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The Ultimate Guide to Prediction Markets¹

- What is a prediction market?
 - A prediction market is a marketplace for buying and selling shares in predictions, whereby shares and payouts dependent upon future events.
 - A prediction market absorbs the world's information to make predictions
 - In a stock market, you get shares in a company, whereas in a prediction market, you get shares in the outcome of a future event.
 - Two types of shares: YES (long) and NO (short).
 - Payouts are dependent upon outcome occurring or not occurring.
 - The price of a share is directly proportional to how likely shareholders believe the outcome in question is to occur.
 - Price equals perceived probability (e.g., if each YES share costs 75 cents, that means the market thinks there's a ~ 75% chance that the outcome will occur).
 - The price is an equilibrium that represents the highest price buyers will pay and the lowest price sellers will accept.
- Why are prediction markets useful?
 - They offer alternate forecast: prediction markets often foreshadow the future
 - They are 'quite accurate': studies indicate that prediction markets outperform traditional, centralized forecasting methods (e.g., orange juice futures produce more accurate weather predictions than National Weather Service).
 - They provide economic incentive to 'bring truth to light' by compensating good predictions and imposing costs for bad ones, prediction markets reward greater leverage to so-called superforecasters over time while discouraging dishonest or inaccurate ones.
 - They produce knowledge: for instance, prediction markets on the weather might motivate meteorologists to develop improved forecasting models on it.
 - They aggregate information by economically incentivizing a diverse crowd to disclose private knowledge and do so as soon as possible.
- The limits of centralized prediction markets
 - Closed: subject to borders, capital controls, and regulation.
 - Constrained/Censored: limited predictive power.
 - Costly: fees discourage participation.
 - In sum, illiquid: centralized prediction markets are illiquid and only centralized operators can make markets.
- The advantages of decentralized prediction markets:
 - Open: ownerless entities free of centralized planners; stock market alternative
 - Free: minimal fees, trending toward zero over time.
 - Reliable: eliminates custodial risk.
 - Resilient: resistant to censorship and corruption.
 - The magic: a borderless liquidity pool that serves as an efficient market for absorbing and aggregating the world's information.
- The rise of decentralized prediction markets:
 - Ethereum facilitates self-executing 'smart contracts' written in and enforced by code rather than third parties and are guaranteed to execute as written.
 - No "code behind closed doors" as with a Facebook or Uber. Everything is open.

¹ <https://www.augur.net/blog/prediction-markets/>

- A DPM is, in essence, a set of smart contracts that say who gets paid how much under what conditions.
 - DApps replace centralization with code, cryptography, communal incentives.
 - DPM protocols built on Ethereum include Stox, Gnosis, and Augur
 - Related protocols on other blockchains include Hivemind (built on Bitcoin) and Bodhi (built on Qtum).
 - These are early days for DPMs — just as early iPhones traded off screen size and computing power for new features like portability and GPS, today's blockchains trade off speed and efficiency for trust and resilience. Due to scalability issues, DPMs today can be slow and costly to use. But these are issues that can and will be resolved with time.
- Solving the oracle problem:
 - An oracle is whatever feeds truth about the real world into a blockchain.
 - In a centralized market an operator decides which outcome occurred. A DPM is a set of smart contracts that say who will get paid how much if X or Y event occurs, but there is no operator. This is a facet of the oracle problem.
 - There are different ways to solve this challenge. Augur, for example, uses an incentivized communal resolution system.

Prediction Markets² (Wolfers and Zitzewitz)

- Foreward
 - Prediction market/information market/event futures are markets where participants trade in contracts and payoffs depend on unknown future events.
 - Efficient Markets Hypothesis: in a truly efficient prediction market, the market price will be the best predictor of the event.
 - Summary: this paper describes the types of contracts that might be traded in prediction markets, shares findings from experiments, raises market design issues, and concludes with evidence on limitations of prediction markets.
- Types of Prediction Markets
 - Three types of contracts, where price represents probability, mean or median
 1. Winner-take-all: payoff occurs if event occurs or does not occur (e.g., whether a candidate wins an election). The contract price represents the market's expectation of the probability that the event will occur.
 2. Index: payoff varies based on a number that rises or falls (e.g., percentage of a vote received by a candidate). The contract price represents the mean value that the market assigns to the outcome.
 3. Spread: traders bid on the cutoff that determines whether an event occurs (e.g., whether a candidate receives more than a certain % of the popular vote). When spread betting is combined with an even-money bet (aka winners double money while losers receive zero), the outcome can yield the market's expectation of the median outcome.
- Applications and Evidence
 - Famous prediction market: the Iowa Electronic Market, which has yielded very accurate predictions and outperformed large-scale polling organizations.
 - Prominent examples of companies that provide a range of trading and gambling services: tradesports.com, betfair.com, and pseudomarkets (trading with virtual currency) such as newsfutures.com and ideosphere.com
 - Some prediction markets focus on economic statistics (e.g., Goldman Sachs and Deutsche Bank have markets on the likely outcome of future readings of statistics such as employment, retail sales, production, inflation, etc.)
 - The Hollywood Stock Exchange allows people to use virtual currency to speculate on movie-related questions (e.g., opening weekend performance, total box office returns, and who will win Oscars).
 - Possibilities for arbitrage: prediction markets present few opportunities
 - Evidence from psychology and economics suggests that people tend to overvalue small probabilities and undervalue near certainties (in other words, bettors tend to overvalue extreme long shots aka long-shot bias).
 - 'Volatility smile': suggests that prediction markets may perform poorly at predicting small probability events.
 - A further possible limitation of prediction market pricing arises if speculative bubbles drive prices away from likely outcomes.
 - Empirically, prediction market accuracy is, on average, 'pretty good,' whether or not specific markets were in some cases distorted by biases or bubbles.
 - Attempts at manipulating these markets have been largely unsuccessful — and instances for which they have represent the maturity of the market.

² <https://www.dartmouth.edu/~ericz/predictionmarkets.pdf>

- Market Design
 - Success of prediction markets depends on design and implementation.
 - Key design issues include how buyers are matched to sellers, the specification of the contract, whether real money is used, and whether a diversity of information exists in a way that provides a basis for trading.
 - In most prediction markets, the mechanism that matches buyers to sellers is a continuous double auction with buyers submitting bids and sellers submitting asking prices, and with the mechanism executing a trade whenever the two sides of the market reach a mutually agreeable price.
 - With respect to economics, prediction markets operate like pari-mutuel systems that are common in horse-race betting — all of the money that is bet goes into a common pot and is then divided among the winners.
 - For a prediction market to work well, contracts must be clear, easily understood, and easily adjudicated.
 - Real money vs play money: play money exchanges may outperform real-money exchanges because 'wealth' can only be accumulated through a history of accurate prediction.
 - Even well-designed markets will fail unless a motivation to trade exists (e.g., inflation futures market on certain commodities — little volume led to failure)
 - Prediction markets will likely work better when they concern events that are widely discussed, since trading on such events will have higher entertainment value and there will be more information for which sufficient volume exists.
 - Attempts to set up markets on topics where insiders are likely to possess substantial information advantages have typically failed.
 - Power of prediction markets derives from the fact that they provide incentives for truthful revelation, information discovery, and aggregated opinions.
 - Prediction markets are unlikely to perform well when there is little useful intelligence to aggregate or when public information is inaccurate/misleading.
- Making Inferences from Prediction Markets
 - Results from prediction markets can aid planning (e.g., expectations of future printer sales were of direct interest to HP for internal planning purposes).
 - Decision markets do not distinguish correlation from causation.
- Innovative Future Applications?
 - Prediction markets are useful for estimating the market's expectations of a certain event.
 - Simple market design can elicit expected means or probabilities as well as other statistical indicators.
 - Prediction markets provide three important roles:
 1. Incentives to seek information
 2. Incentives for truthful information to be elevated
 3. Algorithmic way of aggregating diverse opinions

