A Uniswap-Powered Decentralized Exchange for Carbon Trading

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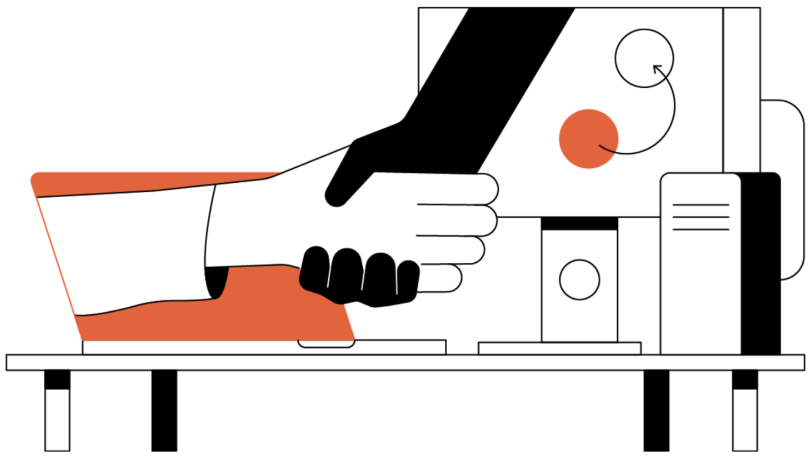

Figure 1: A decentralized exchange (DEX) [1]

ABSTRACT

This is a coursework project submitted to the course *Data Analysis and Privacy Protection in Blockchain*. In this project, we propose a decentralized exchange for carbon trading based on the Uniswap protocol. We first introduce the background of carbon trading and the Uniswap protocol. Then we describe the design of our decentralized exchange, including the smart contracts and the user interface. Finally, we discuss the potential issues of our design and propose some future work.

This report seeks to elucidate a novel undertaking - the conception and implementation of a decentralized exchange project predicated on blockchain architecture. Specifically, this project capitalizes on the emergent popularity of carbon-related trading products in the Chinese market. Our report commences with a thorough introduction of the project, followed by a detailed delineation of its design structure and the intricacies of the underlying blockchain architecture. We also expound upon the nature and prominence of carbon trading products in China, which constitute the principal commodities of our exchange. In addition to trading, we posit that our platform can significantly contribute to the field of carbon finance, with an emphasis on carbon pricing. The utilization of blockchain technology and decentralized exchanges in carbon finance presents unprecedented potential in terms of efficiency, transparency, and accessibility. While the project is currently underway, this paper serves as a comprehensive overview of our progress thus far, highlighting the unique contributions that the project has already made and outlining the future avenues of work and potential expansions.

KEYWORDS

Uniswap, Decentralized Exchange, Carbon Trading, Smart Contract

1 INTRODUCTION

Climate change and associated environmental concerns form the primary impetus for our project, with a focus on leveraging the transformative potential of decentralized exchanges (DEX) and blockchain solutions. Our overarching ambition is to contribute substantially to global climate change mitigation efforts.

The urgency of addressing climate change cannot be overstated. As evidenced by [2] , we are rapidly approaching the critical threshold of 1.5 degrees of average warming, with less than 7.5 years remaining. Historical CO_2 concentration levels have risen dramatically from 280 parts per million (ppm) in the pre-industrial era to approximately 419 ppm at present due to fossil fuel combustion. With current projections estimating a rise by 2ppm per annum, we are fast nearing the critical level of 430 ppm, the point at which we hit 1.5 degrees of warming. In order to return to safe levels, there is a daunting task of removing nearly one trillion tons of CO_2 from the atmosphere. Hence, there is a pressing need for innovative solutions to mitigate climate change.

The European Union (EU) has manifested its commitment to climate change mitigation by aiming for a 55% reduction in greenhouse gas emissions by 2030 (compared to 1990 levels), with a view to achieving net-zero emissions by 2050. As part of these efforts, the EU has introduced the Carbon Border Adjustment Mechanism (CBAM), which mandates importers to account for the emissions produced during the manufacturing of imported goods. Importers are required to obtain CBAM certificates corresponding to the volume of emissions associated with their imports, thereby contributing to the EU's ambitious carbon reduction targets and fostering sustainable practices in international trade.

