Partial$f$: The First Decentralized, Tokenized Derivatives Platform

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September 26, 2021

Abstract

We present our vision for the creation of a series of decentralized derivatives for cryptocurrencies. The advent of such derivatives will provide a stepping stone to more legitimized, mature, and efficient markets. The primary proposal outlined in this paper is a financial product whose aim is to inversely track the movement in the price of an underlying asset. The method proposed to achieve this involves collateralizing cryptocurrencies through the use of smart contracts. This proposal is accompanied by a simple quantity-theoretic argument as well as a more thorough supply and demand analysis, both of which demonstrate the suitability of the proposed method for achieving the desired price dynamics.

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1 Introduction

Blockchain technology enables the transfer of assets across an open financial network without the need for third parties. There has been a significant rise in the number of digital assets existing on the blockchain, and consequently a frenzy of investment and speculation, but investors remain unable to take complex financial positions.

Our vision is for a more developed blockchain financial ecosystem and we will achieve this by establishing a series of decentralized, tokenized derivatives. We aim to create a number of tokens that replicate the behavior of traditional financial derivatives but for cryptocurrencies. Consequently, these types of products will be fungible, trustless, and easily tradeable. Tokens have been pivotal to the cryptocurrency ecosystem and we believe that decentralized, tokenized derivatives will be instrumental to its advancement and maturity. Implementing cryptocurrency derivatives natively on the blockchain permits seamless 24/7 trading of a fungible product while at the same time eliminates the need for any interaction with the traditional financial system or any other trusted intermediary.

Derivatives are vital to financial markets as they give investors the ability to manage risk effectively as well as create numerous avenues for speculation. This allows for more complex positions to be taken, aiding in price discovery and hence improving market efficiency. The traditional derivatives market has grown substantially over the years to be worth an estimated $1.2 quadrillion [1]. These markets are both highly regulated and designed to favor select participants, leaving positions exposed [2]. The aforementioned issues stem from placing trust in centralized actors that may or may not have your best interests in mind.

Decentralized, trustless financial products are an important development for the blockchain space. Currently, there is a severe lack of legitimacy surrounding blockchain as a medium of value storage and transfer. This is partly due to the extreme volatility experienced in the market, the absence of efficient risk mitigation tools, and poorly managed centralized exchanges that can go offline without prior notice, often for unknown and lengthy periods of time. This can leave traders vulnerable due to exposed positions [3, 4].

Partialf will offer a number of decentralized, tokenized derivatives for cryptocurrencies. The first product, CTB, is a fungible token which aims to inversely track the price of Bitcoin. We aim to create a series of fungible tokens offering this derivative type for several cryptocurrencies, such as Ethereum, as well as tokens for other derivative types. In this whitepaper, we put forward our vision and lay the foundations for a more advanced financial ecosystem.

2 Existing Work

The creation of the Osaka Dojima Rice Exchange in 1697 marked the first commodities futures exchange [5] and the beginning of the current financial era. This was followed by a flurry of traditional financial institutions who have, more recently, attempted to create derivative products for Bitcoin. The CBOE and CME listed Bitcoin futures on December 10th and December 17th, 2017 respectively [6, 7]. These are cash-settled futures contracts with the settlement price being taken directly from a variety of centralized exchanges. While these centralized clearing houses have enabled some institutional clients to take positions on the price of Bitcoin, they are costly and vulnerable to systemic risk [8].

An inevitable step in the development of the ecosystem, and the financial products that exist within, has been the creation of stable coins - coins that are designed to offer price stability. There have been numerous attempts to achieve this through different mechanisms such as fiat-collateralized (USDC, Tether), cryptocurrency-collateralized (MakerDao), and non-collateralized (Basis). Some of these embrace the ethos of the system in which they exist while others replicate characteristics inherent in more opaque and old-fashioned trust based models.

The progression towards decentralized derivatives provides many advantages over their traditional analogs. It is counter-intuitive to utilize the decentralized aspects of cryptocurrencies but then has to rely on traditional financial exchanges to provide trading and adequate risk management instruments. In particular, this results in a lack of accessibility in that it most often requires the exchange from cryptocurrency to fiat somewhere down the line, forcing one to exit the ecosystem in order to trade instruments which are derived from the products in the system itself. This is the case with the cash-settled Bitcoin futures currently being offered by CME and CBOE. In addition to this, the lack of derivatives products currently being offered by exchanges is indicative of the custody problem that remains an issue when handling cryptocurrency-settled derivatives. This reflects regulatory concerns surrounding the offering of traditional derivative products through old-fashioned mechanisms - especially in the case of ETFs, which can be seen with the denied Bitcoin ETF proposal from the Winklevoss twins [9].

There have been a number of attempts to create underlying protocols to facilitate the creation and trading of derivative products in a decentralized manner. The majority of these have failed, are seldom used, or are still in the development phase. While many of these startups aim to bring derivatives and other financial products to cryptocurrencies, their focus is on developing underlying protocols to facilitate derivative creation and trading.

