus more likely to face higher opportunity costs for implementing CF, leading to a negative effect on contract acceptance.

Interestingly, *arable* farmers are not significantly less likely to accept CF contracts. Contrastingly, Thiermann *et al.* (2023) find that *arable* farmers are more likely to accept. In contrast to dairy farmers, *arable* farmers had to enrol their whole farm when accepting a CF contract. Evidently, this has not affected *arable* farmers that much. This is possibly due to the fact that farmers forgot the QU.A.L.ITY requirements. During the in-person interviews, farmers often had to be reminded of the requirements associated with accepting a contract.

An examination of the standard deviations of our MXL reveals that all the coefficients of the attributes are significant at the 1% level. The exceptions are *CC price* and *free soil health training* which are significant at the 5% level. The significance of these standard deviations indicates the presence of substantial preference heterogeneity among respondents in the sample. The standard deviation of the predicted probability also suggests that there is significant price heterogeneity. The LCM can handle heterogeneity (Mariel *et al.,* 2021). Barnes and Toma (2012) and Hyland *et al.* (2015) provide qualitative classifications of different farmer types, Block *et al.* (2024) offer quantitative evidence of variations in preferences among farmer groups. Therefore, the choice for running an LCM is justified.

5.1.2 LCM

The LCM indicated that there are 2 latent classes in our group. Class 1 farmers exhibit a strong negative perception of accepting CF contracts when controlling for contract attributes and sociodemographic characteristics. They require higher *compensation of costs* and prefer a shorter *contract length*, emphasising their preference for financial security. They place a higher value on flexibility as well, as the WTA for *premature termination contract* is twice as high. Interestingly, *CC price* is not significant for this group, while *compensation of costs* is significant at the 1% level. Farmers of this group thus prefer the financial stability of *compensation of costs* over extra potential income *CC price.* The predicted probability of accepting a contract is only 9.9%. A suitable label for class 1 farmers is 'risk-averse sceptics'. These farmers demand substantial financial compensation and security before considering participation in CF contracts. 57% of our sample falls into the group 'risk-averse sceptics'. Finding a generally negative group occurs often in environmental DCEs (see e.g. Anastassiadis & Mußhoff, 2013; Niskanen *et al.*, 2020).

Class 2 farmers perceive accepting a CF contract negatively when controlling for contract attributes and sociodemographic characteristics, however much less so than class 1 farmers. Looking at the WTA, they require significantly less money than class 1 farmers to overcome their negative perception, suggesting a more positive perception of CF contracts under the QU.A.L.LITY criteria. Class 2 famers also value shorter *contract length* and the *option premature termination*, but less than class 1 farmers*.* They value *support for sustainable soil management* higher, but only *0.5% cheaper loans* is significant. All the contract attributes, but one, have significant effects, signalling that their negative perception of CF contracts is surmountable by correctly specified attributes. Interestingly, class 2 farmers value a €1 increase of *CC price* higher than a 1% increase in *compensation of costs.* Class 2 farmers seem to place higher trust in the feasibility of CC. The predicted probability of accepting a contract is 81.6%. A suitable label for class 2 farmers is 'pragmatic adopters'. They are more willing to engage with CF contracts, yet their participation remains predominantly driven by financial benefits rather than ideological beliefs. 43% of our sample belongs to the group 'pragmatic adopters'. Finding a generally positive group occurs often in environmental DCEs (see e.g. Anastassiadis & Mußhoff, 2013; Niskanen *et al.*, 2020).

The class membership probability of belonging to class 1 is significantly and negatively affected by the characteristics *already implementing* at least three CF practices and *not receiving external funding* for already implemented CF methods. This is in line with the results of the MXL. The characteristics *full-time, farm size* and *negative impact climate change* do not significantly affect class membership, where for the MXL it did have a significant effect on CF contract acceptance.

Robustness of results can be checked by carrying out different models on the same data (Rigby *et al.*, 2015). Running both the MXL and LCM serves as robustness check by examining whether findings remain consistent across varying model specifications. As the LCM found two latent classes, logically, the MXL results should fall between the LCM estimates. The predicted probability of 58% falls between the predicted probabilities of the LCM of 9.9% and 81.6%. The MXL and LCM estimates cannot directly be compared, so we use the WTA values. Four out of six MXL WTAs fall in between the two LCM WTAs. Only *contract length* and *0.5% cheaper loans* do not fall in between the LCM WTAs. However, if we look at the 95% confidence intervals of the MXL and LCM results, the estimates overlap. The results indicate robust results. However, for a definitive answer future research is needed based on different data and models.

5.2 Limitations

5.2.1 Limitations of DCE

While DCEs provide valuable insights, they also have inherent limitations. As a stated preference method, DCE results must be interpreted cautiously, as respondents may behave differently when faced with real-world decisions (Train, 2009). To combat this, this DCE was designed to mimic reality as closely as possible. However, complexity can pose problems to respondents. Respondents might struggle to process all presented information and attributes, necessitating simplifications (Mariel *et al.,* 2021). Both issues can lead to over- or underestimation of effects. DCEs face a trade-off between realism and comprehensibility.

Furthermore, to obtain a sufficiently large sample size, it was decided to include all types of farmers in this research. There was no distinction made between respondents when filling out the choice cards, which means that the choice cards were drawn out of the same group. As the QU.A.L.ITY criteria mean different requirements per farm type, the requirements behind the choice cards also differ by farm type. Results therefore contain choice sets with very different requirements behind them. Future research should test the findings of this work by focusing on only one farmer type.

This DCEs design was based on a literature review and was built on previous results of Kik (2023) and Matis (2023). While this does provide a good basis, it was not checked with a focus group. It is recommended to carry out between two and eight focus groups (Mariel *et al.,* 2021). Future research should implement the use of focus groups to improve the design of the DCE.