Prediction Markets³ (Gwern)

- Predict Markets and Personal Bets (1 and 2)
 - Prediction markets reward clear thinking and insider information on topics that'd be difficult to clearly bet for or against on regular financial markets.
 - Prediction markets offer a way to cut through all the confounding effects of proxies, and bet directly and precisely on a bit of information.
 - There's something of an efficient market issue with prediction markets — a no-trade theorem. Unlike the regular stock market, trades in prediction markets are usually zero-sum; therefore, lots of traders are going to be net losers and not want to trade at all.
 - To figure out what to bet, consider mitigating biases by helping users calibrate their bets by using tools/formulas such as Kelly criterion by reducing it to what is simple and easy to use in the process of placing a logical bet.
 - Largest players of real money prediction markets include Betfair, BETDAQ, Intrade, Tradesports, HedgeStreet, and the Iowa Electronic Markets.
 - Prediction markets are known to have a number of biases such as 'long-shot favoritism' in horse-racing and the inverse of it, 'favorite bias' (where traders buck conventional wisdom despite it being more correct).
 - Bitcoin is a prediction market — one is simply predicting what the ultimate price of bitcoins will be. Will they be worthless, or a global currency? The current price is the probability, against an unknown payoff. To predict the latter, one simply holds bitcoins. To predict the former, one simply sells bitcoins. Bitcoins are not commodities in any sense.
 - Bitcoin prediction market is subject to price manipulation such as those conducted by potential Ponzi schemers, pumpers and dumpers, etc.
- Predictions (3)
 - Well-known predictions sites include PredictionBook, Long Bets, FutureTimeline, and WrongTomorrow.
 - Calibration: calibrating your own ignorance is better than blindly betting.
 - Prediction markets will be flawed for the foreseeable future, with individual contracts subject to long-shot bias or simply bizarre claims due to illiquidity.
 - Lessons learned: "I am too optimistic and not cynical enough" and writing down/recording reasons for placing bets helped to mitigate hindsight bias.
 - 3 step way to make predictions is to consider the following:
 - (1) the specification, (2) the due-date, (3) the probability
 - Probability can be calibrated with a number of heuristics further outlined.

³ <https://www.gwern.net/Prediction-markets#benefits-from-making-predictions>

Augur Master Plan⁴

- Background
 - If Bitcoin gave us decentralized currency and Ethereum brought decentralized computation, Augur will enable a decentralized financial system.
 - Prediction markets provide better forecasts for the future, direct hedging and speculation mechanisms, and fulfill the vision set out by Hayek, Arrow, Debreu.
 - Lower transaction costs because it runs on Ethereum, eliminating middlemen.
- What is needed to make a killer derivatives app/prediction market platform
 1. Fees lower than current options available.
 2. Censorship resistant and trustless global trading platform.
 3. Ability to create your own markets.
 4. Markets that resolve without a trusted third part.
 5. Stablecoins (cryptocurrencies that are stable with respect to the dollar).
 6. Faster trades.
 7. Higher transactions per second.
 8. Margin.
 9. Leverage.
 10. Automatic rollovers.
 11. Dark pools.

⁴ <https://medium.com/@AugurProject/augur-master-plan-42dda65a3e3d>

The Radical Potential of Augur⁵

- Due to scaling woes on Ethereum, Augur will remain sluggish and costly for a few years (hence Moore's Law) — "We're trying to stream HD videos in 1995."
- Augur could transform how we forecast the future, make decisions, and manage risk in everyday life, fact-check and agree on the state of reality, and even hold politicians accountable — and even become the world's largest financial market.
- Augur has been called 'Uber for Knowledge' by Vitalik Buterin — like unused cars sitting idly around, we all have information or insights lying dormant in our brains. Like calling an Uber, creating markets on Augur recruits this idle information into action and transforms it into a shared resource.
- Augur is the world's first decentralized prediction market (DPM).
- DPM in layman terms:
 1. Market — a place to buy and sell (predictions)
 2. Predictions — betting on likelihood of events
 3. Decentralized — no central controller/owner
- When you buy a share, you enter a contract with someone betting the opposite outcome and whoever is right will collect the combined amount of cash put into the contract by both sides (which always adds up to a dollar) and whoever is wrong gets nothing.
- On centralized markets like PredictIt, only the the organization that runs the site can start the markets and report on outcomes, traders can only bet limited amounts, and the market is prone to regulation (may be shut down at any time); therefore, you end up with a market too inefficient to make strong predictions.
- On decentralized markets like Augur, anyone can create a market on anything because it requires no permission. It is like Wikipedia meets the stock market.
- Decentralized markets are open, frictionless, borderless pools of liquidity that are efficient markets for predicting future and determining present reality.
- With no censorship, Augur can generate utopian and/or dystopian possibilities (e.g., betting on someone's death, thereby incentivizing assassination).
- While Augur is censorship-resistant, the community plays a powerful role in determining whether predictions end up true, false or 'invalid.' This is where Augur's token, REP (short for reputation), comes into play.
- REP is used to report on the outcomes of predictions and to incentivize honest reporting. Reporters stake their REP on the outcome of a market. If their stated outcome matches consensus, they earn settlement fees from the market. If their staked outcome differs from consensus, they lose their REP. But if they still think they're right, they can appeal by staking a larger amount of REP.
- Today, Augur is hard to use, slow, and costly. Its success will ride not only on the hard work of its developers and community but also on broader infrastructure improvements like sharding, stablecoins, and offchain exchange (Ox).

⁵ <https://medium.com/sunrise-over-the-merkle-trees/forecasting-kanyes-presidency-to-futarchy-the-radical-potential-of-augur-c1049b7f1fc5>

A Comparison of Decentralized Exchange Designs⁶

- Foreward:
 - Decentralized exchanges (DEXs) have emerged as a solution to centralized exchange hacks. The main innovation is the allowance of users to trade directly from their wallets without a third party intermediary (e.g., an exchange).
 - The three main models for designing an exchange are the order book model, the automated market making model, and the Dutch auction model.
- Order book model:
 - An order book contains a list of buy and sell orders for a specific token.
 - An order to buy is called a bid and order to sell is called an ask.
 - An order book lists the number of tokens being bid or asked at each price point.
 - The difference between the highest bid and lowest ask is called the spread.
 - On order book exchanges, you can submit two types of orders: a market order or a limit order. When submitting a market order, you buy or sell immediately for the best available price. When submitting a limit order, you buy or sell a set number of tokens at a specific price and your order sits on the order book.
 - Examples of order book DEXs include IDEX, DDEX, Radar Relay, EtherDelta, Paradex, and Ethfinex.
 - Order book DEXs store their order books either on-chain or off-chain.
 - Off-chain order book DEXs, such as 0x, need relayers to store the order books on centralized servers.
 - On-chain order book DEXs do not and thus have the benefit of censorship resistance, but users will need to create transactions and pay for gas to place limit orders and to cancel existing orders.
 - Pros: good for liquid markets.
 - Cons: bad for illiquid markets, front-running, and market manipulation.