One such protocol, dYdX, is attempting to facilitate derivative products for cryptocurrencies. They take the straightforward approach to constructing short-type instruments by simply pairing up participants on opposite sides of a given trade. Their system uses the 0x protocol to allow holders of some cryptocurrency to offer loans to short sellers, with the proceeds of the short sale kept by the system to secure the loan. In this approach, individual lenders and short sellers are directly paired up one-on-one. This immediately implies that lenders and short sellers cannot simultaneously have the freedom to enter or exit their position at will. Lenders have the ability to call in their loans, triggering a countdown forcing the short seller to close their position and repay the loan. The attempted solution to this problem, a reputation system identifying "good" lenders that only call in under-collateralized loans, is vulnerable to a Sybil attack whereby fraudulently-rated lenders could amass sizable loan portfolios for a coordinated call-in, precipitating a short squeeze.

Partialf avoids these problems entirely, allowing both longs and shorts to freely enter and exit their positions, with their action having an effect on the market as a whole but not on any one particular trader with an opposite position.

3 Conversely Tracking Bitcoin (CTB): The First Tokenized Derivative

Our first product, which we term CTB, is a decentralized and fungible token which aims to inversely track the price of Bitcoin (BTC). Broadly, it is designed to have price movements anti-correlated with those of BTC, with the aim of exactly mirroring BTC's price movement. Such a token offers investors an easy way to hedge a cryptocurrency portfolio or income stream (as from mining) or to speculate on price movements. From the short perspective, one can simply purchase CTB tokens on an exchange and no special smart contract interaction or the traditional infrastructure of short selling is necessary. In this respect, CTB is like an inverse exchange-traded product, though the underlying is BTC rather than a stock index.

This product has been chosen as the first derivative to be released because there currently exists no decentralized method of profiting from a decline in the price of an asset on a financial market. Bitcoin has been chosen as the underlying asset in this derivative primarily because the price movement in Bitcoin continues to be a trendsetter for the wider cryptocurrency markets. It is also the most widely-used and popular cryptocurrency to date and appeals to the largest number of investors. However, the following discussion applies quite broadly and inverse tokens for other cryptocurrencies will be constructed in the same way.

In the current state, if one wishes to take a short position on the price of Bitcoin, certain centralized exchanges provide methods of doing so (primarily done using the traditional shorting mechanism of borrowing assets). However, taking a short position using one of these exchanges poses a large number of risks and drawbacks for the user. These include, but are not limited to, the exchange intermittently going offline, the high fees of entering a position, and the financial limits that can be imposed by the exchange. The problem of the unannounced downtime of exchanges for unknown periods of time is common across cryptocurrency exchanges and can leave positions exposed resulting in large losses for the user. In addition to these, an issue which is fundamental to the traditional method of shorting is the asymmetric risk/reward - the user is exposed to the unlimited downside but only limited upside. Our initial product utilizes a system of smart contracts to fix the issues outlined above.

The inverse price mechanism is achieved through a system of smart contracts, called Collateralized Dynamic Debts (CDDs) for reasons explained below, that involve users collateralizing their cryptocurrency assets by posting to a smart contract, allowing them to print a number of fungible CTB tokens (see Architecture below for specifics). These users are the ultimate source of all CTB tokens and, by printing CTB, they incur a debt that must be repaid to unlock the posted collateral as well as an interest fee on this debt. In our system, this debt must be repaid or rolled-over on a weekly basis.

Once generated, CTB can be freely traded and used in the same manner as any other cryptocurrency. The market price of CTB is influenced by two mechanisms in the system: (i) The Target Price, which determines how much collateral is required to print CTB and the value of the fees incurred in doing so, (ii) The Dynamic Debt Rule, which dynamically alters the number of CTB tokens owed on the debt. Both of these mechanisms are designed to anti-correlate CTB to BTC. For example, increases in the BTC price generate a decrease in the Target Price as well as a decrease in the debt owed on all outstanding CDDs, the latter effect tending to decrease the market price of CTB due to the lowered demand to satisfy CDD loans. In this way, CDD holders are effectively long BTC while CTB holders are effectively short. This is made more precise below.

This system is partly inspired by the Collateralized Debt Position (CDP) smart contract created by MakerDAO, so some knowledge of their approach is helpful [10]. As in that system, we utilize a governance token Delta (DLT) separate from the product token (CTB). The holders of Delta vote on system parameters, such as fees and minimum required collateralization, and all fees are paid in Delta.

3.1 Architecture

In this section, we present an in-depth description of the mechanisms behind our first product, CTB, a token designed to perform inversely to the price of Bitcoin.

3.1.1 Collateralized Dynamic Debt (CDD) Smart Contracts

Anyone who is in possession of crypto-assets and wishes to collateralize them and create CTB is able to do so on our platform through the use of a CDD.

