Fair Price Discovery with Decentrlized Exchange

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Abstract

Ever since bitcoin solved peer to peer digital cash was possible, poeple have been trying to apply similar technoques to solve other hard problems. One such problem, peer to peer exchange, is one of the most difficult of these problems.

An exchange is a financial market, where trading of securities occur. The pupose of an exchange is two fold. 1) for price discovery, 2) for counter party settlement..

Centralized Exchanges (CEX), have been well researched and developed in traditional finaince for well over a century. [exchage cite] They evoled from trading under a tree, the Chicago trading pits, to electroic exchanges with continuous limit order books. Modern exchanges provide 24/7 trading, and offer co-location for the most prolfic traders, High Freaquency Trading (HFT) bots.

Decentralized exchange (DEX), aims to bring tradition centralized exchanges into a peer to peer blockchain protocol. Due to early bitcoin CEX hacks, most DEXs have been focused on the settlement utility of exchange. As price discovery is an emergent property of the real-time trading and difficult to research.

We present a DEX with focus on providing price discovery. Our solution, Fair Price Disovery (FPD)

1 Introduction

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The word "central" is part of the common definitio of an exchange. "A central place where buying and sellers come to finf price and execute trades.

The pupose of exchage is two fold. 1 - for price disoverry [cite] 2 - for counter party settlement

Due to early bitcoin exchange hacks, Decentrlized Exchange or (DEX), has been mostly focused on the non-custodial side for the settlement utility.

We focusing on the real public service of an Exchange, the price disovery utility. We design price discovery within a DEX, with a pupose of "Fair Price Discovery".

With, Fair Price Disovery (FPD), as our goal. We focus on a mechanism designed exchange, for reaching equalibriam which produces price.

Taking inspiratiuon from Rational Protocol Design analysis of Bitcoin, and looking back to the origional Bitcoin white-paper.

examaning the state of teh art in price-disovery, High Freaquernncy Market Making, and electronic exchange matching engines

Since Bitcoin showed us how peer to peer electroic cash was possible, we have researching if and how peer-to-peer exchange was possible.

Exchanges are a critial part of the finanical markets.

Ecological balalnce otherwise the order-driven market can colapse Transparency is an importtant feature

first to win is most important

Price Discovery

Price disovery as a key goal in the design of the market structure. In fact, the goal of the architecure of an exchange meachanism, is to attract as much liquidity needed to for price discovery. [3]

Price discovery is described in microstruture research as a search for an equalibrian price, from new external information. This new information is reflected in the traders orders, and is ultimatly coverted into a market price. [5]

> price discovery is dynamic in nature, and an efficient price discovery process is characterized by the fast adjustment of market prices from the old equilibrium to the new equilibrium with the arrival of new information [6]

> From a definitional perspective, any trading facility that has as its primary function the delivery of good price discovery can, de facto at least, be considered an exchange. Unfortunately, however, the price discovery function of an exchange typically receives insufficient attention in market structure discussions. This is largely attributable to the non-observability of equilibrium prices and, therefore, to the difficulty of quantifying the deviations of transaction prices from their equilibrium values [3]

Limit order books and price discovery are tightly related. [5] [4]

To achive price discovery exchanges offer two order types. Limit orders, and Market orders. All orders are sent to a centralized matching engine in the exchange servers.

Market orders have a quantity but no price.

1. "Buy 1 @ market" - an order to buy 1 unit of the asset at the market

Limit orders have a quantity and a price.

1. "Buy 1 @ 100" - an order to buy 1 unit of the asset at the market

Continuous limit order books (CLOB) are the market micro struture that leads to price discovery [1]. There are two order types. Limit orders, where you provide your own price, with the risk of waiting to be matched. And market-orders, where you get filled immediatly in return for a possible worse price.

Directional liquiidy traders - use market orders Market Makers - use limit orders

HFT-bandit

Adverse Selection Show HFT Alpha Show how market-orders are the cryponite

Perfect Alpha and the High Freaquency Trading (HFT) arms race

We define *Perfect Alpha* as recurring risk-less real-time arbitrage with positive EV. Beleive it or not, *Perfect Alpha* is a product of centralized exchanges and continous limit-order books.