Automated market making (AMM) model:

- Automated market makers are algorithmic agents that provide liquidity.
- AMM has been known within academic games theory and mechanism design for over a decade, yet only recently made its way into crypto.
- AMM exchange does not require an order book. Instead of specifying which prices buyers and sellers want to trade at, an AMM exchange pools liquidity together and makes markets according to a deterministic algorithm.
- The algorithm quotes prices to the end user according to predefined formula.
- Uniswap is a DEX that uses the Constant Product Market Maker model, whereby anyone can provide liquidity to the exchange for a particular trading pair and earn fees from trading activity. This is one of the main attractiveness of the automated market making model — anyone in the community can be a liquidity providers and own a share of the upside when a public utility like Uniswap succeeds.
- Pros of AMM: always provides liquidity for illiquid markets.
- Cons of AMM: high slippage for large orders and risks for liquidity providers.

Dutch auction model:

- Blockchain time is discrete, not continuous. Each block splits time into discrete intervals, and the time between each block lets miners know before everyone else what transactions will be included in the next block.
- Decentralized exchanges based on discrete time — as opposed to centralized exchanges based on continuous time — are inherently designed to favor the

⁶ <https://thecontrol.co/a-comparison-of-decentralized-exchange-designs-1deef249f56a>

miners. What if we could design a DEX that takes advantage of the fact that blockchain time is discrete rather than continuous?

- In a Dutch auction exchange, there are discrete time windows for trading. Before an auction starts, all sell orders are collected in a batch. (Sellers can still submit orders during an auction; the orders will just be batched in the next available auction.) When the auction starts, the initial price is set at twice the closing price of the previous auction, and the price gradually decreases until the price clears the quantity of tokens sold and bought. During the auction, each buyer submits their bids when the current price reflects their maximum willingness to pay.
- The key part of the exchange design is that every buyer receives his or her tokens at the closing time for the same price.
- Gnosis has built a Dutch auction exchange trading protocol called DutchX, and FairDEX is a trading platform to interact with the protocol.
- Ox has a Dutch Auction Contract to create markets based on the Dutch auction model rather than the traditional order book model.
- Pros of Dutch auction model: good price discovery of illiquid tokens and reduces front-running.
- Cons of Dutch auction model: slow trading time.

So What?

- Each model has its own pros and cons, but what ultimately matters is price and liquidity in order to win in the exchange space.
- Users may endure poorly designed products if they can get better prices (e.g., lower fees) and there is enough liquidity on the exchange to fill users' orders.
- For liquid tokens (e.g., BTC, ETH) order book exchanges will likely continue to dominate volume.
- For long-tail illiquid tokens, automated market making exchanges and Dutch auction exchanges will likely complement order book exchanges and help users get better prices.

Decision Markets for Policy Advice⁷

- This article makes the case for prediction markets to inform policy; it is one application of prediction/information markets in the context of government.
- Lack of information often leads to bad policy decisions.
- Speculative markets remarkably aggregate information; in every head-to-head field comparison made so far, their forecasts have been at least as accurate as those of competing institutions, such as official government estimates.
- Organizations are experimenting with prediction/information markets to forecast future events such as product sales and project completion dates.
- Speculation takes place when an actor buys or sells something today in the hope of reversing her trade later for a profit. When durable commodities are traded in markets with low transaction costs, speculation becomes cheap.
- Speculative markets aggregate relevant information 'remarkably well.'
- Speculative markets are usually created for other reasons, such as to allow traders to entertain or insure themselves.
- Recently some new markets have been created specifically to take advantage of these effects — prediction markets, information markets, virtual stock markets, artificial markets, or idea futures.
- Hard cash versions have done well in every known head-to-head field comparison with other social institutions that forecast.
 - Examples: orange juice futures improve on National Weather Service forecasts, horse race markets beat horse race experts, Academy Award markets beat columnist forecasts, gas demand markets beat gas demand experts, stock markets beat the official NASA panel at fingering the guilty company in the Challenger accident, election markets beat national opinion polls, and corporate sales markets beat official corporate forecasts.
- Whatever the details of the exchange mechanisms (e.g., auction, automated, etc.), the important thing would be the appearance of two market prices, or trading rates of exchange.
- Requirements for Decision Markets
 - Important-enough claims (must answer important enough questions that the 'added accuracy' is of interest to already existing research mechanisms).
 - Enough influence (decision options considered need to have a large enough influence on the outcomes).
 - Distinct options (There must be a way after the fact to determine whether a particular decision option was chosen or not).
 - Measured outcomes (There must be a way to create measures of some of the important outcomes of interest after the fact and to identify what those measures will be before the fact).
 - Decision-insider traders (Relevant expectations must be calculated relative to the beliefs of the agent who will actually make the decision).
 - Enough informed traders (liquidity).
 - Enough trader incentives (what's in it for me?).
 - Trader anonymity (safe for users to place bets).
 - Aggregate-enough outcomes (can shape present reality negatively).
 - Linear-enough outcomes (manipulation not an issue).
 - Conditional-enough outcomes (avoid self-fulfilling prophecies by making the contract conditional).
 - Intermediate-Intermediate-enough estimates (avoid long-shot bias).
 - Can show prices (prices reveal close to best estimates).

⁷ <http://mason.gmu.edu/~rhanson/impolite.pdf>

- Legal permission (avoid high legal fixed costs).
- Public credibility (policy audience must perceive decision market estimates to be relatively accurate and difficult for interested parties to bias).
- Advantages of decision markets
 - Can influence policy decisions by providing more information.
 - Decision market price estimates should be numerical, precise, respond quickly to new information, be self-consistent across a wide range of issues, and be at least as accurate as other publicly available estimates.
- Disadvantages of decision markets
 - Have not gained enough credibility in public mind to be an attractive forum in which to inform public policy decisions.
 - Huge legal barriers preventing the creation of public markets trading hard currency.
 - Decision markets have accuracy and nontrivial costs (e.g., carefully define relevant options and outcomes and to induce informed traders to participate).
- Policy Analysis Market: A Case Study
 - “Terrorism futures” or “Terrorism betting”.
 - Tested price manipulation.
 - Planned to forecast military and political instability around the world, how U.S. policies would affect such instability, and how such instability would influence U.S. and global aggregates of interest. The reasoning behind this choice was that the cost to create markets does not depend much on the topic, but the value of estimates varies enormously with the topic. Thus, the greatest benefit relative to cost would come from the highest value estimates.
 - The final plan was to cover eight nations. For each nation in each quarter of a year (over the two year final phase), traders would estimate five parameters: its military activity, political instability, economic growth, U.S. military activity, and U.S. financial involvement. In addition traders would predict U.S. GDP, world trade, U.S. military casualties, and western terrorist casualties, and a few-to-be determined miscellaneous items.
 - Dissenting Senators described PAM as being “designed to predict terrorist events,” when in fact it was focused on geopolitical trends.
 - Wyden and Dorgan mainly complained that “terrorists themselves could drive up the market for an event they are planning and profit from an attack, or even make false bets to mislead intelligence authorities.”
 - PAM seems to have been accused of crossing a moral boundary, which can be paraphrased roughly as “none of us should intend to benefit when some of them hurt some of us.”
- Conclusion
 - Problems of acquiring and aggregating information on policy consequences lie at the core of most political failures, and these problems are often severe.
 - Decision markets are a new policy information process intended to help overcome these problems.
 - Decision markets would be at least as accurate as any coexisting policy information process. Such markets are also precise, consistent, responsive, difficult to bias, and equalitarian in the sense of allowing broad participation.
 - They will not function without the ability to create distinct options that have a measurable influence on relevant aggregate outcomes, and the problem has to be important enough to be worth paying to give traders, some of them insiders, enough incentive to trade.
 - The two biggest limitations: the legal costs of market creation also must be low enough, and the public must see market estimates as credible, accurate, and neutral. Without lower legal costs we will not see many trials, and without

successful trials the approach cannot gain enough public credibility. Yet without that public credibility there is not enough political support to pass a bill to lower those legal costs to allow more trials.