5.2.2 Limitations of this research

This thesis is based on a sample size of 94 Dutch farmers, which is relatively small for an MXL and especially for an LCM. Sinha *et al.* (2020) state that LCM with sample sizes under 100 respondents are at high risk of misestimation. The small sample size affects the interpretation of results. While the study provides insights into the views of farmers from the sample, it may not fully reflect the true Dutch farmers' willingness to accept CF contracts based on the QU.A.L.ITY criteria.

LCM used for environmental DCEs often find more than two classes (see e.g. Schaak & Musshoff, 2019; Schulz *et al*., 2013). Deciding the number of classes is dependent on sample size, large sample sizes allow for easier distinctions between classes and smaller sample sizes may lead to overfitting (Nylund *et al.,* 2007). Policy recommendations based on class segmentation should be treated with caution, as additional classes could exist with distinct preferences that were not captured.

Several factors may explain the low response rate to this study. One possibility is survey fatigue, as farmers reported receiving many survey invitations each month during in-person interviews. Additionally, those who do respond may be particularly motivated or demotivated by CF schemes, which could affect the representativeness of the sample.

Another contributing factor could be that many respondents were already familiar with CF and its potential. Most farmers indicated they had heard of CF during the in-person interviews.

Combined with the negative perception of CF reflected in the ASC, this suggest that it is possible that the low response rate stems from a lack of belief in the feasibility of CF among farmers. Some, but not all, farmers also indicated this during the in-person interviews.

During the in-person interviews, respondents judged the attribute *compensation of costs* as abstract, as it represents a percentage of an unknown absolute value, potentially leading to undervaluation of the attribute. With *option premature termination contract,* farmers frequently needed reminders that termination was only possible under specific conditions, potentially leading to overvaluation of the attribute. *Free soil health training* was often disregarded, as respondents did not find it sufficiently appealing. Additionally, some farmers viewed the contract requirements as too demanding and the financial compensation as inadequate, rejecting all contract options outright. This made it challenging to distinguish protest responses. Protest responses are given by respondents who refuse to reveal their true preference for any reason (Villanueva *et al.*, 2017). A respondent who disagrees with the QU.A.L.ITY criteria can look very similar to a respondent giving a protest response. To ensure data quality, all responses with a completion time of less than five minutes were reviewed and deleted if necessary. Due to difficulty of interpretation, the variables *compensation of costs* and *option premature termination contract* could be subject to biased estimates.

While this thesis provides valuable insights into farmer preferences for CF contracts, the limitations suggest that findings should be viewed as indicative rather than definitive. Future research with larger samples would strengthen the robustness of the findings. Additionally, a revealed-preference experiment, involving a real-world pilot, would provide a valuable comparison to the stated-preference methods used in this study. Another possibility for future research could explore the implications of different contracting parties and payment types in CF contracts, specifically investigating whether farmers prefer engaging with the EU, national governments or private companies, as well as whether they prefer action-, result-based or hybrid payments for CF schemes. Finally, doing research on the preferences of peatland farmers could be very valuable. Peatland farmers have by far the highest potential to sequester carbon of all Dutch farmer types. Applying CF on their land does imply that the traditional farming business model is no longer viable. This research only has one peatland farmer in its sample.

5.3 Policy recommendations

Targeting the right farmers is essential for the success of CF policies. Small-scale farmers, farmers already implementing at least three CF measures, part-time farmers and farmers who believe climate change negatively affects their farm are more likely to accept CF contracts and should be the primary focus, as well as farmers belonging to the 'pragmatic adopter' class.

Policymakers should prioritize financial security and contractual flexibility when designing CF contracts, as these factors are critical to farmers. Introducing minimum per-hectare payments can enhance financial stability while still incentivizing maximum carbon sequestration. This is a form of hybrid payments.

Contractual flexibility can be incorporated through an *option premature termination contract*, enabling longer contract durations. Termination requirements should be explicitly defined and clearly communicated.

Given the heterogeneity in farmer preferences, introducing negotiable contract elements could further increase acceptance. Allowing flexibility in key attributes, such as compensation structures and termination clauses, ensures contracts align with diverse farmer needs, improving participation rates.

To address the negative perception of CF contracts among farmers, policymakers should highlight successful farms implementing CF to build trust and demonstrate feasibility.

Chapter 6 Conclusion

In the EUs fight against climate change, carbon farming has come up as a solution. Carbon farming allows agricultural soils to take up and hold more carbon. This combats climate change as well as increases soil health. Carbon farming schemes have arisen to finance farmers who partake in carbon farming. Farmer voluntarily apply carbon farming practices, and they are renumerated for their sequestration efforts. To legitimise carbon farming schemes as a business model and to minimise the risk of greenwashing the EU has proposed the QU.A.L.ITY criteria.

This thesis aimed to assess Dutch farmers' preferences for CF contracts based on the QU.A.L.ITY criteria. A discrete choice experiment proposed hypothetical contracts to Dutch farmers. The contracts consisted of the following attributes: shared costs, carbon credit price, contract length, option for premature termination of contract and support for sustainable soil management. Each farmer was shown seven choice cards, with varying levels for the contract attributes. The sample consists of 94 Dutch arable, diary and peatland farmers. An MXL and an LCM were run.

The results of the MXL show that average probability of farmers accepting such a contract is 58.0%. Respondents are cautiously optimistic about the proposed contracts. When controlling for all contract attributes, farmers have a negative perception of carbon farming. Contract attributes that positively affect contract acceptance are (1) a higher percentage of compensated costs (2) a higher carbon credit price (3) a shorter contract duration (4) the option to prematurely terminate the contract (5) a 0.5% discount on interest of future loans. The results of the LCM showed two latent groups in our sample. The first group, labelled 'risk-averse sceptics', has a predicted probability of accepting a contract of 9.9%. The second group, labelled 'pragmatic adopters', has a predicted probability of accepting a contract of 81.6%.