Notably, the chief purchasers of EU ETS offsets are corporations with emissions reduction obligations. These entities may opt to purchase offsets as a cost-effective alternative to reducing emissions within their own operations. CBAM, scheduled for implementation on October 1st, 2023, with full enforcement by 2026, aims to ensure that importers account for the emissions associated with their imported goods. The mechanism as shown in Table 1 encompasses several sectors, including cement, iron and steel, aluminium, fertiliser, electricity, polymers, organic chemicals, hydrogen, and ammonia. CBAM, by incorporating both direct and indirect emissions, unlike its predecessor, the ETS, aims to enforce a mandatory carbon price, thereby advancing the EU's annual emissions reduction target of 2.20% to 4.20%.

Table 1: Comparison of different mechanisms

Criteria	**Option 1**	**Option 2**
Annual emissions reduction target	2.20%	4.20%
Mechanism	Cap-and-trade	Mandatory carbon price
Covered sectors	All sectors	Cement, iron and steel, aluminum, fertilizer, electricity, polymers, organic chemicals, hydrogen, ammonia
Emissions	Direct emissions only	Include indirect emissions
Centralized authority	27 competent authorities	One centralized EU CBAM authority
Incentives	No	Yes

Given the EU's ambitious emissions reduction targets and the global impetus for sustainability, it is evident that emissions pricing is an effective mechanism to incentivize the reduction of carbon footprints. In light of this, we propose the development of a smart contract that employs a specialized approach to predict carbon pricing, which can support policy-making, promote compliance, and potentially catalyze the transition to a low-carbon economy. This tool would empower governments and regulatory bodies to assess the efficacy of existing policies and formulate new ones, while businesses could leverage it for regulatory compliance and environmental reporting.

2 PROJECT OVERVIEW

The objective of this project is to delve into the development of a Uniswap-powered decentralized exchange designed for carbon trading. The paramount focus for the duration of this course will be on the third aspect of the project: Verification. This aspect embodies the creation of a certification and registry system for the transaction of carbon credits.

The project revolves around four interwoven concepts: monitoring, reporting, verification, and trading. The primary goal is to orchestrate a system to track carbon emissions across supply chains, thus affording users the capacity to obtain precise information about the carbon emissions resultant from their operations. This knowledge will empower them to take informed steps towards reducing their environmental footprint.

Further to this, the project seeks to furnish tools that facilitate users in the calculation of emissions, the comparison against industry norms, and the reporting of these emissions in adherence with prescribed guidelines. Through this, we aim to facilitate compliance with regulatory reporting mandates, whilst empowering our users to adopt a data-driven approach to the reduction of their carbon emissions.

The verification facet of the project, which forms the crux of this course, involves the design of an accredited registry for the transaction of carbon credits. This seeks to provide a transparent and secure platform for the trading of these credits, which can be used as a mechanism to offset emissions. The ultimate goal is to promote the transition towards a lower-carbon economy.

Lastly, the project endeavours to provide a suite of services such as product ratings, bid matching, and transaction facilitation, specifically geared towards the trading of sustainably sourced and carbon-neutral products. The overarching intention behind these services is to further the cause of sustainable practices, helping users attain their individual sustainability targets.

In conclusion, this project has been conceived to address the urgent need for a comprehensive and efficient system for the monitoring, reporting, verification, and trading of carbon emissions and credits. Given the constraints of time, however, this course will concentrate on the critical aspect of verification within the broader project scope.

3 BLOCKCHAIN ARCHITECTURE DESIGN

In the pursuit of developing a Uniswap-powered Decentralized Exchange for Carbon Trading, the architecture design for the project will leverage several cutting-edge technologies, which include a distributed ledger, smart contracts, and Internet of Things (IoT) devices for the acquisition of external grid emission factor data. However, within the time frame of this course, the focus will be primarily on the construction of a decentralized platform for carbon emissions trading.

It is important to note that while ensuring the integrity and veracity of data through IoT devices is an imperative facet of the project, it does not form the primary focus of the present stage. Rather, the immediate attention is centred on the provision of a secure, transparent, and reliable platform for carbon trading. The aim is to foster the adoption of sustainable practices, thus making a valuable contribution to the ongoing global efforts to mitigate the adverse impacts of climate change.

At this juncture, it is pertinent to highlight what this project will facilitate trading in, and how it introduces innovation to the realm of carbon emissions trading. A detailed exploration of these aspects will follow in subsequent sections of this report. The underlying objective remains the development of a system that is both robust and efficient, and which offers a new paradigm in the trading of carbon credits, promoting both environmental sustainability and regulatory compliance.