- The aborted Policy Analysis Market shows that, absent such credibility, decision markets can be misrepresented and turned into political poison.
- Most familiar financial products, including stocks, insurance, futures, and options markets, were once prohibited by laws against gambling.
- It took a long time for the relevant industries to convince the public to see each of these products as not “just gambling.” Of course, all of these products are ways to gamble, but, because they serve useful social functions, they have become politically and morally acceptable.

What Explains the Rise of AMMs?⁸

- Uniswap is an automated market maker — a market making bot — and the world's largest DEX by volume.
- Impermanent loss: whenever the exchange rate moves, this manifests as arbitrageurs sniping cheap assets until the pool is correctly priced. (These losses are “impermanent” because if the true exchange rate later reverts back to 1:1, then now it's like you never lost that money to begin with).
- Pools make money through fees, and they lose money via impermanent loss. It's all a function of demand and price divergence — demand works for you, and price divergence works against you.
- Original version of Uniswap was only 300 lines of code; it is permissionless and can be funded by anyone — it doesn't even need an oracle.
- Since Uniswap's rise, there has been an explosion of innovation in AMMs.
- There are even shifted curves that can run out of inventory, like the ones Foundation uses to sell limited edition goods.
- There are infinitely many specific curves an AMM could adopt for pricing — but the whole category is known as CFMMs: constant function market makers.
- To the extent that the pool exhibits impermanent loss, the fees need to more than make up for it.
- The Uniswap thesis works best when the two assets are mean-reverting. Think a pool like USDC/DAI, or WBTC/TBTC — these are assets that should exhibit minimal impermanent loss and will purely accrue fees over time.
- Impermanent loss is not merely a question of volatility (actually, highly volatile mean-reverting pairs are great, because they'll produce lots of trading fees).
- Example: take someone on a prediction market going long Trump, long Biden, and putting both longs in a Uniswap pool. By definition, eventually one of these two assets will be worth \$1 and the other will be worth \$0. At the end of the pool, an LP will have nothing but impermanent loss! (Prediction markets always stop trading before the markets resolve, but outcomes are often decided well before the market actually resolves).
- Almost all of the top Uniswap pools so far have been profitable because market makers are in the business of providing liquidity, thereby obtaining profit off it.
- There are three primary ways market makers make money: designated market making arrangements (traditionally paid by asset issuers), fee rebates (traditionally paid by an exchange), and by pocketing a spread when they're making a market (what Uniswap does).
- All market making is a battle against two kinds of order flow: informed flow, and uninformed flow. Market makers make money off the uninformed flow.
- Uninformed flow is willing to pay above true value for an asset — the spread.
- Informed flow is only willing to pay below the true value of an asset, so when you trade against them, you're actually the one who's mispricing the trade. These orders know something you don't.
- On Uniswap, some people are trading because they randomly want to swap some ETH for DAI today. This is uninformed retail flow, the random walk of trading activity that just produces fees. This is how market makers reap profits.
- Arbitrageurs are the informed flow. They are picking off mispriced pools — in a sense, performing work for Uniswap by bringing its prices back in line. In another sense, they are transferring money from liquidity providers to themselves.
- For any market maker to make money, they need to maximize the ratio of uninformed retail flow to arbitrageur flow.

⁸ <https://medium.com/dragonfly-research/what-explains-the-rise-of-amms-7d008af1c399>

- Uniswap is the first scrappy merchant to set up shop in this new marketplace called DeFi. Despite its flaws, Uniswap has a virtual monopoly, obtaining all retail flow. And if the ratio between retail flow and arbitrageur flow is what principally determines the profitability of Uniswap, no wonder Uniswap is raking it in.
- Uniswap beat out order swap exchanges for four reasons:
 1. Simple (low complexity, low surface area for hacks, low integration costs).
 2. Small regulatory surface (decentralized, requires no off-chain inputs).
 3. Easy to provide liquidity.
 4. Incentivized pools (liquidity farming, whereby pool creators airdrop tokens).
- CFMMs (constant function market makers) like Uniswap are unlikely to maintain success in this way over time. By 2025, CFMMs will likely look very different and these may just be a stepping stone to something to else.

Rethinking the Order Book: March Towards Automated Markets ⁹

- A shift away from the traditional human-driven order book towards automated market makers on the blockchain could minimize market abuses, smooth price fluctuations and free up trillions in profit currently captured by rent-seekers.
- AMM is the next phase of digitization and decentralization in financial markets.
- The advent of digitized broker services moved markets to a system where anyone could provide liquidity to markets by submitting a buy or sell intent order.
- The advent of smart contract-operated trading networks now allows anyone to create or contribute liquidity to an AMM by staking their funds in a smart contract to facilitate fair, stable and low-cost trading of any digital asset.
- The market for a single asset (digital or otherwise) is thought to be most efficient if all orders come through a single point, also known as the “order book”.
- An order book is an aggregation of buy and sell orders, showing the number of assets being sought or offered at each price level.
- Market books are intended to provide traders with better market information, but in some cases can actually distort market information.
- Traders refer to the change in price during the execution of a trade as “slippage”.
- Some amount of slippage is expected in most trades, but it tends to be higher in markets for lightly-traded assets where the order book is said to be “thin”.
- Thin order books have fewer offers at various price levels.
- In crypto markets, order books are particularly susceptible to a variety of abuses like pump and dumps, spoofing and wash trading. These abuses create unstable market conditions and fake or inflated volumes across exchanges — further exacerbating fears of instability and bad actors. Moreover, exchanges have weak incentives to crack down on such abuses as policing could potentially diminish their trading volumes (and perceived levels of liquidity) — hurting profits.
- Liquidity is said to reduce both spreads and slippage.
- Bancor proposes a new kind of liquidity not reliant on trade volume (or order book depth), one that is fully automated, non-profit and decentralized. At the core of this system is a new kind of market maker called a Relay Token.
- A Relay Token is a type of Smart Token based on the Bancor Protocol. Similar to standard market makers, Relay Tokens stand ready at all times to buy or sell.
- Relay Tokens differ from standard market makers in two crucial ways: 1) they need to be profit seeking, and 2) liquidity is determined by quantity of assets stored in Relay’s smart contract.
- Relay Tokens give traders a simple way to accurately measure and fully automate the liquidity of a digital asset.
- A Relay Token is a smart contract that holds two token balances in its contract as “reserves”. The Relay allows traders to convert between the two tokens according to a price which is calculated by the contract in real-time.
- If today’s market makers are like taxi cab drivers, and market takers (traders or users) are their passengers, you can think of a Relay Token like a self-driving car.
- Storing full order books and complete trade data on the blockchain is one way to ensure that everybody plays by the same rules.
- A “liquidity network” is a collection of Relay Tokens that hold a common “Network Token” — such as BNT — as one of the tokens in their reserves.