A CDD is a smart contract that allows the owner to deposit collateral in the form of some crypto-asset. The user is then permitted to create a number of CTB tokens. The user must maintain a minimum Collateralization Ratio defined by

$$r_C = \frac{C[\$]}{D \times P_T} \geq r_L \tag{1}$$

where $C[\$]$ is the dollar value of the posted collateral, D is the number of CTB tokens printed (i.e., the value of the CTB denominated debt owed by the CDD owner), P_T is the current target price of CTB (defined below in terms of the change in the price of BTC), and r_L is the Liquidation Ratio. The Liquidation Ratio depends on the type of collateral posted. This is generally higher for more volatile collateral but the precise value, as with other system parameters, is determined by a vote of the governance token (DLT) holders.

Aside from the ceiling imposed by this requirement (Eq. (1)), the user can print whatever quantity of CTB they choose. Upon printing the desired quantity of CTB, a loan is added to the loan book on the CDD. Whenever r_C drops below r_L, the loan is put into liquidation and the collateral backing it is used to purchase CTB on the market in the amount necessary to satisfy the debt owed by the CDD holder. The remaining collateral is then returned to the CDD holder, less a liquidation fee. Thus, an active CDD is always collateralized in excess, meaning that the value of the collateral inside the contract is greater than the value of the debt associated with it.

3.1.2 The CDD Interaction Process

We can illustrate the process of interacting with a CDD by following the life-cycle of a loan on the platform.

1. Generating the CDD and Depositing Collateral

    - The user first sends a transaction to Delta to create a CDD and then sends another transaction to fund it with the amount and type of collateral that will be used to generate CTB. At this point, the CDD is considered collateralized.

2. Generating CTB from the Collateralized CDD

    - The CDD user then sends a transaction to retrieve the amount of CTB they want from the CDD. A corresponding loan, tagged with the amount of the loan and the time it was created, is added to CDD loan book. This loan must be repaid in CTB tokens with the amount determined by the Dynamic Debt Rule.

- The CDD user can, in this way, create any desired number of CTB tokens subject to

$$D \leq \frac{C[\$]}{r_L \times P_T} \tag{2}$$

  which is just Eq. (1) rewritten. Here, D is the number of CTB tokens created by the CDD user (i.e., the debt taken on by the CDD user) and r_L is the Liquidation Ratio, which will depend on the type of collateral (i.e., will be different for DAI *vs.* ETH or something more volatile). The Liquidation Ratio for each collateral type is chosen by the DLT token holders.

- Upon taking out the CTB loan, the CDD user incurs an interest fee corresponding to 0.2% per week that the loan is outstanding. This fee must be paid in DLT and this process happens automatically using a portion of the deposited collateral on the CDD to place an order on a decentralized exchange for the necessary quantity of DLT. The amount of this fee is set by the Delta token holders who must balance their dual interests of encouraging system participation *via* sufficiently low fees while also obtaining profit by creating demand for the Delta token.

- If there is more than one loan in the CDD's loan book, the CDD's collateral is smart-apportioned amongst the various loans so that liquidation is automatically avoided or pushed to the smallest value loans first as this is least costly for the user.

3. Paying Down the Debt and Withdrawing Collateral

   - When the user wants to retrieve their collateral, they must first pay down the debt in the CDD. Once the user sends the requisite CTB, the CDD becomes debt free and all collateral can be freely withdrawn, which is accomplished by sending a withdraw transaction to Delta.

4. Rolling Over a Loan

   - Loans must be repaid within the Settlement Period. This time period is set by a vote of the DLT holders; we suggest 7 days. Any debt that remains outstanding after this period of time enters the liquidation process (see section 3.5). CDD holders can alternatively elect to have their loans automatically rolled over so as to avoid the Liquidation Fee. In that case, if a user fails to manually repay their loan by maturity, another loan will automatically be taken out in the amount necessary to repay the first loan. If the user's CDD does not have sufficient collateral for such a roll-over loan, then their initial loan enters liquidation instead.

3.2 Price Mechanisms

CTB is designed to have opposite-direction price movements compared to BTC. As briefly outlined above, we accomplish this *via* two mechanisms: (i) The Target Price P_T, which determines how much collateral is required to print CTB (note the presence of P_T in the denominator of Eq. (1)) and the value of the fees incurred in doing so (see section 3.1.2), (ii) The Dynamic Debt Rule, which dynamically alters the number of CTB tokens owed on all outstanding debt. Both of these mechanisms are designed to anti-correlate CTB to BTC. In this section, we give explicit formulas for the evolution of the Target Price and the Dynamic Debt Rule. In the next section, these choices will be shown to be concomitant under a simple quantity-based model of the price.