Policy makers should focus on finding farmers already applying at least three carbon farming practices, farmers receiving no external funding for these practices, small-scale farms, farmers who view the effect of climate change as negative and farmers in the pragmatic adopter class.

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Appendix A: Survey

A translated version can be supplied by the author.

Introduction

Beste boer/ boerin,

Bodemgezondheid krijgt steeds meer aandacht in de politiek. Gezonde bodems zijn van vitaal belang voor diverse aspecten zoals productiviteit, waterbeheer en biodiversiteit. Bovendien spelen ze een cruciale rol bij het vastleggen van CO2, wat van essentieel belang is voor het bestrijden van klimaatverandering.

In dit experiment onderzoeken we verschillende financieringsmogelijkheden om de bodemgezondheid te verbeteren, waaronder natuurbeschermingscontracten via het ANLb en de koolstoflandbouw (carbon farming).

Uw deelname aan dit onderzoek is van grote waarde - **Door uw inbreng kunnen we beter begrijpen hoe dergelijke initiatieven het beste kunnen worden georganiseerd en welke financieringsmogelijkheden het meest aantrekkelijk zijn.**

Het invullen van de vragenlijst neemt ongeveer 20 minuten in beslag en uw anonimiteit wordt volledig gewaarborgd. **Als blijk van waardering wordt onder alle deelnemers een cadeaubon ter waarde van € 500 verloot.**

Doe mee en help mee om een positieve verandering in gang te zetten voor onze bodems en het klimaat.

Met vriendelijke groet,

Insa Thiermann (insa.thiermann@wur.nl) & Liesbeth Dries (liesbeth.dries@wur.nl)

1. Heeft u de informatie over gegevensbescherming gelezen en begrepen, en stemt u in met deelname?
   - ○ Ja, ik heb het gelezen en ga akkoord
   - ○ Nee, ik heb het gelezen en ga niet akkoord

Explanation experiment

Stelt u zich voor dat u benaderd wordt om deel te nemen aan een contract dat tot doel heeft de bodemgezondheid te bevorderen en de CO2 in de atmosfeer te verminderen. Dit zal bereikt worden door uw landbouwbedrijf te beheren met de focus op bodemgezondheid.

De maatregelen die u moet nemen als u voor een hypothetisch contract kiest, hangen af van het overheersend bodemtype van uw bedrijf en de teeltintensiteit op het akkerland (intensieve - gewasrotatie omvat ook uien, wortelen, aardappelen, suikerbiet enz., extensieve - gewasrotatie omvat eerder standaard akkerbouwgewassen).

Het contract voorziet in de volgende maatregelen:

1. **Uitgebreidere vruchtwisseling -** Om deel te nemen moet je **minstens 50% granen verbouwen op je land** (dit is inclusief maïs) - twee opeenvolgende teelten van wintergerst zijn niet toegestaan.
2. Je moet **tussengewassen telen** op al je percelen verbouwen als er nog minstens acht weken over zijn voor de volgende uitzaai.
3. **Minimaal 100 kg N/ha moet afkomstig zijn van dierlijke mest of compost voor het hele bedrijf.** De dierlijke mest moet vaste of vloeibare **rundermest** zijn.

Simulaties waarin bovenstaande maatregelen werden ingevoerd, laten zien dat landbouwbedrijven die deze maatregelen nemen, hun winstgevendheid op de lange termijn aanzienlijk kunnen verbeteren. Dit komt door besparingen op minerale meststoffen en stabielere opbrengsten.

Nieuw is dat boeren de mogelijkheid krijgen om zogenaamde **koolstofkredieten te verkopen.** Eén koolstofkrediet staat voor de besparing van één ton CO_2. Wanneer de maatregelen worden uitgevoerd, wordt CO_2 opgeslagen.

Uit simulaties blijkt dat er totaal **ongeveer 0.5 ton CO_2/ha/jaar kan worden bespaard.** De huidige prijs voor een koolstofkrediet bedraagt € 25/ton, dit zou leiden tot een **vergoeding van €12.25 per hectare/jaar**.

De aangeboden hypothetische contracten verschillen op vijf punten van elkaar:

1: % compensatie kosten: 0%, 25%, 50%, 75%, 100%
Bodemgezondheidspraktijken leiden initieel tot extra kosten maar betalen zich terug op lange termijn. Op deze basis werden in een aantal gevallen de kosten volledig of gedeeltelijk vergoed. De extra kosten worden jaarlijks bepaald voor elk individueel bedrijf. Een aandeel van 0% betekent dat het initiatief geen vaste, jaarlijkse compensatie van de extra kosten biedt. Een aandeel van 100% betekent dat het initiatief volledige compensatie biedt.

Zo worden bijvoorbeeld gedeeltelijk terugbetaald: extra kosten voor het aanpassen van de vruchtwisseling, zaad voor tussengewassen, kosten voor de aankoop van organische meststoffen, verliezen door aanvankelijke opbrengstvermindering, enz.

2 Koolstofkrediet Prijs: €10 per ton, €20 per ton, €30 per ton, €40 per ton, €50 per ton

Dit is de prijs die u voor uw verkochte koolstofkredieten zal ontvangen. De prijs is bepaald per ton opgeslagen CO_2 (één koolstofkrediet = één ton CO_2). De prijzen vertegenwoordigen verschillende denkbare prijsniveaus voor de toekomst.

3 Contractduur: 10 jaar, 20 jaar, 30 jaar

Dit is de lengte van het contract. Gedurende deze periode moeten alle managementvoorwaarden gevolgd worden.