⁹ <https://blog.bancor.network/rethinking-the-order-book-the-march-towards-automated-markets-150f1325fb8c>

Automated Market Makers for Prediction Markets¹⁰

- Prediction markets require liquidity to function well.
- A simple case without a market maker:
 - Let's say Alice and Bob are trying to figure out if it will rain on Saturday. The outcomes of the event are Yes and No. Alice thinks that there's at least an 80% chance it will rain, but Bob thinks that while it seems likely that it will rain, it's maybe a 70% chance at most. They trade in the following manner:
 - Alice converts \$7.50 into 7.5 Yes and 7.5 No tokens.
 - Bob converts \$2.50 into 2.5 Yes and 2.5 No tokens.
 - Alice then swaps her 7.5 No tokens for Bob's 2.5 Yes tokens.
 - If it rains, Alice redeems her 10 Yes tokens for the \$10 collateralized by the system; If it doesn't rain, Bob redeems his 10 No tokens for the \$10.
 - They agree to this trade because Alice thought hers were worth at least \$8 (she paid \$7.50), while Bob thought his was worth at least \$3 (he paid \$2.50).
- Aggregating the trading data from order books to come up with a concise measure of the probability of an outcome has become more difficult. These are issues which can be ameliorated with the use of an automated market maker.
- An automated market maker (AMM) is a market participant that's a bot, making sure there are always some outcome tokens for every outcome in its inventory and that there is always a price that can be offered for an outcome token.
- As long as the AMM is active, traders can buy and sell outcome tokens for a prediction market, and the AMM will aggregate the trade data to produce estimates for the odds of outcomes.
- Gnosis offers smart contract implementations of two automated market makers for prediction markets: the logarithmic market scoring rule (LMSR) market maker, and the constant product market maker (CPMM).
- The LMSR market maker is designed specifically for the prediction market use case, and its properties have been well researched.
- The CPMM is a newer market maker using the same mechanism as Uniswap and Balancer pools. It is also known as the fixed product market maker (FPMM) in Gnosis' codebase. It was originally designed for the more general use case of swapping tokens, but has been tailored for the prediction market use case in the FixedProductMarketMaker contract.
- Both market makers can be described in terms of an invariant value kept between trades. This invariant value can be considered in the context of a constant function market maker.
- LMSR (more precise math with logarithmic functions) advantages:
 - More credible: it has more recognition in academic work, and its properties are much more studied than CPMM. It is easier to find papers on the properties of LMSR, or to leverage existing research on this market maker.
 - LMSR breaks down into self-similar components when applied to combinatorial prediction markets. Its analysis in those scenarios has been quite explored in the literature.
 - Closed form expressions for buying and selling with the LMSR allow calculating a net cost for a batch of buys and sells done simultaneously.
- CPMM (less precise math) advantages:
 - More elementary arithmetic.
 - Easily crowdfunded (like Uniswap).

¹⁰ <https://docs.gnosis.io/conditionaltokens/docs/introduction3/>

A Call To Adventure (Part I)¹¹

- Adventure: remaking collective decision-making via decision markets (futarchy).
- Much of the pain and loss in the world results from bad decisions by key organizations — some of these bad decisions result because actors with the wrong mix of values hold too much power. But most result from our not aggregating info well; people who could have or did know better were not enticed enough to share what they know. Or others didn't believe them.
- We actually know of a family of simple robust mechanisms that typically do much better at aggregating info. And we have a rough idea of how organizations could use such mechanisms. We even had a large academic literature testing and elaborating these mechanisms, resulting in a big pile of designs, theorems, software, computer simulations, lab tests, and field tests. (No need for more).
- What we need is a concrete evolution within real organizations. Like most good abstract ideas, what this innovation most needs is businesses to test this out. That is, to design and try out variations that can avoid the several practical obstacles that we know about, and help identify more such obstacles to work on.
- In short, we need people to trial collect decision-making markets in real world.

¹¹ <https://www.overcomingbias.com/2017/06/a-call-to-adventure.html>

How to Get Better at Predicting the Future¹²

- The idea is to estimate the effects of political events and every policy we considered (e.g., raising interest rates, passing a bill, starting a war).
- There's a very simple idea behind them: bet on anything you want
- The point is that you can make money by making good bets. And that incentive is what can make prediction markets a pretty good forecaster of what's to come.
- Economic incentives are aligned to reward accurate predictions/information
- PredictIt caps its bets at a fairly small total and there are transaction fees, which means that it's easier for bad predictions to stand. (Fees mean that betting against predictions that are off, but not outrageously far off, isn't worthwhile).
- Advocates say that to be really useful, prediction markets will need higher betting limits and smoother transactions.
- There are significant legal and logistical hurdles to making that happen.
- Betting on political and international events is prohibited in much of the world as part of restrictions on gambling.
- If using prediction markets for policy, there'd be some powerful incentives to distort them on purpose.
- While prediction markets work pretty well, you can actually get most of the benefits just by surveying people — if careful about aggregating answers.
- The dream of prediction markets is a world where we know what effects policy will have (to the extent it is possible) in an unbiased way.

¹² <https://www.vox.com/future-perfect/2019/4/5/18290870/forecasting-tetlock-prediction-markets-betting>

Introducing Veil¹³

- Veil is a peer-to-peer prediction market and derivatives platform built on top of Augur, Ox, and Ethereum. (Similar product to Polymarket).
- Veil is built on Augur, which provides its smart contracts and lets anyone create, trade in, and report on prediction markets.
- Veil is designed to bring Augur mainstream; to make Augur easy to use.
- All markets listed on Veil are represented as Augur markets on Ethereum and have augmented the Augur experience in two ways:
 - Veil makes trading faster and cheaper.
 - Veil helps you get paid faster.
- Three ways to use Veil: Veil (default UI designed for easy and fast trading as well as accessibility and sharing), Veil Pro (an exchange-like UI meant for frequent and sophisticated traders), and Veil API (for algorithmic traders).
- Supported markets: cryptocurrency derivatives, Ethereum network hedging products, Grin markets, and Academy Award markets.

¹³ <https://medium.com/veil-blog/introducing-veil-649036f9d492>

A Guide to Augur Market Economics and How to Trade on Veil¹⁴

- For context, Augur is a prediction market protocol built on Ethereum. And Veil is a trading platform for Augur. Veil hosts its own order books for markets and uses Augur to represent markets and settle them.
- Augur supports many types of markets, but today we'll focus on two kinds: binary markets and scalar markets.
- Each market is implemented as its own smart contract on Ethereum which holds the collateral for that market as Ether.
- Complete sets of outcome shares: any complete set of shares (i.e. one "Long" and one "Short" in a given market) is worth 1 ETH.
- Market resolution and payout: When a market expires, the value of each of the two outcome shares is set. All the money escrowed in the market contract is allocated between the two outcome shares. Still, any complete set of outcome shares is worth 1 ETH, but the fraction of 1 ETH for each outcome share is set by the market.
- Binary markets: sometimes called "yes/no" markets — the simplest markets to understand because they are similar to betting. These markets are "binary" because they are winner-take-all—either the holders of "Long" shares take all the money or "Short" holders do. Outcome of shares are connected to probabilities.
- Scalar markets: like binary markets in that they have two outcome shares — "Long" and "Short"—but the payout is not winner-take-all. The payout of one "Long" share and one "Short" share always sums to 1 ETH, but the allocation can be any two fractions from 0.0 to 1.0; for situations where you want to trade on the direction of something or don't want to expose yourself to winner-take-all risk. These are for events that have less binary outcomes by nature because they allow for betting on a value in a range (e.g., sports: rather than betting on what team wins (binary), you can bet on number of points that a player scores).

¹⁴ <https://medium.com/veil-blog/a-guide-to-augur-market-economics-16c66d956b6c>

Create Your Own Prediction Market on Veil¹⁵

- Step 1: decide what you want to bet on as a binary or scalar market
 - Binary example: will the Patriots win the super bowl?
 - Scalar example: how many goals will Ronaldo score tomorrow?
- Step 2: create a draft market that clearly stipulates the resolution rules. (You'll notice there are two ways for you to earn money—settlement fees and trading fees. Settlement fees are charged when users redeem their positions, and trading fees are charged per trade in your market).
- Step 3: gather interest for your market: collect pre-orders to ensure interest.
- Step 4: activate market: once you've shared your draft market and are happy with the community buy-in, it's time to activate your market. All markets on Veil are represented as Augur markets under the hood. Augur helps resolve and secure any arbitrary prediction market. But that work has to be paid for, so in order to activate your market (and get paid yourself) you have to make two deposits—one in ETH and one in REP. You'll get these deposits back once the market ultimately resolves, but the idea is to limit spam in the Augur network.
- Step 5: you report what happened to determine outcome (subject to dispute).