4 PRESENT TRADING PRODUCTS AND TOKENIZATION

The current market for carbon emissions trading and tokenization is a vibrant, rapidly-evolving sector. A primary example of this is found in China, where a mandatory quota trading system is in place for key emission-producing enterprises. In tandem with quota trading, voluntary project-based offset trading also exists, providing flexibility for entities seeking to manage their carbon footprints.

Tokenization presents a path to greater efficiency and accountability in the realm of carbon trading. Within this model, tokens become the representation of carbon credits and offsets, available for purchase, sale, or trade within the marketplace. This approach leads to a diversified portfolio of carbon products, and importantly, encourages sustainable business practices.

While the field of carbon emissions trading and tokenization remains in its nascent stages, growth has been exponential. As an increasing number of countries and corporations pledge to shrink their carbon footprints, the demand for carbon credits and offsets is predicted to rise. Thus, the development of sustainable solutions, such as our proposed decentralized carbon emissions trading platform, is imperative to address the urgent problem of climate change.

Among the plethora of products on offer, this project is especially interested in Carbon Index Tokens. These tokens provide an opportunity for a diversified portfolio of carbon products, mitigating risks linked to exposure to individual carbon products. Traded on carbon emissions markets, these tokens enhance both market accessibility and transparency.

The allure of Carbon Index Tokens lies in their transparency, where the performance of the underlying carbon products can be monitored and verified, offering investors a lucid understanding of their investments. This transparency additionally aids investors in hedging against potential price fluctuations within the carbon market, thereby lowering exposure to market risks.

Accessibility forms another major advantage of Carbon Index Tokens. They provide a route for investors, irrespective of their knowledge or resources, to engage in the carbon market. This simplifies the investment process in sustainable practices and aids the transition towards a low-carbon economy.

In summary, Carbon Index Tokens furnish investors with a valuable instrument for long-term exposure to the potential growth of the carbon market. They further sustainable practices and contribute to mitigating climate change by fostering the progression towards a low-carbon economy.

5 SMART CONTRACTS STRUCTURE

In the pursuit of creating a robust decentralized carbon trading platform, a carefully designed contract structure forms the backbone of our system, prioritising liquidity, efficient trading, and a seamless user experience.

At the heart of our platform lies the COREarth ERC20 contract, a fundamental mechanism that underpins all transactional and trading activities on the platform. This smart contract furnishes the necessary functionalities to facilitate the tokenization and subsequent trading of carbon credits.

To ascertain the provision of liquidity and efficient trading, the COREarth Router contract is implemented as an integral part of our platform. This contract streamlines the swapping of tokens, hence delivering an intuitive and seamless user experience.

Complementing these central contracts, the COREarth Pair and COREarth Factory contracts are further embedded within our system. The Pair contract is instrumental in the pairing of tokens, while the Factory contract establishes a comprehensive framework for the genesis of new tokens.

In essence, our platform's smart contract structure epitomizes a carefully calibrated system designed to offer liquidity, efficient trading, and a user-friendly experience in the burgeoning field of decentralized carbon trading.

5.1 COREarthPair Contract

In the context of the Uniswap V2 decentralized exchange protocol built on the Ethereum blockchain, the COREarthPair smart contract plays a central role. This section will elucidate the initialization process of the contract, delve into its primary functions, and shed light on a few auxiliary functions, all aimed at fostering a comprehensive understanding of the contract's functionality.

5.2 Contract Initialization

The initialization of the UniswapV2Pair contract comprises two main steps. Initially, within the constructor, the factory address is defined. This address corresponds to the UniswapV2Factory contract, tasked with the creation of new token pairs. Subsequently, the ‘initialize‘ function assigns the token0 and token1 addresses. These represent the pair of ERC20 tokens which are subject to trading.

5.3 Core Functions

The UniswapV2Pair contract is governed by three core functions, namely ‘mint‘, ‘burn‘, and ‘swap‘. The ‘mint‘ function facilitates users in depositing tokens and receiving liquidity tokens in return. It computes the amount of liquidity to mint based on the reserves and provided token amounts, updates the reserves, and emits a Mint event. Contrarily, the ‘burn‘ function enables users to eliminate liquidity by burning their respective liquidity tokens. It calculates the amount of token0 and token1 to return, contingent on the user's pool share, updates the reserves, and emits a Burn event. Lastly, the ‘swap‘ function enables trades between token0 and token1. It establishes the input and output amounts based on the available reserves and desired output amount, updates the reserves, and emits a Swap event.