4 Optie beëindiging: ja, nee

Sommige contracten bevatten een speciaal annuleringsrecht: als u uw bedrijf binnen de contracttermijn doorgeeft of verkoopt, hebt u de mogelijkheid om het contract op te zeggen.

5 Steun duurzaam bodembeheer: geen, jaarlijkse opleiding over duurzaam beheer, -0,5% korting op nieuwe leningen voor de boerderij

Sommige bestaande initiatieven voor koolstoflandbouw bieden opleidingen aan en gesubsidieerde leningen zouden ook een manier kunnen zijn om deelname te stimuleren. Daarom omvatten sommige contracten opleiding en lagere rentevoeten.

Aangezien uw keuzes invloed kunnen hebben op politieke beslissingen, vragen we u om uw keuzes in het experiment zo realistisch mogelijk te maken.

Voor het experiment is het belangrijk dat u elk van de keuzes apart van elkaar beschouwt.

In totaal wordt u zeven keer gevraagd om te kiezen tussen verschillende contracten.

Experiment

	Alternatief 1	Alternatief 2	Alternatief 3
% compensatie kosten	75%	50%	Geen deelname
Koolstofkrediet prijs	20 €	10 €	
Contractduur	20 jaar	10 jaar	
Optie beëindiging	Nee	Ja	
Steun duurzaam beheer	Geen	Training	

CS1

Koolstofopslag & vergoeding
Leem: 0.5 ton/ha/jaar * €25 (huidige prijs) = € 12.25 ha/jaar
Löss: 0.5 ton/ha/jaar * €25 (huidige prijs) = € 12.25 ha/jaar
Klei: 0.27 ton/ha/jaar * €25 (huidige prijs) = € 6.75 ha/jaar
Zand: 0.7 ton/ha/jaar * €25 (huidige prijs) = € 17.5 ha/jaar
Veen: 8 ton/ha/jaar * €25 (huidige prijs) = € 200 ha/jaar

Welk alternatief zou u kiezen?

- Alternatief 1
- Alternatief 2
- Alternatief 3 – geen deelname

(this is repeated 6 more times)

Follow up survey

U bent bijna klaar. Nog enkele algemene vragen en stellingen over uzelf en uw boerderij en opvattingen betreffende actuele problemen en wetgeving.

10. In welk jaar bent u geboren (jjjj)?
11. Wat is uw hoogst behaalde onderwijsniveau?
12. In welke provincie is uw bedrijf gevestigd?
13. Mijn boerderij is mijn…
    - Primaire inkomstenbron (fulltime)
    - Secundaire inkomstenbron (parttime)
14. Ik beheer mijn boerderij...
    - Conventioneel
    - Biologisch/in transitie
15. Hoeveel hectare grond bewerkt u? Hoeveel akkerland en hoeveel grasland
16. Welk deel van uw land is in bezit en welk deel huurt u?
17. Welk deel (%) van uw vruchtwisseling bestaat uit granen (inclusief maïs)?
18. Hoeveel kg N/ha haalt u gemiddeld uit dierlijke meststoffen?
19. Kies alstublieft de sectoren waarin u actief bent
    - Veeteelt
    - Varkenshouderij
    - Pluimveehouderij
    - Akkerbouw
    - Anders, namelijk…
20. Wat zal er de komende tien jaar met uw bedrijf gebeuren?
    - Ik zal het zelf beheren
    - Het gaat over op een opvolger in de familie
    - Het wordt opgegeven (verkocht, geleased)
    - Ik weet het niet
21. Heeft u al technieken in gebruik die de bodemkwaliteit ten goede komen en die boven het wettelijk minimum liggen (Selecteer a.u.b.)?
    - Minder/geen grondbewerking (no-till, strip-till)Varkenshouderij
    - Omzetting van akkerland naar grasland
    - Integratie van extra bedekkingsgewassen
    - Begrazing op grasland
    - Gebruik van bodemverbeteraars (bijv. biochar)
    - Gebruik van machines bijv. met lagere bandenspanning
    - Aanplanting van extra houtachtige elementen (laatste tien jaar)
    - Door over te schakelen op biologische landbouw (laatste tien jaar)
    - Door gebruik van bredere vruchtwisseling
    - Andere, namelijk…
22. Welke technieken zijn volgens u het meest geschikt om de bodemgezondheid te verbeteren?
    - Minder/geen grondbewerking (no-till, strip-till)Varkenshouderij
    - Omzetting van akkerland naar grasland
    - Integratie van extra bedekkingsgewassen
    - Begrazing op grasland
    - Gebruik van bodemverbeteraars (bijv. biochar)
    - Gebruik van machines bijv. met lagere bandenspanning
    - Aanplanting van extra houtachtige elementen (laatste tien jaar)
    - Door over te schakelen op biologische landbouw (laatste tien jaar)
    - Door gebruik van bredere vruchtwisseling
    - Andere, namelijk…
23. Hoe hebt u deze maatregelen gefinancierd?
    - Overheidssubsidies
    - Natuurbeschermingscontracten met partners in de waardeketen (bijvoorbeeld van Friesland Campina)
    - Andere private natuurbeschermingscontracten (natuurbeschermingscertificaten)
    - Initiatieven voor koolstofboeren (bijv. ZLTO, Rabobank)

- Uit eigen middelen
- Geen maatregelen
- Andere, namelijk…

24. Volgt u in uw vrije tijd trainingen over agrarische technieken en bodemgezondheid?
    - Ja
    - Nee
25. Bent u het eens of oneens met de volgende stelling? Klimaatverandering heeft een negatieve impact op mijn boerderij
    - Ik ben het er helemaal niet mee eens
    - Ik ben het er niet mee eens
    - Neutraal
    - Ik ben het er mee eens
    - Ik ben het er helemaal mee eens
26. Bent u het eens of oneens met de volgende stelling? Bodemgezondheid is één van de belangrijkste factoren als het gaat om de productiviteit van mijn bedrijf.
    - Ik ben het er helemaal niet mee eens
    - Ik ben het er niet mee eens
    - Neutraal
    - Ik ben het er mee eens
    - Ik ben het er helemaal mee eens
27. Bent u het eens of oneens met de volgende stelling? Om mijn winst te maximaliseren, neem ik meer risico's dan andere landbouwers.
    - Ik ben het er helemaal niet mee eens
    - Ik ben het er niet mee eens
    - Neutraal
    - Ik ben het er mee eens
    - Ik ben het er helemaal mee eens

28 (Only shown to dairy farmers) Laatste vraag - Als u heeft gekozen om deel te nemen aan ten minste één hypothetisch contract. Hoeveel hectare zou u willen inbrengen?