3.2.1 The Target Price

The Target Price of CTB is chosen so that, in a given time period, the percentage change in the Target Price is the opposite of the percentage change in the price of BTC during the same time period:

$$P_T(t) = P_T(t - \Delta_t)\left[2 - \frac{P_B(t)}{P_B(t - \Delta_t)}\right], \tag{3}$$

where P_B is the price of BTC and t is the current time, and Δ_t is a system parameter, set once-and-for-all, that represents the duration over which CTB is intended to mirror BTC. In our system, Δ_t is 1 week. As an example, if the price of BTC decreases by 10% over the course of a week, then the target price of CTB will increase by 10% over the same time period.

It is clear that the above Target Price cannot hold if the price of BTC more than doubles, as then the Target Price would have to go negative. To avoid this scenario, we use a Cutoff

$$2 - \bar{\delta}_T \leq \frac{P_T(t)}{P_T(t - \Delta_t)} \leq \bar{\delta}_T \tag{4}$$

where $\bar{\delta}_T$ is some maximum change in the Target Price over the time period Δ_t. If this ratio is 1, then the Target Price is unchanged over the week. Similarly, a doubling of P_T corresponds to a ratio of 2. In our system, the maximum weekly change of P_T, given by $\bar{\delta}_T$ is set once-and-for-all at an appropriate level. For reasons that will be made clearer below when we examine the Dynamic Debt Rule, the dynamics of the Target Price are restricted so that the Target Price will never vary by more than 40% in a given week, i.e., $\bar{\delta}_T = 1.4$.

3.3 Supply and Demand of CTB

In this section, we discuss the consequences of the Dynamic Debt Rule and Target Price mechanisms on the supply and demand of CTB. This will provide a qualitative picture of the net price effects on the CTB token. For these purposes, no knowledge of the particular formulas for the Target Price or Dynamic Debt Rule is necessary. Intuitive explanations based on which direction these change for a given circumstance are sufficient.

3.3.1 Influencing Demand with the Dynamic Debt Rule

When a CDD holder prints CTB, they create a debt that they must repay within a certain timeframe (we will proceed under the assumption that the CDD holder takes steps to avoid entering the liquidation process but will return to this point later). They have thus created a future demand for CTB. The total quantity of CTB demanded by the market Q can be partitioned into the demand coming from the need to satisfy such debts Q_D and that coming from all other demand $\tilde{Q}$ such as from those who wish to hold CTB as a hedge on BTC. We note that Q_D is price-insensitive as the CDD holders must repurchase this quantity or enter liquidation, during which this quantity will be repurchased using the CDD holders' collateral. By the law of demand, we can then write

$$Q = Q_D + \tilde{Q} = Q_D + f(P); \qquad \frac{\partial f}{\partial \tilde{Q}} < 0 \tag{5}$$

where P is the price of CTB and f is the demand function. The logic here is that market participants are less willing to purchase CTB as a short/hedge/speculation when the price of CTB increases and vice-versa. The effect of the Dynamic Debt Rule is to increase or decrease Q_D. An increase in the price of BTC P_B generates a debt decrease which directly lowers Q_D, causing the demand curve Q for CTB to shift to the left (a drop in demand), which tends to lower the price P of CTB. Conversely, a decrease in P_B generates an increase in the debt of CDD holders which directly raises Q_D, causing a positive shift in the CTB demand curve, tending to increase P.

To quantify this increase in demand precisely requires knowledge of the shape of the f function or, taking $\tilde{Q}$ constant, the ratio $\tilde{Q}/Q_D$. Regardless, it is clear that $\tilde{Q}$ won't generally be negligible (unless there is no demand for the CTB token as a hedge or speculative short instrument). Since our system only directly impacts the demand by changing Q_D, a given percent change in outstanding debts *via* the Dynamic Debt Rule will only change the total demand for CTB by a fraction of this percent. This is an important point that highlights the necessity of having a Dynamic Debt mechanism on top of the Target Price mechanism as both work in concert to achieve the desired change in the market price of CTB.

3.3.2 Influencing Supply with the Target Price

The Target Price is the price of CTB if it were a perfect inverse instrument on a weekly timescale (see Eq. (3)). The Target Price is important because it determines the Collateralization Ratio *via* Eq. (1), where it appears in the denominator. Since CDD holders must maintain collateral above the liquidation ratio, $r_C > r_L$, an increase in P_T will cause an instant increase in demand for CTB assuming CDD holders wish to maintain a constant risk of liquidation as measured by r_C. However, this does not alter the total demand in the long run because the outstanding debt, which is denominated and repaid in CTB tokens, doesn't change. Of more importance is the impact of Target Price changes on the supply curve. The relationship giving the price at which a particular quantity of CTB is supplied to the market can be written as

$$S = g(P), \qquad \frac{\partial g}{\partial P} > 0, \tag{6}$$

where S is the supply curve for CTB. As for the demand curve f above, the inequality constraint captures the logic about the impacts of price on supply. In the case of the supply curve g, more demand is unlocked at higher prices and vice-versa. The impact of a change in P_T is to require more or less collateral to create a given quantity of CTB tokens while also increasing or decreasing the loan fee. In fact, we can write the cost of creating a CTB token as