¹⁵ <https://medium.com/veil-blog/create-your-own-prediction-market-d41ec7c19675>

Policy Market (Hanson)¹⁶

- A policy market is a market created to directly inform policy decisions with its price. That is, while the market may also serve other functions, such as hedging or entertainment, its primary function is to create prices which embodies information which is directly relevant to people considering some choice between policy alternatives.
- In contrast, the perceived function of most financial markets is to allow people to hedge and rebalance their portfolios and the perceived function of most gambling markets is to entertain.
- There are questions about verifiable and directly relevant consequences of various policy choices. But while there is no shortage of pundits with opinions on these sort of questions, the possibility of self-interested bias makes most people reasonably skeptical about such opinions. And so people lack reliable sources of information to guide their policy choices.
- Why we need them:
 - They are precise and continuously updated, relatively cheap to create, and would be open to contributions from anyone, regardless of how articulate they are, what degrees they have, or whether they look good on TV.
 - In the few markets that are constructed primarily for the information they create (e.g., Iowa Electronic Markets) the questions are at best indirectly relevant to specific policy choices. (They bet on who will be elected, not on what would happen then).
- How to Make Them Easier
 - We can avoid the paper-work involved in calling off bets, if we instead trade certain "contingent assets" with each other.

¹⁶ <http://mason.gmu.edu/~rhanson/policymarkets.html>

Idea Futures (Hanson)¹⁷

- The Idea: policy-makers and media rely too much on the "expert" advice of a self-interested insider's club of pundits and big-shot academics. These pundits are rewarded for telling good stories and supporting each other, rather than for being "right". Instead, let us create betting markets on most controversial questions, and treat the current market odds as our best expert consensus. The real experts (maybe you), would then be rewarded for their contributions, while clueless pundits would learn to stay away. A new form of government on idea futures.
- One can subsidize a market on a question, offering extra rewards to those who bet right on this question. This subsidy is an "information prize", offered to those who first provide information on a question.
- Web Games: many web sites which let one bet on sports, but the Foresight Exchange (FX, previously called Idea Futures) was the first general web betting game, and was the first to allow users to introduce new claims to bet on.
- Other Demonstrations
 - Real money political markets, such as Iowa Electronic Markets and WahlStreet, predict election outcomes better than opinion polls.
 - Financial instruments - stocks, insurance, commodity futures, options -- were once forbidden by anti-gambling laws.
 - Some credit derivatives pay out if agencies downgrade the credit rating of a company's debt. This shows that subjective judgements by established judges can be used to settle bets.
 - Governments tend to use prizes less than private patrons. When science was patronized more by private sources, prizes were used much more often.
- Legal Limits: the main immediate limitation to larger scale demonstrations are the facts that betting is generally illegal, and that securities are highly regulated.
- Close, but not enough: already existing applications fall short in numerous ways.

¹⁷ <http://mason.gmu.edu/~rhanson/ideafutures.html>

Information Prizes (Hanson)¹⁸

- Foreward
 - Information prizes can allow research patrons to focus on questions they would like answered, while still minimizing judging flexibility.
 - Prizes can directly support the generation of policy-relevant consensus.
- Introduction
 - How to fund basic research is a vexing economic problem.
 - This paper will content itself to propose a novel mechanism for funding some types of basic research, and to describe qualitatively how this mechanism might plausibly address common agency problems.
 - The mechanism proposed here is an "information prize", and can be considered a variation on ordinary accomplishment-based prizes.
 - "Information prizes" are suggested for situations where research patrons can reasonably estimate the value to them of "answering" some question they expect may eventually be relatively "objectively" answered. (e.g., a patron might offer an information prize directly on the question of future sea levels given greenhouse emissions. "Answering" just means changing the patron's estimated probabilities regarding various possible answers to a question).
 - To fund an information prize, a patron subsidizes a certain automatic broker which trades in assets contingent on various possible answer to a question.
 - A major problem with the information prize is that it is in general illegal to trade in contingent assets.
 - This paper will qualitatively review a wide range of mechanisms for funding basic research, review prizes in more detail, and then focus specifically on the information prize, describing each of its aspects in some detail.
- History of Patronage
 - Past funding models have relied heavily on academia and peer-review, which have a slew of problems associated with them.
- Accountability Types
 - The ideal form of accountability is when the principal and the agent, in this case the patron and the researcher, are one and the same person, either a dedicated amateur or a wealthy professional. This arrangement should offer the most productivity toward the patron's goals.
 - A general approach to accountability is to "piggyback" on some other accountability mechanism. Most social institutions rely to some extent on support from their wider social context. (e.g., a bank may rely in part on a wider legal system to prevent thefts, in addition to more direct monitoring and security precautions. And law may rely on wider moral attitudes or desires for revenge. Thus in practice most institutions rely on some mixture of contract, monitoring, and piggyback accountability).
- Peer Review
 - Many forms of peer-review can be thought of as piggyback funding, at least in part. The patron is hoping that the reviewer is both knowledgeable, possessing good indicators of research quality, *and* shares the patron's values, and so will make the same judgement that that patron would, if that patron had the time and knowledge to participate.
- If Prizes Dominated
 - Prizes require researchers to risk their own time and capital in their attempt to win, rewarding only successful researchers after their work is done.

¹⁸ <http://mason.gmu.edu/~rhanson/infoprize.html>

- If prizes were to again dominate the funding of basic research, researchers might again become more accountable to their patrons. Patrons using prizes and patrons relying on piggyback peer-review should both benefit.
- Information Prizes
 - Ordinary prizes are for "accomplishments", specific events caused by a specific person or group. (e.g., an accomplishment prize might have been offered for the first experiment to show the (recently demonstrated) fluctuations in the cosmological microwave background).
 - But often the more fundamental interest surrounds a *question*, such as whether the universe is open or closed (infinite or finite), which is likely to be answered as a result of many difficult to foresee accomplishments.
 - To allow more direct patronage of such questions, this paper suggests an "information prize". A patron, or their agent, would approve a specific question to be answered, and a set of possible answers to that question. (e.g., "Is the spatial curvature of the universe on the scale of ten billion light years positive (closed), negative (open), or within error E of zero?" The patron would then define how decisions are to be made regarding who might judge this question when, and authorize the creation and sale of assets contingent on the different possible answers to this question.
 - Finally, the patron would allocate a certain pot of money to subsidize a dumb broker to buy and sell these assets within some open marketplace, and advertize this fact. Researchers would then have an incentive to learn more about, for example, the large scale curvature of space, in order to make money by being the first to trade with the dumb broker. Basically, the patron offers researchers the chance to "bet" with an actor ignorant about this important science question. The market "odds" can then provide a consensus which policy makers can defer to.
 - In short, researchers are incentivized to research a topic that has been propagated because they stand to profit off their knowledge.
- Claims
 - Many questions in ethics, religion, and aesthetics have remained open and unsettled for as long as anyone has records.
 - But debate on most questions associated with what people call "science" seems to become "closed" within at most a few centuries.
 - The main risk of judging flexibility, and therefore possible bias comes from questions where it never becomes clear whether or not that question will ever become clear enough to judge.
- Assets
 - Trading in contingent assets is in general prohibited by anti-betting laws through most of the world. In the U.S., Nevada allows betting on sporting events, but not more generally. Therefore information prizes require legislative changes before they could be implemented.
- Funding
 - A patron can subsidize a market simply by directly thickening it, ensuring that many substantial offers to buy or sell will be available near any given price.
 - Once this all were legal, then for science claims relevant for public policy, such as the greenhouse effect, or which capture the public imagination, public interest might by itself create substantial information prizes.
 - Trading in science markets might even allow science amateurs, or amateur wanna-bes, to feel more involved in the whole process. And extra speculation activity might provide enough market liquidity to make feasible new forms of corporate insurance against technological risk.