Hartelijk dank! Om kans te maken op de voucher van €500, klik op de volgende link en vul uw email in:

E-Mail

Ook hier zal uw anonimiteit gewaarborgd worden. Uw antwoorden kunnen niet aan uw email adres worden gelinkt, uw emailadres zal alleen worden gebruikt voor het verloten van de voucher.

Appendix B: Stata code

This appendix contains all the code used in this thesis, including data preparation, implementation of the MXL and LCM models, and calculations for their respective WTA, ME, and predicted probabilities. The code is written for Stata, with explanations denoted by **.

Data preparation:

```
log using "C:\Users\steve\OneDrive\Documents\Wageningen University\Master Economics of Sustainability\Master thesis\CF logbook 3.smcl"

import delimited "C:\Users\steve\OneDrive\Documents\Wageningen University\Master Economics of Sustainability\Master thesis\FINAL DATA.csv", clear

gen number=1
sort number
quietly by number: gen dup = cond(_N==1,0,_n)

rename responseid qualtrics_id

rename dup observation_number

expand 7
sort observation_number
quietly by observation_number: gen dup = cond(_N==1,0,_n)
label variable dup "Choice number displayed to each participant 1-7"

rename dup Choicecard_number
generate Case=1
sort  Case
quietly by Case: gen dup = cond(_N==1,0,_n)
drop Case
rename dup Case

expand 3

sort Case Choicecard_number
quietly by Case Choicecard_number: gen dup = cond(_N==1,0,_n)
label variable dup "Alternatives in each CS"
rename dup Alternative


rename observation_number id

drop startdate enddate status ipaddress progress durationinseconds finished recordeddate recipientlastname recipientfirstname recipientemail externalreference locationlatitude locationlongitude distributionchannel userlanguage q_recaptchascore data_protection time_leem_e_firstclick time_leem_e_lastclick time_leem_e_pagesubmit time_leem_e_clickcount time_leem_i_firstclick time_leem_i_lastclick time_leem_i_pagesubmit time_leem_i_clickcount time_zande_lastclick time_zande_pagesubmit time_zande_clickcount time_zandi_firstclick time_zandi_lastclick time_zandi_pagesubmit time_klei_e_firstclick time_klei_e_lastclick time_klei_e_clickcount time_klei_i_firstclick time_klei_i_lastclick time_klei_i_pagesubmit time_klei_i_clickcount time_veen_firstclick time_veen_lastclick time_veen_pagesubmit
```

```
time_veen_clickcount time_dairy_firstclick time_dairy_lastclick time_dairy_pagesubmit
time_dairy_clickcount time_zande_firstclick time_zandi_clickcount time_klei_e_pagesubmit


gen cs1 = cs1_choice
gen cs2 = cs2_choice
gen cs3 = cs3_choice
gen cs4 = cs4_choice
gen cs5 = cs5_choice
gen cs6 = cs6_choice
gen cs7 = cs7_choice
gen cs8 = cs8_choice
gen cs9 = cs9_choice
gen cs10 = cs10_choice
gen cs11 = cs11_choice
gen cs12 = cs12_choice
gen cs14 = cs14_choice
gen cs15 = cs15_choice
gen cs16 = cs16_choice
gen cs17 = cs17_choice
gen cs18 = cs18_choice
gen cs19 = cs19_choice
gen cs20 = cs20_choice

rename cs1_choice choice_1
rename cs2_choice choice_2
rename cs3_choice choice_3
rename cs4_choice choice_4
rename cs5_choice choice_5
rename cs6_choice choice_6
rename cs7_choice choice_7
rename cs8_choice choice_8
rename cs9_choice choice_9
rename cs10_choice choice_10
rename cs11_choice choice_11
rename cs12_choice choice_12
rename cs14_choice choice_14
rename cs15_choice choice_15
rename cs16_choice choice_16
rename cs17_choice choice_17
rename cs18_choice choice_18
rename cs19_choice choice_19
rename cs20_choice choice_20



generate choice_set_answered=.

foreach i in 1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 {
   replace choice_set_answered = `i' if choice_set_answered == . & choice_`i' != .
   replace choice_`i' = . if choice_set_answered == `i'
}

replace choice_set_answered=. if Choicecard_number>1
```

```
foreach i in 1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 {
   replace choice_set_answered = `i' if choice_set_answered == . & choice_`i' != .
   replace choice_`i' = . if choice_set_answered == `i'
}


replace choice_set_answered=. if Choicecard_number>2



foreach i in 1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 {
   replace choice_set_answered = `i' if choice_set_answered == . & choice_`i' != .
   replace choice_`i' = . if choice_set_answered == `i'
}


replace choice_set_answered=. if Choicecard_number>3


foreach i in 1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 {
   replace choice_set_answered = `i' if choice_set_answered == . & choice_`i' != .
   replace choice_`i' = . if choice_set_answered == `i'
}
replace choice_set_answered=. if Choicecard_number>4


foreach i in 1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 {
   replace choice_set_answered = `i' if choice_set_answered == . & choice_`i' != .
   replace choice_`i' = . if choice_set_answered == `i'
}

replace choice_set_answered=. if Choicecard_number>5


foreach i in 1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 {
   replace choice_set_answered = `i' if choice_set_answered == . & choice_`i' != .
   replace choice_`i' = . if choice_set_answered == `i'
}

replace choice_set_answered=. if Choicecard_number>6

foreach i in 1 2 3 4 5 6 7 8 9 10 11 12 14 15 16 17 18 19 20 {
   replace choice_set_answered = `i' if choice_set_answered == . & choice_`i' != .
   replace choice_`i' = . if choice_set_answered == `i'
}

replace choice_set_answered=. if Choicecard_number>7

gen Choice = 0

forvalues i = 1/12 {
   foreach alt in 1 2 3 {
```

```
      replace Choice = 1 if Alternative == `alt' & choice_set_answered == `i' & cs`i' == `alt'
   }
}


forvalues i = 14/20 {
   foreach alt in 1 2 3 {
      replace Choice = 1 if Alternative == `alt' & choice_set_answered == `i' & cs`i' == `alt'
   }
}



merge m:m choice_set_answered Alternative using
"C:\Users\steve\Downloads\Design_Novasoil.dta", update


sort id Choicecard_number Case Alternative

gen D_Arable =1
replace D_Arable =0 if strpos( soil_type_intensity, "grasland")
replace D_Arable =0 if strpos( soil_type_intensity, "veengrond")

gen D_extensive=0
replace D_extensive =1 if strpos(soil_type_intensity, "Extensieve") > 0
label variable D_extensive "0 intensive 1 extensive"

gen education_d= 0
replace education_d=1 if education == "Middelbare School"
replace education_d=2 if education == "MBO"
replace education_d=3 if education == "HBO"
replace education_d=4 if education == "Universitair (Bachelor, Master, PhD)"
label variable education_d "0 basisschool 1 Middelbare school 2 MBO 3 HBO 4 Universitair"

gen D_hoog_opgeleid=0
replace D_hoog_opgeleid =1 if education_d==3 | education_d==4
label variable D_hoog_opgeleid "0 nee 1 ja"

gen province_d =0
replace province_d=1 if province == "Drenthe"