$$\text{Cost} = P_T \times (r_F + r_0 \times r_L)\,, \tag{7}$$

where r_F, r_0, and r_L are the fee rate, the risk-free rate, and the liquidation ratio respectively. The risk-free rate r_0 may sometimes be zero but could be well-approximated by the yield gained from staking in the case of an inverse token for a Proof-of-Stake based coin. The effect of a change in P_T is thus to change the cost of supplying CTB to the market. This shifts the supply curve to lower quantities if P_T increases and higher quantities if P_T decreases. That is, if P_T increases, then the cost of supplying CTB to the market also increases and so at a given market price P, a lesser quantity S of CTB will be supplied to the market and vice-versa if P_T decreases.

We note that the shifts in the supply curve reinforce the effect of the demand curve shift discussed above. That is, if P_B increases then P_T and D both decrease, implying a higher supply and lower demand, both of which tend to lower the price P of CTB. The opposite effect occurs if P_B decreases.

3.4 Price Dynamics Analysis

In this section, we discuss the consequences of the market price deviating from the Target Price. We illustrate how the system is designed so that, if this deviation grows too large, profit opportunities are opened that will tend to be closed by the market, narrowing the deviation.

If the Target Price exceeds the market price, CDD users of path 1 (those that will hold their CTB for the duration of the loan) will tend to produce and hold more CTB to optimize profits (maximize $r_{TM}(t_0)$). These CDD users will then look for a time where the market price exceeds the Target price (minimizing $r_{TM}(t)$), or at least compares more favorably than when they took out their loan, before closing their position and selling any excess CTB for profit. This selling will help drive down the market price back toward the Target Price, where such selling is no longer incentivized.

In contrast, CDD users of path 2 (those that will sell their CTB and rebuy at the end of the loan), will tend to initiate their positions when the market price is comparable to or higher than the Target Price and close their positions when the market price is at or below the Target. As can be seen from Eq. (**??**)), the quotient of the ratio of Target to market price and opening and closing of the position is important for understanding the profit/loss and even leave the trader with a finite gain or loss when the BTC price remains unchanged. Moreover, these users are unlikely to sell their CTB for significantly less than the value of the collateral backing it $r_L \times P_T$, the product of the target price of a CTB token and the liquidation ratio, and are sure to buy CTB above this price point.

Thus, both types of CDD users are incentivized to take actions that keep the market price closely tracking the Target Price. Finally, knowing this property of the system, short-side traders are less likely to initiate a trade (buy CTB) when the market price is significantly above Target, knowing that its tendency to drift toward the Target price will make their purchase ill-timed, and vice-versa when they realize any profits by selling CTB.

3.4.1 Incentivizing Long-Side Participation

As described, all short tokens (CTB) in our system are created by participants collateralizing a contract and taking a long position. That is, our system relies on long-side participation to supply the market with short tokens. This reliance means that there could be more demand for short tokens than longs are willing to supply. Equivalently, the demand curve for long positions need not match the demand curve for short positions. Moreover, relative ease of taking on a passive short position *vs.* the active leveraged long position (simply buying CTB for short exposure *vs.* collateralizing a contract to print CTB for long exposure), is expected to result in additional demand for on the short side relative to the long. The result of such a mismatch would clearly be higher prices of the short token, i.e., a market price in excess of the Target Price.

The analysis of price dynamics above clearly shows how this divergence in market price and Target Price would result in a profit opportunity for prospective longs that would incentivize the creation of more inverse tokens. Only the amount of posted collateral limits the number of available short tokens. Long positions can be initiated or rolled-over at the Target Price, essentially preventing a reverse short squeeze that would otherwise lead to irrational pricing of the inverse token.

Nonetheless, the fundamental structure of our system puts additional burdens on the long positions that the short positions do not face. These include the necessity of dealing with collateralization and time-delimited positions. Most notably, it is the long side that directly pays fees to the system as a percentage of the dollar value of printed inverse tokens (evaluated at the Target Price). However, the burden of these fees can be shifted to the short side by adding a time-decay factor to the Dynamic Debt Rule. For example, we could modify the Dynamic Debt Rule with a linear decay

$$D'(t) = [1 - \lambda(t - t_0)] \times D(t) \tag{8}$$

where $D'(t)$ is the adjusted debt with the time-decay factor and $D(t)$ is the dynamic debt from Eq. (5). The decay parameter λ can then be chosen to facilitate the desired price dynamics. By reducing the number of CTB tokens that longs must repurchase in order to close their position, we lower the demand for CTB. In this way, we can indirectly tax CTB holders so as to shift the burden of system fees to the short side.