5.4 Auxiliary Functions

A suite of auxiliary functions is also incorporated within the UniswapV2Pair contract. For instance, the ‘getReserves‘ function returns the current reserves for token0 and token1. Moreover, the ‘skim‘ and ‘sync‘ functions address disparities between the actual token balances and the recorded reserves. The ‘skim‘ function aligns balances with reserves, while the ‘sync‘ function aligns reserves with balances.

In summary, the UniswapV2Pair smart contract is an essential element of the Uniswap V2 protocol. It regulates the primary functionalities of token pairs, such as minting and burning of liquidity tokens, as well as swapping tokens. Comprehending its inner workings is crucial to appreciate the decentralized exchange mechanism and the innovative strides brought forth by the Uniswap protocol.

Two distinctive innovations are embedded within our system. Firstly, our tokenization targets the carbon index, which embodies a diversified portfolio of carbon products. Secondly, the Factory contract, while referencing the UniswapV2Pair contract, does not inherit from it but dynamically deploys Pair contracts for different token pairs as and when required.

6 COREARTHFACTORY

The UniswapV2Factory contract serves as an indispensable element within the Uniswap V2 decentralized exchange ecosystem, enabling the creation and management of unique token pairs. This contract underpins the operation and liquidity management within the Uniswap V2 platform. In our application, it introduces a unique feature where the "feeToSetter" address can be assigned to a governmental body, paving the way for institutional oversight.

6.1 UniswapV2Factory Overview

The UniswapV2Factory contract initiates with a constructor that designates the initial feeToSetter address. This particular address possesses the privilege to amend fee-oriented configurations.

A user can query the aggregate count of pairs created through the allPairsLength() function, providing a snapshot of the exchange's expansion over time. The pivotal function of the contract, createPair(), checks for the existence of a pair when presented with two distinct tokens. If non-existent, it generates a new UniswapV2Pair utilizing the create2 assembly method and initializes the pair with the sorted tokens. Upon creation, the contract updates the getPair mapping in both directions, introduces the pair into the allPairs array, and triggers a PairCreated event.

The contract facilitates modification of the feeTo address, where platform fees are directed, via the setFeeTo() function, executable only by the feeToSetter. The feeToSetter address itself can be altered through the setFeeToSetter() function, a privilege reserved for the current feeToSetter.

6.2 COREarthFactory Contract and Fee Mechanism

Building upon the UniswapV2Factory at address 0x5, the COREarthFactory contract incorporates a protocol fee of 0.05% which is toggleable. The fee is regulated by the "feeToSetter" address, which in our case, can be assigned to a governmental institution, thus incorporating an element of institutional oversight.

On creating a new token pair using the "createPair" function, a fee of 0.30% is levied on all trades. From this fee, 83.3% (0.25%) is apportioned to liquidity providers and the remaining 16.6% (0.05%) is directed to the "feeTo" address (if set).

The "setFeeTo" function designates the "feeTo" address, the recipient of collected trade fees, while the "setFeeToSetter" function assigns the "feeToSetter" address, the regulator of the protocol fee and the entity authorized to alter the "feeTo" address.

The "allPairsLength" function returns the length of the "allPairs" array which encapsulates information pertaining to all token pairs created on the platform. The "getPair" function computes the new liquidity tokens to be minted for the "feeTo" address.

In essence, the COREarthFactory contract embeds a fee mechanism that encourages liquidity and incentivizes liquidity providers while ensuring appropriate fee collection and distribution. This mechanism fortifies the long-term sustainability and success of our decentralized carbon emissions trading platform.

7 COREARTHROUTER

The Uniswap V2 decentralized exchange plays host to an essential smart contract known as UniswapV2Router01, providing a simplified interface to Uniswap V2's core functionalities. These encompass adding and removing liquidity, swapping tokens, and calculating input and output amounts for trading pairs. Furthermore, UniswapV2Router02, an upgrade over its predecessor, introduces additional features and optimizations.