replace province_d=2 if province == "Flevoland"
replace province_d=3 if province == "Friesland"
replace province_d=4 if province == "Gelderland"
replace province_d=5 if province == "Groningen"
replace province_d=6 if province == "Limburg"
replace province_d=7 if province == "Noord-Brabant"
replace province_d=8 if province == "Noord-Holland"
replace province_d=9 if province == "Overijssel"
replace province_d=10 if province == "Utrecht"
replace province_d=11 if province == "Zeeland"
label variable province_d "0 Zuid Holland 1 Drenthe 2 Flevoland 3 Friesland 4 Gelderland 5
Groningen 6 Limburg 7 Noord-Brabant 8 Noord-Holland 9 Overijssel 10 Utrecht 11 Zeeland"

gen D_Randstad =0
```

```
replace D_Randstad =1 if strpos(province, "Holland") > 0
replace D_Randstad =1 if strpos(province, "Utrecht") > 0
label variable D_Randstad "0 overig 1 provincies randstad"

gen D_fulltime= 0
replace D_fulltime=1 if fulltime== "Primaire inkomstenbron (fulltime)"
label variable D_fulltime "0 part time 1 full time"

gen D_training= 0
replace D_training=1 if training =="ja"
label variable D_training "0 nee 1 ja"

gen size = hectares_1 + hectares_2

gen D_organic= 0
replace D_organic=1 if organic == "conventioneel"
label variable D_organic"0 organisch 1 conventioneel"

gen D_remain_family = 0
replace D_remain_family =1 if strpos(succession, "Het gaat over op een opvolger in de familie")
> 0
replace D_remain_family =1 if strpos(succession, "Ik blijf het beheren") > 0
label variable D_remain_family "0 not staying or unsure 1 staying in family"

gen soilhealth_t_d_till = 0
gen soilhealth_t_d_akkerland=0
gen soilhealth_t_d_bedekking=0
gen soilhealth_t_d_begrazing=0
gen soilhealth_t_d_verbeteraar=0
gen soilhealth_t_d_spanning=0
gen soilhealth_t_d_houtachtige=0
gen soilhealth_t_d_bio=0
gen soilhealth_t_d_vrucht=0
gen soilhealth_t_d_andere=0

replace soilhealth_t_d_till = 1 if strpos(soilhealth_tech, "minder/geen grondbewerking (no-till,
strip-till )") > 0
replace soilhealth_t_d_akkerland= 1 if strpos(soilhealth_tech, "omzetting van akkerland naar
grasland") > 0
replace soilhealth_t_d_bedekking= 1 if strpos(soilhealth_tech, "integratie van extra
bedekkingsgewassen") > 0
replace soilhealth_t_d_begrazing= 1 if strpos(soilhealth_tech, "begrazing op grasland") > 0
replace soilhealth_t_d_verbeteraar= 1 if strpos(soilhealth_tech, "gebruik van
bodemverbeteraars (bijv. biochar)") > 0
replace soilhealth_t_d_spanning= 1 if strpos(soilhealth_tech, "gebruik van machines bijv. met
lagere bandenspanning") > 0
replace soilhealth_t_d_houtachtige= 1 if strpos(soilhealth_tech, "aanplanting van extra
houtachtige elementen (laatste tien jaar)") > 0
replace soilhealth_t_d_bio= 1 if strpos(soilhealth_tech, "door over te schakelen op biologische
landbouw (laatste tien jaar)") > 0
replace soilhealth_t_d_vrucht= 1 if strpos(soilhealth_tech, "door gebruik van bredere
vruchtwisseling") > 0
replace soilhealth_t_d_andere= 1 if strpos(soilhealth_tech, "andere") > 0
```

```
gen count_t=0

replace count_t = count_t +1 if soilhealth_t_d_till==1
replace count_t = count_t +1 if soilhealth_t_d_akkerland==1
replace count_t = count_t +1 if soilhealth_t_d_bedekking==1
replace count_t = count_t +1 if soilhealth_t_d_begrazing==1
replace count_t = count_t +1 if soilhealth_t_d_verbeteraar==1
replace count_t = count_t +1 if soilhealth_t_d_spanning==1
replace count_t = count_t +1 if soilhealth_t_d_houtachtige==1
replace count_t = count_t +1 if soilhealth_t_d_bio==1
replace count_t = count_t +1 if soilhealth_t_d_vrucht==1
replace count_t = count_t +1 if soilhealth_t_d_andere==1

gen D_applying =0
replace D_applying =1 if count_t >2
label variable D_applying "0 applying two or less CF practices 1 three or more measures"

gen D_no_measures= 0
replace D_no_measures =1 if strpos(financing, "geen maatregelen")>0
label variable D_no_measures "0 financing measures 1 no measures"

gen klimaat_d=0

replace klimaat_d=1 if strpos(rate_klimaat, "Ik ben het er niet mee eens") > 0
replace klimaat_d=2 if strpos(rate_klimaat, "neutraal") > 0
replace klimaat_d=3 if strpos(rate_klimaat, "Ik ben het er mee eens") > 0
replace klimaat_d=4 if strpos(rate_klimaat, "Ik ben het er helemaal mee eens") > 0
label variable klimaat_d "0 helemaal niet mee eens 1 niet mee eens 2 neutraal 3 mee eens 4
helemaal mee eens"

gen D_climate_positive = 0
replace D_climate_positive =1 if klimaat_d==3 | klimaat_d==4
label variable D_climate_positive "0 negatief/neutraal 1 positief"

gen risk_d=0

replace risk_d=1 if strpos(rate_risk, "Ik ben het er niet mee eens") > 0
replace risk_d=2 if strpos(rate_risk, "neutraal") > 0
replace risk_d=3 if strpos(rate_risk, "Ik ben het er mee eens") > 0
replace risk_d=4 if strpos(rate_risk, "Ik ben het er helemaal mee eens") > 0
label variable risk_d "0 helemaal niet mee eens 1 niet mee eens 2 neutraal 3 mee eens 4
helemaal mee eens"

gen D_risk = 0
replace D_risk = 1 if risk_d == 3 | risk_d == 4
label variable D_risk "0 minder/neutraal risico 1 meer risico"

gen soilhealth_d=0

replace soilhealth_d=1 if strpos(rate_bodem, "Ik ben het er niet mee eens") > 0
replace soilhealth_d=2 if strpos(rate_bodem, "neutraal") > 0
replace soilhealth_d=3 if strpos(rate_bodem, "Ik ben het er mee eens") > 0
replace soilhealth_d=4 if strpos(rate_bodem, "Ik ben het er helemaal mee eens") > 0
```

```
label variable soilhealth_d "0 helemaal niet mee eens 1 niet mee eens 2 neutraal 3 mee eens 4 helemaal mee eens"

gen D_soil_importance = 0
replace D_soil_importance =1 if soilhealth_d==3 | soilhealth_d==4
label variable D_soil_importance "0 negatief/neutraal 1 positief"

gen ASC=0
replace ASC=1 if Alternative!=3



local varlist "D_Arable age_y D_hoog_opgeleid D_Randstad D_fulltime size share_tenure_1 grain_share D_applying D_remain_family D_no_measures D_training D_climate_positive D_soil_importance D_risk D_extensive D_organic     "
foreach var of local varlist {
   gen ASC_`var' = ASC * `var'
}

drop if age==.
drop choice_1 choice_2 choice_3 choice_4 choice_5 choice_6 choice_7 choice_8 choice_9 choice_10 choice_11 choice_12 choice_14 choice_15 choice_16 choice_17 choice_18 choice_19 choice_20

gen Steun_duurzam_beheer=0
replace Steun_duurzam_beheer =1 if Steun_duurzam_beheer2=="Training"
replace Steun_duurzam_beheer =2 if Steun_duurzam_beheer2=="-0.5% korting op leningen"

gen Optie_beeindiging=0
replace Optie_beeindiging=1 if Optie_beeindiging2 == "Ja"

replace Gedeelde_kosten= 0 if Alternative==3
replace Carbon_credit_prijs=0 if Alternative==3
replace Contractduur=0 if Alternative==3

sort id Choicecard_number Alternative

save data_preperation_Final_version.dta, replace

log close
translate CF logbook 3.smcl CF logbook 3.pdf
```