- Trading
 - The simplest information prize scenario involves one researcher working to win one prize, and obtaining their reward upon a judge's verdict.
 - Markets, particularly in contingent assets, offer many opportunities for specialization not easily supported by other forms of patronage.
 - With any funding mechanism, researchers have incentives to keep quiet about special insights until they can reap their reward through funding mechanism.
- Judging
 - An information prize induces a current consensus estimate regarding probabilities of the various possible answers to its question, in market prices.
 - The judging process produces a consensus, but is not intended to be the engine of knowledge production.
- Consensus
 - Perhaps the most promising feature of information prizes, and the contingent asset markets they use, is that they can function not only as a patronage institution, but also as a consensus institution.
- Conclusion
 - We may be relying too heavily on piggyback accountability when we fund basic research through proposal peer review, and so we may risk popularity equilibria wherein the interests of research patrons are largely ignored, and even the interests of insiders may be greatly diluted by efforts to signal insidership. But federal funding and the nature of basic research make it difficult to rely more on accountability by monitoring. Thus we should consider relying more on contract accountability, and on prizes in particular.
 - Ordinary prizes focus on specific accomplishments of foreseeable value, or they must allow judging flexibility, which can hide bias. Information prizes, however, allow patrons to focus on questions they would like answered, while still minimizing judge flexibility. In addition, related contingent asset markets can serve as robust institutions for generating policy relevant consensus, relatively resistant to directly political influence.
 - Information prizes work by subsidizing brokers trading in assets contingent on different possible answers to the funded question. Information prizes do not, however, require active trading in these assets; one person alone can win a prize much like someone winning a first-to-file patent by paying to file a claim before anyone else. There is a real issue regarding the optimal granularity for information prizes, and the overhead costs at this optimum relative to other funding mechanisms.
 - A variety of specific mechanisms have been suggested to allow wide application of information prizes, and the reduction of overhead costs, and reasoned speculations have been offered regarding the consequences of wide use of such prizes. This paper has attempted to make the case for information prizes plausible, but no more than plausible. More precise models and experiments, however, might be useful in making a more careful evaluation.

Issues In Information Market Design (Hanson)¹⁹

- Information markets (a.k.a. prediction markets and idea futures) are markets whose primary purpose is to aggregate information, instead of to hedge risk or entertain. This article reviews many issues in the design of such markets.
- A common task is how to induce people to collect information on chosen topics, and to reveal what they know to each other, in order to produce consensus estimates on those topics.
- Information markets reward those with relevant knowledge and incentivize truth.
- The expense and expressiveness limitations of markets relative to ordinary conversation suggest these design issues: how can we lower the costs of trading, how can we expand the set of things that one can say by trading, and which questions should we ask of traders? There are also many problems to consider.
- One potential problem is that market prices can fail to reflect what traders know when traders suspect that decision makers will know even more. This problem is avoided if decision makers and their advisors can trade, if the decision time is known to traders, and if we only rely on prices just before this decision time.
- Another potential problem is that people may lie to gain favorable decisions.
- A potential problem with creating incentives to say what is true is that people might cause harm to make what they say true.
- There is also the problem of how to induce people to say things at all via markets, rather than otherwise going about their lives.
- There still remain computational difficulties in supporting such trades, however, and it is still not clear how to best integrate such market makers into a general combinatorial matching market.
- It is not clear what sorts of user interfaces can best allow people to browse the current estimates to find ones they want to change, and to help them determine what sorts of package offers they would then want to make.
- In summary, the fact that traders must “put their money where their mouth is” when they say things via markets can help us to better share information.
- We should ask markets the questions that would most inform our decisions, and we should seek to allow and encourage traders to say as many kinds of things as possible, so that a big picture can emerge from many pieces.

<http://mason.gmu.edu/~rhanson/infomkts.html>

The Policy Analysis Market (and FutureMAP) Archive (Hanson)²⁰

- In 2001, the US Defense Department funded prediction markets (Michael Foster). This research program was named "FutureMAP", but the first DARPA call for proposals went out under the name "Electronic Market-Based Decision Support."
- Prediction markets are speculative markets created for the purpose of aggregating information on topics of interest.
- Previous field studies had found that such markets out-predict co-existing institutions regarding weather, printer sales, movie sales, elections, and more.
- From the very start, the Net Exchange team began laboratory experiments to study the issue of price manipulation, as this was a widely expressed concern.
- Used to forecast military and political instability around the world, how US policies would effect such instability, and how such instability would impact US and global aggregates of interest — the Policy Analysis Market (PAM).
- Focus narrowed to smaller region, the Mideast, because the Economist Intelligence Unit charged a high price to judge after the fact what instability had actually occurred in each nation.
- We planned to cover eight nations. For each nation in each quarter of a year, we planned to have traders predict its military activity, political instability, economic growth, US military activity, and US financial involvement.
- Traders would predict US GDP, world trade, US military casualties, and western terrorist casualties, and a few to-be-determined miscellaneous items. This would require a hundred or so base markets.
- Wanted to let our traders predict combinations of these, such as how moving US troops out of Saudi Arabia would effect political stability there, how that would effect stability in neighboring nations, and how all that might change oil prices.
- Struggled to obtain enough predictors, so they had to pay their predictors.
- On May 20, 2000, DARPA reported to congress on the IAO, and described FutureMAP in terms of predicting a bioweapons attack against Israel.
- In the summer of 2003, the Senate but not the House had cancelled IAO funding, which included all FutureMAP funding, because of privacy concerns with another IAO project, "Total Information Awareness."
- Media storm hit in 2003, when two senators (falsely) complained that we were planning to let people bet on individual terrorist attacks. Then it was cancelled.

Futarchy: Vole Values, But Bet Beliefs (Hanson)²¹

- This "manifesto" describes a new form of government. In "futarchy," we would vote on values, but bet on beliefs. Elected representatives would formally define and manage an after-the-fact measurement of national welfare, while market speculators would say which policies they expect to raise national welfare.
- Familiar forms of government seem to frequently fail by ignoring the advice of relevant experts (i.e., people who know relevant things).
- "Futarchy" is an untried form of government intended to address missing information problems.
- In futarchy, democracy would continue to say what we want, but betting markets would now say how to get it — elected representatives would formally define and manage an after-the-fact measurement of national welfare, while market speculators would say which policies they expect to raise national welfare.
- The basic rule of government would be:
 - When a betting market clearly estimates that a proposed policy would increase expected national welfare, that proposal becomes law.
- Futarchy is intended to be ideologically neutral; it could result in anything from an extreme socialism to an extreme monarchy, depending on what voters say they want, and on what speculators think would get it for them.
- The basic rule of government would be:
 - Democracies fail largely by not aggregating available information.
 - It is not that hard to tell rich happy nations from poor miserable ones.
 - Betting markets are our best known institution for aggregating information.
- Speculative market exhibit long-shot bias when there are high transaction costs, and perhaps also excess volatility in long term aggregate price movements.
- A betting market can estimate whether a proposed policy would increase national welfare by comparing two conditional estimates: national welfare conditional on adopting the proposed policy, and national welfare conditional on not adopting the proposed policy.