Appropriately choosing the value for the time-decay factor λ is a nontrivial task, the solution to which depends on the supply and demand dynamics. Our upcoming simulation paper analyzes a variety of possible settings for this factor and the results can be used to inform this choice. Moreover, this factor λ can itself be time-dependent, determined *via* a feedback system sensitive to the recent demand and price movements of CTB. Such a system can be combined with techniques from the well-developed field of feedback control theory to provide the desired price mechanics and stability.

3.5 Liquidation

To ensure that the system's pricing mechanisms continue to suitably impact the price, the outstanding debts of CDD users must be repaid. Otherwise, the total amount of outstanding CTB could become un-anchored, making the system's automated contractions and expansions of supply and demand (*via* the Target Price and Dynamic Debt Rule) less effective with time as there are more and more surplus CTB tokens on the market. To prevent this from occurring, a number of precautions are taken which are discussed in this section.

We first note that CDD holders can always bail themselves out to prevent a default by posting new collateral and printing new CTB, which they can effectively do at the Target Price. Thus, if the market price of CTB has spiked due to some irrationality or illiquidity of the CTB market specifically while the Target Price, which is a direct function of the change in the price of BTC, remains less volatile, the temporary condition can be waited-out by rolling over the position. Nonetheless, CDD holders will have an economic incentive to default on their loans if the sum of the value of their debt and the cost of maintaining it, both evaluated at the Target Price, exceeds the value of their collateral.

Second, as noted in section 3.1.1, there is a system parameter called the Liquidation Ratio, which is chosen by a vote of the DLT token holders and may be different for each type of collateral, that determines the minimum amount of collateral required to take out a loan of a given quantity of CTB according to Eq. (1). The Partialf Platform compares the Collateralization Ratio of each outstanding loan to the Liquidation Ratio and, if the former is smaller than the latter, that loan is liquidated. The purpose of the Liquidation Ratio is thus to stipulate a minimum "cushion"; it must therefore neither be set too low, as market volatility could lead to frequent defaults, or too high, as the opportunity cost would disincentivize participation in the system.

The liquidation process itself consists of the Partialf Platform automatically using the collateral attached to the CDD to trade for CTB tokens. A quantity of CTB tokens sufficient to discharge any outstanding debts on the CDD is purchased in this way. Because the debt is dynamic, there may well be some small amount of CTB tokens remaining after the debt is paid down. Any such excess CTB along with the remaining collateral (whatever was not used in trading for CTB to satisfy the debt) is returned to the CDD, unencumbered and ready for withdrawal or further use by the CDD holder. To strongly disincentivize CDD users from allowing their loans to fall into liquidation, the system applies a Liquidation Fee to all loans in liquidation. This fee is calculated as 5% of the value of the loan at closing.

In the event of rapid price movements, a problem arises: what if the system cannot liquidate the collateral fast enough to repurchase the required amount of CTB? We are left with the same problem of an uncontrolled CTB supply. This highlights the importance of the Liquidation Ratio. It must be chosen sufficiently high so that such occurrences are rare but not so high that the costs of creating CTB are prohibitive (see section 3.3.2). Since the Liquidation Ratio is chosen by the DLT token holders, responsible governance is key to the system. Of course, DLT token holders have an incentive to set the Liquidation Ratio low so as to attract more CDD users to take out loans and generate fees.

Since the DLT holders are responsible for setting the Liquidation Ratio and benefit from the fees generated by the system, they bear the ultimate responsibility for ensuring the repayment of all CTB loans. In the event that an under-collateralized loan enters liquidation and the collateral proves insufficient to repurchase the owed quantity of CTB, DLT tokens are created and automatically exchanged for CTB to fill the gap and satisfy the debt in full. This both ensures that the supply-demand feedback mechanisms in the system continue to operate on every loan and incentivizes the DLT holders to choose the system parameters wisely, helping to ensure stability.

4 Delta Token Governance

In addition to receiving the interest fees associated with active CDDs, the DLT holders also implicitly govern the system and decide the values of select parameters. This is done through voting for a smart contract which has the power to modify the internal system parameters. It is also possible for Delta holders to proxy vote by delegating their voting power to another user.

Any account on the Ethereum network is able to broadcast a smart contract which proposes modifications to the system parameters. Holders of the Delta token are then able to use their holding power to vote on a contract which they believe optimal for the system. The contract with the largest number of votes is then chosen to implement the hard-coded system parameters.

The Delta token grants the holders proportional voting power over the following system parameters inherent to the system:

1. Maintaining the Oracle Pool: The nodes that comprise the Oracle Pool are decided upon by the holders of the Delta tokens. This collection of oracles provide data from the external world regarding the market price of cryptocurrencies.

2. Interest Fee Determination - r_F: The percentage fees required to write a new CDD are decided upon by the Delta holders. This fee is quoted in percent per week and is applied on the base amount of the product of the number of CTB tokens loaned out and the Target Price $D * P_T$

3. Creating a template for instances of a new class of CDD object: Delta holders have the ability to create a template for CDDs for a new token. All Delta holders then vote to determine the collateralization type and the liquidation ratio for the new type of specific CDD.