MXL code:

```
use "C:\Users\steve\OneDrive\Documents\data_preperation_Final_version.dta"

ssc install mixlogit

constraint 1[1]_cons = [2]_cons
constraint 2[2]_cons = [3]_cons
asclogit Choice, casevars() case(Case) alternatives(Alternative) base(3) constraint(1 2)
```

```
mixlogit Choice, rand( Gedeelde_kosten Carbon_credit_prijs Contractduur Optie_beeindiging
Steun_duurzam_beheer ASC) group(Case) id(id) nrep(100)

mixlpred p, nrep(200)
sum p if Alternative==3
drop p

gen pseudoR= 1-( -381.39094/-631.54371)
list pseudoR in 1

** all possible
clogit Choice  ASC_D_Arable ASC_age_y ASC_D_hoog_opgeleid ASC_D_Randstad ASC_D_fulltime
ASC_size ASC_share_tenure_1 ASC_grain_share ASC_D_applying ASC_D_remain_family
ASC_D_no_measures ASC_D_training ASC_D_climate_positive ASC_D_soil_importance ASC_D_risk
ASC_D_extensive ASC_D_organic Gedeelde_kosten Carbon_credit_prijs Contractduur
Steun_duurzam_beheer Optie_beeindiging ASC, group(Case)
scalar m1 = e(ll)

estimates store M1

** when finished with deleting insignificant, this was left
clogit Choice ASC_D_fulltime ASC_size  ASC_grain_share ASC_D_applying  ASC_D_no_measures
ASC_D_climate_positive     Gedeelde_kosten Carbon_credit_prijs Contractduur
Steun_duurzam_beheer Optie_beeindiging ASC, group(Case)
scalar m2 = e(ll)
estimates store M2


estat ic
lrtest M1 M2, force

di "chi2(2) = " 2*(m2-m1)
di "Prob > chi2 = "chi2tail(2, 2*(m2-m1))

mixlogit Choice  ASC_D_fulltime ASC_size  ASC_grain_share ASC_D_applying  ASC_D_no_measures
ASC_D_climate_positive, rand( Gedeelde_kosten Carbon_credit_prijs Contractduur
Steun_duurzam_beheer Optie_beeindiging ASC) group(Case) id(id) nrep(1000)


preserve
set seed 12345
gen rnd = runiform()
bysort id Case (rnd): gen alt = _n
replace Optie_beeindiging = 0 if alt!=3
mixlpred p0, nrep(500)
replace Optie_beeindiging = 1 if alt!=3
mixlpred p1, nrep(500)
gen p_diff = p1-p0
sum p_diff if alt!=3
restore

preserve
set seed 12345
gen rnd = runiform()
```

```
bysort id Case (rnd): gen alt = _n
replace Steun_duurzam_beheer = 0 if alt!=3
mixlpred p0, nrep(500)
replace Steun_duurzam_beheer = 1 if alt!=3
mixlpred p1, nrep(500)
gen p_diff = p1-p0
sum p_diff if alt!=3
restore

preserve
set seed 12345
gen rnd = runiform()
bysort id Case (rnd): gen alt = _n
replace Contractduur = 20 if alt!=3
mixlpred p0, nrep(500)
replace Contractduur = 21 if alt!=3
mixlpred p1, nrep(500)
gen p_diff = p1-p0
sum p_diff if alt!=3
restore

preserve
set seed 12345
gen rnd = runiform()
bysort id Case (rnd): gen alt = _n
replace Carbon_credit_prijs = 25 if alt!=3
mixlpred p0, nrep(500)
replace Carbon_credit_prijs = 26 if alt!=3
mixlpred p1, nrep(500)
gen p_diff = p1-p0
sum p_diff if alt!=3
restore

preserve
set seed 12345
gen rnd = runiform()
bysort id Case (rnd): gen alt = _n
replace Gedeelde_kosten = 50 if alt!=3
mixlpred p0, nrep(500)
replace Gedeelde_kosten = 51 if alt!=3
mixlpred p1, nrep(500)
gen p_diff = p1-p0
sum p_diff if alt!=3
restore

ssc install wtp
wtp Carbon_credit_prijs  Gedeelde_kosten  Contractduur Steun_duurzam_beheer
Optie_beeindiging

mixlpred p, nrep(1000)
bysort Alternative ( p ): summarize p

preserve
set seed 12345
```

```
gen rnd = runiform()
bysort id Case (rnd): gen alt = _n
replace Steun_duurzam_beheer = 0 if alt==1
mixlpred p0, nrep(500)
replace Steun_duurzam_beheer = 1 if alt==1
mixlpred p1, nrep(500)
gen p_diff = p1-p0
sum p_diff if alt==1
replace Optie_beeindiging = 0 if alt==1
mixlpred p2, nrep(500)
replace Optie_beeindiging = 1 if alt==1
mixlpred p3, nrep(500)
gen p_diff2 = p3-p2
sum p_diff2 if alt==1

mixlpred pr

sum if pr if Alternative ==3
```