7.1 UniswapV2Router01 Overview

The UniswapV2Router01 contract is structured into seven primary sections:

(1) Add Liquidity
(2) Remove Liquidity
(3) Swap Tokens
(4) Swap ETH
(5) Swap Exact Tokens for ETH
(6) Quote
(7) Get Amounts

Each section is dedicated to a specific functionality. Sections 1 and 2 pertain to adding and removing liquidity via the 'addLiquidity', 'addLiquidityETH', 'removeLiquidity', and 'removeLiquidityETH' functions. Section 3 handles token-to-token swaps, while Section 4 is responsible for Ether-to-token and token-to-Ether swaps. Section 5 addresses swapping tokens for an exact Ether amount, and Section 6 computes the output amount of a trade with the 'quote' function. Lastly, Section 7 provides the 'getAmountsOut' and 'getAmountsIn' functions to calculate input and output amounts for trades.

7.2 UniswapV2Router02: An Upgraded Interface

The UniswapV2Router02 contract extends UniswapV2Router01's functionalities, offering a range of additional features:

(1) Functions **‘swapExactTokensForTokensSupportingFeeOnTransferTokens‘** and **‘swapExactETHForTokensSupportingFeeOnTransferTokens‘** facilitate seamless trading of tokens with a built-in transfer fee mechanism, such as deflationary tokens.
(2) The function **‘swapExactTokensForETH‘** includes an optional **‘address‘** parameter to designate an Ether recipient, unlike its counterpart in UniswapV2Router01.
(3) The **‘swapExactTokensForTokensWithRoute‘** function allows users to set a custom route for their token swaps.
(4) The **‘getAmountsOutExactETH‘** function calculates the precise output tokens amount against a specific Ether input.
(5) The **‘getAmountsOutExactTokens‘** function computes the exact Ether output against a specific token input.

To conclude, UniswapV2Router01 and UniswapV2Router02 contracts serve as indispensable elements within the Uniswap V2 decentralized exchange ecosystem. The upgraded UniswapV2Router02 contract enhances the user experience by offering additional features, making it a more comprehensive and flexible solution for interacting with the Uniswap V2 ecosystem.

8 CARBON FINANCE

The application of decentralized exchanges (DEX) to carbon trading provides a potential pathway to incentivize environmental sustainability and promote a greener economy. The platform designed in this study facilitates the smooth exchange of carbon credit tokens (Token A) and stablecoins (Token B). This section outlines the process and steps involved in implementing this system.

The proposed procedure can be broken down into several steps:

(1) **Factory Contract Deployment:** The initiation phase involves the establishment of the primary contract responsible for creating trading pairs.
(2) **Fee Manager Assignment:** A fee manager is designated to administer transaction fees, fostering a fair exchange environment.
(3) **Trading Pair Creation:** A new trading pair, comprising Token A and Token B, is established to facilitate the exchange of carbon credits and stablecoins.
(4) **Token Addresses Provision:** The contract addresses for both tokens are input into the system.
(5) **Pair Contract Deployment:** Subsequently, the Factory Contract deploys a new Pair Contract specific to the established trading pair.
(6) **Liquidity Addition:** Users deposit both Token A and Token B into the Pair Contract, providing the necessary liquidity for trading operations.
(7) **Liquidity Token Generation:** The Pair Contract, in turn, issues ERC20-compatible liquidity tokens to the users, representing their stake in the liquidity pool.
(8) **Trading Operation:** With the system adequately set up, users can now engage in token swaps, as well as adding or removing liquidity.
(9) **Token Swap:** Users have the option to exchange Token A for Token B, incurring a transaction fee of 0.3
(10) **Liquidity Management:** Users are enabled to deposit or withdraw additional tokens to or from the Pair Contract.
(11) **Underlying Tokens Return:** Upon opting to remove liquidity, users destroy their respective liquidity tokens, prompting the Pair Contract to return both Token A and Token B.

This innovative approach to integrating carbon credit trading within a decentralized exchange allows users to engage with carbon finance effortlessly. By making carbon trading more accessible and streamlined, the platform promotes environmental sustainability and a shift towards a greener future. It also provides a foundation upon which policy makers and supervisory agencies can evaluate the effectiveness of current policies and develop new initiatives encouraging a low-carbon economy.

REFERENCES

[1] Gemini [n. d.]. *Decentralized Exchange Platforms in Crypto Trading*. Gemini. https://www.gemini.com/cryptopedia/decentralized-exchange-crypto-dex, https://www.gemini.com/cryptopedia/decentralized-exchange-crypto-dex
[2] [n. d.]. *Remaining Carbon Budget - Mercator Research Institute on Global Commons and Climate Change (MCC)*. https://www.mcc-berlin.net/en/research/co2-budget.html

Received 20 February 2007; revised 12 March 2009; accepted 5 June 2009