Theorem 1 *When 2 or more orders coem in after your order, there exists a free arbitrage, provided 1) each order is for 1 share at a time, 2) you are first to act. Perfect Alpha exists in Continous Limit Order books.*

1. HFT - "Buy 1 @ 100"

[1] Other types of markets such as call auctions, and dealer markets, dont provide the robustness of limit orders for price discovery. [2]

2. Bob - ”Buy 1 @ 100”

qty	bid	ask	qty
2	100		

1.1 Decentralized Limit Order Books

make these problems much worse, by removing the one defensive market-order

1.2 Standard Blockchain Solutions

1.2.1 Permissionless

Ethereum smart contracts create MEV

MEV and front-running

Uniswap -

Total Ordering Consenusns

1.2.2 Permissioned blockchains

remove the issues with open blockchains, and uses BFT techniques

1.2.3 Why does bitcoin work

Only when asking why? do we come with a new theory *Ration Design*

1.2.4 Why does it not work with Ethereum, Aequitas and BFT?

Theproblem is abtractions. Solving generic solution with frameworks vs solving for a spefici utility

2 A new blockchain abstraction

Only when designing for a specific utility are we able to use designer intent vc averserial modiivations

1. First design with intent using Mechanism Design

2. Release the code and protocol

3. Test results from empiracle evidense

We now have mechanism designed system that matched a reational design theory of decentrlaized exchange.

3 Fair Price Discovery

3.1 Preliminaries

Order book transaction are like advertisements. Sender wants to broadcast intent. Intent of other seeing your transactions eliminates the commit/reveal strategies

1. Full transpareency - no commit-reveal
2. Remove rent-seeking co-location
3. Acknolege impossibility of total-ordering Consenusns
4. Make front-runnig explicit, but limited to reording - no inseting new orders

Centralized matching gives market-order privacy in return for co-location issues Decentralized matching removes co-location advantage in return for loss of market-order privacy

Covert Adversaries we learn that just being able to show cheating can reduce it.

3.2 On-Chain Solution

We focus on solving for decentralized matching engine that results in price discovery. Note, an on-chain solution with assets controls by the procol eliminates the centralized custody and settlement issues.

Goal is to eliminate front-running when there is consensus on order, and allow explic front-running where total order consensus is not possible.

Step1: Hybrid blockchain, acts permissioned with BFT consensus by each node selecting quarum slices (Stellar) Step2: Node select quarums based on reputation and trading activity. Bigger trading operations with good uptime, and heavy volume, will be sleected by many. Step3: Reach consensus on mempool on past 5 seconds. Step4: Pay to re-order blocks by bribing bitcoin miners, or paying centralized exchange operator or buring coins.

3.2.1 Order transaction types

- limit and mraket and cancels.

Buy 1 at 100 Sell 1 at 101 Sell 1 at market Cancel order

Seperating consensus on the orders from the state and result of thos orders.

Order-book is determinisitic based on the set of trasnactions and the ordering of those trasactions

As a new on-chain protocol, with no dependance on smart-contracts or layer 1 like ethereum. The state and code is contained within the node.

Node maintains a matching-engine and the state of the market in real-time. Nodes gossip they ordering in the background - this is not used for consenus but for preventing covert adversaries Node reach quarum with slices on mempool Nodes use results of auction, for reordering block

Node maintains multiple states by looping over all permutations. Most permutation will not change the state. When a permutation changes state the node will compare results and pur a value on the reults - and enter auction when needed.

Honest nodes will agree to default to actual real-time "true" orderings.

Example Honest Front-running Limit order cancelled immediatly after getting filled by a market-order

Example Dis-Honest Front-running Limit order inserted with a higher price to standing limit-order to front-run the fills, due to new market move

In this example, the adversary will try to get a new order in at the end of the time-block. Note: doing this immediatly becomes honest front-running

Difference between honest and dis-honets front-running, is when

Example2 Dis-Honest Front-running Limit order cancelled immediatly after getting filled by a market-order, but gossiping the cancel before gossiping the market order.

3.2.2 Designer intented result

is a decentralized matching engine where no front-running occurs in real-time.

No advantage to real-time front-runnings Disadvantage by losing honest reputation, where nodes will not sure to add you to their quarum slice.

3.2.3 note

note how we dont have liveleness or consitancy or censhorship resistance guarnetees, as those are concepts for the design of protols with differant utilities. As we are seeking the utility of Fair Price Discovery from a decentralized on-chain blockchain matching engine exchange protocol.

4 Results

[1]

References

[1] Jing Chen and Silvio Micali. ALGORAND. `https://arxiv.org/pdf/1607.01341.pdf`, 2017.

[2] Thierry Foucault, Ohad Kadan, and Eugene Kandel. Limit order book as a market for liquidity. Post-print, HAL, 2005.

[3] Reto Francioni and Robert A. Schwartz. *Equity Markets in Transition The Value Chain, Price Discovery, Regulation, and Beyond*. Springer International Publishing, 2017.

[4] Kenneth French and Richard Roll. Stock return variances: The arrival of information and the reaction of traders. *Journal of Financial Economics*, 17(1):5–26, 1986.

[5] Andrew Lo, A. Craig MacKinlay, and June Zhang. Econometric models of limit-order executions. NBER Working Papers 6257, National Bureau of Economic Research, Inc, 1997.

[6] Bingcheng Yan and Eric Zivot. The dynamics of price discovery. Working Papers UWEC-2005-01-R, University of Washington, Department of Economics, 2007.