LCM code:

```
ssc install lclogit2

forvalues c = 2/4 {
	quietly lclogit2 Choice, group(Case) rand( Gedeelde_kosten Carbon_credit_prijs Contractduur Optie_beeindiging Steun_duurzam_beheer ASC) nclasses( `c' )  id( id) membership( size  grain_share D_applying   D_climate_positive)
	matrix b = e(b)
	matrix ic = nullmat(ic) \ `e(nclasses)', `e(ll)', `=colsof(b)',`e(caic)', `e(bic)'
}
matrix colnames ic = "Classes" "LLF" "Nparam" "CAIC" "BIC"
matlist ic, name(columns)

forvalues c = 2/4 {
	quietly lclogitml2 Choice, group(Case) rand( Gedeelde_kosten Carbon_credit_prijs Contractduur Optie_beeindiging Steun_duurzam_beheer ASC) nclasses( `c' )  id( id) membership( size  grain_share D_applying   D_climate_positive)
	matrix b = e(b)
	matrix ic = nullmat(ic) \ `e(nclasses)', `e(ll)', `=colsof(b)',`e(caic)', `e(bic)'
}
matrix colnames ic = "Classes" "LLF" "Nparam" "CAIC" "BIC"
matlist ic, name(columns)

lclogitml2 Choice, group(Case) rand( Gedeelde_kosten Carbon_credit_prijs Contractduur Optie_beeindiging Steun_duurzam_beheer ASC) nclasses( 2 )  id( id) membership( size grain_share D_applying   D_climate_positive)

 lclogitwtp2, income(Carbon_credit_prijs)

lclogitpr2 predb

sum predb1 if Alternative == 3
sum predb2 if Alternative == 3
sum predb3 if Alternative == 3
```