It is my pleasure to finally share with you our research paper, [Combinatorial Auctions without a Numeraire: The Case of Blockchain Trade-Intent Auctions"](#)

The paper's main motivation is to study the "optimal'' design for trade-intent auctions. This turned out to be a difficult task due to two specificities of these auctions:

- They are combinatorial since the quality of execution of a trade by a solver depends on the other trades that this solver also executes (due to coincidence of wants, gas savings, …). So, for example, a solver may bid differently on a trade when this trade is auctioned off alone vs when this trade is part of a batch.

- They lack a numeraire that can be used to reallocate the efficiencies of batching among the different traders. In trade-intents auctions, different traders demand different assets, and trading one asset for another is subject to friction and fees. Because of this, the solution that maximizes surplus may be worse for some traders than another solution. This is a well-known problem that CoW Protocol currently tackles with [an EBBO test](#): an ex-post test checking that each trade on the batch receives an execution above a minimum quality. But there are a few problems with this approach. First, it is an element of centralization. Second, from the mechanism design perspective, the "minimal quality of execution'' is determined by the protocol and not by solvers. But solvers are better informed than the protocol regarding prices, and what constitutes a good or bad execution given the current market conditions. Ideally, therefore, such "minimal quality of execution'' should be elicited from solvers.

We started by building a theoretical model of trade intent auctions with possible complementarities between trade intents. We then used this model to study the two most common auction formats:

- batch auctions, in which different trade intents are auctioned off jointly as a batch,

- individual trade-intent auctions, in which there is a separate auction for each trade intent (of which Dutch auctions are a subcase).

At a superficial level, one could think that holding individual trade-intent auctions is better whenever different solvers are specialized in different orders, because different solvers may win different orders. Batch auctions, instead, are better at exploiting the complementarities between various orders. This reasoning, however, misses an important element: when the benefit of specialization is strong, competition is low in the individual trade-intent auctions. In other words, specialization implies that, in each standard auction, there is a "leader" who can win the auction easily — that is, can win while returning significantly less than the tokens it produced. On the other hand, batching forces all solvers to compete: each "leader" in a given type of trade needs to outbid the other leaders to win any trade. Hence, solvers have a higher incentive to bid (and return a higher fraction of the assets produced) in the batch auction relative to the simultaneous individual trade-intent auctions. At least under the assumptions of our model, we find that batch auctions always deliver a higher surplus than individual trade-intent auctions (such as Dutch auctions).

At the same time, in the absence of additional elements such as the EBBO test discussed earlier, in a batch auction the solvers' payoff only depends on the value of the assets returned to the traders, not how this value is shared. Therefore, the benefit of the batch auction may accrue disproportionally to one trader, leaving the others worse off relative to the simultaneous standard auctions. At an intuitive level, such an outcome seems unfair.

We then use the model to study a new type of auction: the fair combinatorial auction. This type of auction can be seen as a combination of batch auctions and individual trade-intent auctions because solvers are allowed to submit multiple bids, both on individual trades and on batches of trades. The key assumption is that the outcome of the individual trade-intent auctions (as constructed using the individual-trade bids) is used to filter out batched bids: batched bids are considered by the auctioneer only when they are better than the outcome of the individual trade auctions for all traders in the batch. The outcome of the individual trade auctions can therefore be seen as a benchmark for fairness: all batched solutions that improve upon this outcome for all traders are "fair'' and considered in the auction, and all other batched solutions are discarded as "unfair''.

The problem is that even if the mechanism is a combination of batch auctions and individual trade-intent auctions, we shouldn't expect its outcome (or, technically, its equilibrium) to be simply a combination of the outcome of the batch auctions and the outcome of the individual trade-intent auctions. The reason is that solvers anticipate that their bid on the individual trades will be used to construct the reference for fairness. Hence, they may bid differently from the simple individual trade auctions (with no batching possible). In designing such an auction, it is crucial to properly account for these novel strategic incentives, as they matter for what fairness guarantees the auction provides in equilibrium.

For example, we show that when the individual trade-intent auctions are second-price auctions, the fair combinatorial auction does not provide any additional guarantee relative to the simple batch auction. The reason is that there are equilibria in which all solvers bid the minimum amount on individual trades, which is equivalent to skipping the individual auctions and only having a batch auction. If the individual auctions are in second price, then no solver can change this outcome by changing its bid on the individual auctions.

Instead, when the individual trade-intent auctions are first-price auctions, each solver can manipulate the reference for fairness with its bids on individual trades, independently of the bids by other solvers. We show that, in this case, the fair combinatorial auction guarantees that all trader receives more

than what they would earn in the individual trade auctions (like the Duch auction run by 1inch or Uniswap X).

The bottom line is that even though not all fair combinatorial auctions provide strong fairness guarantees in equilibrium, some do. Knowing this, we can now start studying how to evolve CoW Protocol's mechanism to provide within mechanism

fairness guarantees instead of relying on the EBBO test.