4. Alteration of an existing type of CDD: Holders can vote to modify the attributes of each class of CDD instances, including the fees, and the liquidation ratio associated with the particular CDD.

5 Oracles and Pricing Data

Blockchains are entirely self-contained in that all of the information that the blockchain has access to is limited to what, itself, is included in the blockchain. For example, there is no inherent way for a blockchain data structure to know whether there was a protest in Berkeley today, it must interact with the external world to gain this information since the outcome ultimately depends on whether or not a protest did actually occur in Berkeley today (it did).

Oracles and information-sourcing devices will need to be utilized in our systems in order to fetch the price of cryptocurrencies from exchanges. In our proposal of CTB, the price of Bitcoin (and the collateral) must be known at all times in order to adjust the debt associated with a CDD accordingly and also to ensure that the liquidation ratio of any given CDD is not violated.

One way to source this data is to fetch the market price from an exchange (or some weighted average across exchanges) by using the APIs that are currently available. This has the advantage of being convenient and instantaneous, however it also comes with drawbacks. This method of interacting through APIs takes away from the decentralized aspect of the system. It places trust in a centralized third party who would be able to manipulate the functioning of our system at will. Using a well-known exchange may mitigate against these risks slightly, but the fact that such a situation could even hypothetically occur is a deterrent.

Another potential way is to use Reality Keys which was proposed by Edmund Edgar in 2013 [11]. This utilizes a game-theoretic system of agents outbidding each other in favor of correct information. However, if the information markets are not efficient then the agents providing the misinformation may have greater capital to stake than the agents with the correct information are able to post. In the event of indecisiveness, human intervention occurs which undermines the goal of decentralization. It is also infeasible to use this method to continuously fetch the price, given the discrete time nature of Reality Keys.

Another, more theoretical, approach which was also proposed by Edmund Edgar is one in which capitalizes upon the democracy embedded in blockchains (via the ability to hard fork and choose to operate on the chain which correlates with reality) [12]. An issue with this is the complexity of the system and the problem as to whether the outcomes of the empirical model would reflect that of the theoretical model.

We chose to adopt a method of incentivizing users within the system itself to provide correct information. This makes use of a large collection of independently acting oracles that are voted for by the Delta holders. The Delta holders are in control of how many actors make up the set of oracles and they also decide who exactly those actors should be. Given that the 'correct' information will be perceived to be the one with the most votes from the oracles, it follows that the Oracle Pool allows for up to 50% of malicious actors before the system is at risk. This method reinforces the decentralized nature of the system and it capitalizes upon the aligned incentives.

We are looking into ways of streamlining this process and to reduce on-chain congestion associated with the oracle feeds such as having them aggregate data on a side-chain and then compute and submit a verifiable proof of the data to the main chain. This reduces the number of transactions on the Ethereum chain from n (where n is the number of nodes in the pool) to just 1.

6 Use Cases

We envisage early adopters of our system as cryptocurrency funds, stakeholders, enthusiasts, and traders. Average crypto-investors might wish to purchase CTB to hedge existing holdings of the underlying asset or obtain a profit from a decline in BTC. They may also interact with our system as a CDD user to gain leverage on the long side. Miners provide another strong use case as mining provides a future income stream denominated in a crypto-asset. This future income could then be hedged to reduce the risk inherent in mining. Finally, we believe that hedge and investment funds active in the crypto space will find the possibilities our product opens up to be very useful and we believe they will form a substantial part of the market for our products.

7 Future Development

In this whitepaper, we have mostly described a token designed to mirror the price performance of Bitcoin, CTB. Obviously, there is nothing particular about Bitcoin that makes our system uniquely suited to it compared to other cryptocurrencies. Following the implementation of CTB, we plan to introduce analogous inverse tokens for a number of other cryptocurrencies, focusing on the most heavily traded as our system is expected to operate more effectively in more liquid markets.

An inverse token for Ethereum in particular is a natural extension due to its market-leading position and growing network. The volatility of Ethereum reduces its capacity to act as a widely-used applications platform and the availability of an inverse mechanism would allow hedging. This would then permit the cost of running the numerous dApps on the Ethereum network to be hedged against, a very useful ability for any regular users of such dApps. Also of note, Ethereum could itself be used as collateral on a CDD for an Ethereum inverse token. This would create additional leverage for the associated long position.

8 The Team

The team currently consists of a group of individuals from Blockchain at Berkeley. They are experienced, working at a number of leading financial institutions and blockchain companies, between them.

Sebastian Isaacs, co-founder, was an early investor in Bitcoin and Ethereum. He co-founded London Blockchain Labs and also led various technology ventures, including into one of the UK's largest forums as well as an online financial news outlet. Previously, he worked at Citibank as well as a P2P payments company based out of Berlin, now part of Klarna.

Joseph Plaza, co-founder, has been active in the space since 2010 with a focus on advancing Bitcoin protocols. He helped set up the first online Litecoin exchange in 2012 and has founded a variety of tech-based companies since. He has also worked at Fidelity International in the multi-asset division with a focus on fixed income.

Kochise Bennett, co-founder, has a Ph.D. in physics and is currently a post-doctoral research fellow at UC Berkeley. He has over 25 peer-reviewed publications in a variety of high-impact academic journals. His current research is in applying state-of-the-art machine learning techniques to predict properties of complex systems, with a focus on deep neural networks.

Luke Strgar, CTO and a recent graduate of the University of California, Berkeley's Computer Science Program. He co-taught a one of a kind course at UC Berkeley on solidity and distributed application development. He was recently invited to Washington D.C. to discuss his blockchain projects with Federal Legislators. Luke previously worked as a researcher in the public health department focusing on mathematical and computational models of infectious disease transmission.

Andrew Tu, Head of Marketing, has previously worked in the investment banking division at Morgan Stanley and Orient Securities as well as Huaxin Securities in Beijing. He was a founding member and the previous Head of Marketing for Blockchain at Berkeley. He originally joined the Bitcoin Association of Berkeley in 2014 out of a passion for the Austrian School of Economics.

9 Summary

Partialf is a decentralized derivatives platform that plans on launching a range of tokenized derivative types. The first such derivative is an inversely traded token, CTB, that inversely tracks the price of Bitcoin. It will be shortly followed by several others, including an inversely traded token for Ethereum. While the system exists and operates independently of Partialf, we also plan on creating a platform with a user interface for writing, settling, and trading these derivative products.

It is clear regulators across the globe are looking into cryptocurrencies. Accordingly, we are placing a strong emphasis in the coming months on navigating complex regulatory framework. Before the launch of the Partialf Platform, we will be consulting with a distinguished and experienced legal team to ensure the Partialf Platform is in line with the legal requirements of the jurisdictions in which we are based and operate.

After the launch of our inverse tokens, we will turn our attention to researching other types of decentralized derivatives systems. All of the research, tests and project code will be made open-source to allow for development of these products by the community.

Our code throughout this process will undergo rigorous testing and multiple independent security audits from a variety of world-class security experts in addition to expected scrutiny from the cryptocurrency community given the open-source nature of the project.

Glossary

Collateralization Ratio The ratio of collateral (in dollars) to debt (in dollars), with debt valued at the Target Price. Symbol r_C, formula in Eq. (1).

Collateralized Dynamic Debt (CDD) A smart contract to which a user can post collateral, allowing them to then withdraw a number of CTB tokens that depends on the Target Price and the type and amount of collateral posted.

Conversely Tracking Bitcoin (CTB) A token designed to mirror the price performance of Bitcoin over a given week.

Cutoff The maximum change in the Bitcoin price for which the Target Price and Dynamic Debt Rule formulas are active. This is effectively the maximum price change registered by the system in a given week. This value is 40%. Symbol $\bar{\delta}$.

Delta (DLT) The governance token on the Ethereum Network used for voting on system parameters, such as the fees and Liquidation Ratio. Fees on CDD loans are paid in DLT, with the collected DLT being burnt. Serves as a fail-safe against under-collateralized CDD loans as DLT is printed and used to repurchase CTB in the amount required to satisfy any defaulted loans.

Liquidation An automated process whereby collateral attached to a CDD is used to purchase CTB on the market. The purchased CTB is used to cancel debts on the CDD that are currently in liquidation. Any excess collateral is returned to the CDD at the end of the liquidation process. This process occurs automatically, without the CDD holder's permission, when the Collateralization Ratio of a loan drops below the Liquidation Ratio.

Liquidation Fee A fee that is applied when any loan enters liquidation. The fee is calculated as a percentage of the final debt and is paid in DLT tokens, which are burnt upon payment. This fee is voted on by DLT holders but initially set at 5%, high enough to disincentivize defaults but low enough so that it doesn't require that the Liquidation Ratio be raised significantly to ensure fee payment.

Liquidation Ratio The minimum Collateralization Ratio that a loan must maintain. Loans that fail to maintain a Collateralization Ratio above the Liquidation Ratio enter the liquidation process. Symbol r_L.

Oracle A decentralized or third-party data feed service that provide external data to the blockchain.

Oracle Pool A collection of nodes providing an oracle service to the blockchain. The number of nodes, and who these nodes are, is determined by a vote of DLT token holders.

Partialf The team committed to the development and successful launch of the Partialf Platform.

Settlement Period The maximum duration of a CDD loan and the time period Δ_t used to determine the Target Price. Once it is set for a given token it cannot be changed.

Target Price A parameter in the system that represents the intended price movement of the inverse token. Combined with the Loan Fee it determines the price of printing new CTB and determines the minimum required collateral to print a given quantity of CTB tokens *via* the Collateralization Ratio.

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