Intrade's Conditional Prediction Markets²²

- We have often discussed the possible benefits of prediction markets for reducing bias. One key element that could be particularly useful is a conditional prediction market, where betting claims are based on outcomes conditional on some factor.
- Intrade – the large, real-money prediction market – has added conditional claims based on the outcome of the U.S. Presidential elections. These may represent the first major case study of real-money conditional futures markets.
- The lesson, then, is that conditional prediction markets can be informative, but that there is great importance in the detailed structure of the institutions.
- Subsidies (automated market maker algorithms) made all the difference between a failed market and successful market to keep the bid-ask spread within a certain number of points.
- Claims based on price movements on election day are not working as well as the others, so that idea may not be as promising (perhaps circumstances will change as election day approaches).

²² <https://www.overcomingbias.com/2008/07/intrades-condit.html>

The Fall of Intrade and the Business of Betting on Real Life²³

- Intrade was designed to evoke sophisticated investment, not a casino or a horse track; it rewarded analytical calculation over partisanship and wishful thinking.
- Economists believed in a radical-sounding proposition: that free markets could be used to reliably forecast world events.
- Within months of the election, the company had collapsed beneath the weight of a U.S. government lawsuit and a crippling financial scandal.
- Some of the factors in Intrade's demise — regulatory ambiguity, erratic management, flawed business model — ills common to many internet startups.
- But the root source of the market's problems was a gap, perhaps unbridgeable, between a promising model for predicting the future, and legal regulations.
- More than two decades ago, Hanson began to wonder: Why couldn't the same mechanism work for other types of clashes, like contentious scientific debates? "I was a contrarian hanging out with a lot of other contrarians in Silicon Valley," Hanson said, describing people who were both "rabidly libertarian" and interested in exploring the internet's capacity to solve problems. "I sort of pulled those two things together," he explained, "and said how about betting markets?"
- Hanson called his concept "idea futures," and devised a game where people could wager play money on questions like the chances of developing cold fusion. He hoped the prototype would inspire real investors, with real money, to create "a radical, market-based alternative for reaching scientific consensus." (though it later became used by US Intelligence and subsequently shut down).
- Intrade's initial focus was on sports, but it also offered markets on elections, box office returns, and geopolitical events.
- Intrade began, essentially, as a wager in itself — on the possibility that the U.S. government would take a relaxed attitude toward gambling on the internet.
- Wolfers found Intrade's data about Iraq war useful in prediction market theory.
- At the most elemental level, Intrade was a useful tool to test one of the most important questions in economics, how markets absorb information.
- Intrade also served a second function: what Wolfers calls "information discovery." Intrade would respond to gossip of clandestine negotiations, or an extramarital affair, or an "oops" moment in a debate; In other words, Intrade's prices reflected the impact of these news events faster than any poll could.
- In 2008, a group of 22 academics called for loosened regulations in an open letter to Science, describing a "virtually limitless" range of applications for government policy, business and public health.
- Intrade's downfall started to happen the CEO died while hiking a mountain.
- "You are dealing with people who were essentially flouting U.S. law for a decade," says Emile Servan-Schreiber. "At some level, they had to be sort of gangster-like."
- As for the political markets that made Intrade famous, there's a use for the trading platform technology, but the company is done with exploring gray areas.
- "Regulatory avoidance isn't a good business model."

²³ <https://www.buzzfeed.com/andrewrice/the-fall-of-intrade-and-the-business-of-betting-on-real-life>

Radical Markets for Elephants²⁴

- Robin Hanson tells us also that money incentives may trick us into speaking, or signaling, the truth of our expectations.
- Logarithmic Market Scoring Rule, LMSR for short, is the name of Hanson's distinctive solution to the following problem: how to use financial incentives to elicit people's truthful and jealously guarded opinions about a future event.
- Gnosis uses the LMSR market maker for prediction markets.
- The goal of this article is to discuss LMSR: how does it work, why does it work better than any alternative in prediction markets, and what are its drawbacks?
- Scoring rules elicit individual assessment of event-related probabilities.
- A scoring rule is based on a mercenary principle: the better I forecast a future event, the higher is my score, and the larger is the monetary compensation I receive for it.
- A patron is paying my reward in return for the elicited information. However, scoring rules are affected by the thick market problem: aggregating or pooling different people's estimates into a single consensus is remarkably tricky, and partially unreliable in its results.
- The scoring rule is proper if it constrains me to maximize my expected score by reporting my probabilistic assessment truthfully, regardless of my unsolved dilemma between values and beliefs.
- The best scoring rule is Hanson's favorite one, the logarithmic scoring rule, because it can be used both to reward my truthful report and to gauge the statistical likelihood of my prediction.
- Hanson designed the Logarithmic Market Scoring Rule as a market maker mechanism.
- A market maker is the institution (or human, or, in the case of Gnosis' automated market maker, the application) that sets prices for buy (bid) and sell (ask) orders, bears the risk of each trade — since all transactions occur with the market maker as buyer or seller — and may incur losses from trades.
- The market maker turns the market into a positive-sum game, incentivizing thereby rational traders to participate. Since any participant can trade with the market maker whenever s/he finds the current price attractive, the thin-market obstacle is overcome.
- At market closure, the state vector reports the final consensus on the probability estimates — which conveys the probabilistic prediction of the market vis-à-vis the factual turn of events.
- In the context of Robin Hanson's LMSR market maker, the marginal cost of the next share grows proportionally to the number of outstanding shares — which entails that casting one more (long) vote on the future of a certain state of affairs is an exponential expression, moneywise, of my (positive) expectations regarding that state of affairs. This leads to an optimal allocation of shares, or, which is the same, a most reliable expression of expectations.

²⁴ <https://blog.gnosis.pm/radical-markets-for-elephants-a742916812db>

Prediction Markets: When Do They Work²⁵

- Augur (REP) is the crypto prediction market token.
- Augur bets are made in Ether.
- If you bet on an event that is correlated with the currency you're betting in, the fair price can be very different from the true probability.
- By giving people a monetary incentive to solve problems and share information, we can learn probabilities (what will GDP be next year?) and conditional probabilities (what will GDP be next year if we pass this tax cut bill?) and use the answers to make the best decision. This method of making decisions is futarchy.
- Formally, a prediction market allows participants to buy and sell contracts. Those contracts then pay out a variable amount of money. Typically this is either binary (will Donald Trump be elected president?), paying out 100 if the event happens and 0 if it doesn't, or they are continuous (how many electoral college votes will Donald Trump get?) and pay proportionally to the answer.
- There are three types of prediction markets that have gotten non-zero traction: politics (PredictIt, BetFair, and Pinnacle Sports), economics (Futures markets), and sports.
- To get a thriving prediction market, you need five things:
 1. Well-defined outcome.
 2. Quick resolution (faster pay out = more interest).
 3. Probable resolution (conditional outcomes can muddle clarity).
 4. Limited hidden information (insider trading makes price more efficient but drives people away).
 5. Sources of disagreement and interest ('suckers at the table').
- Summary and conclusion:
 - Prediction markets rely on attracting both 'losers' who have natural reasons to participate, and 'winners' who will be attracted by that value.
 - Any critical issue can kill a prediction market and/or its entire ecosystem.
 - If your market isn't well-defined, arguments over price become arguments over the rules, which turn into very angry participants. If this happens even a small percentage of the time, it drives everyone away.
 - If your market doesn't resolve quickly, and quickly is on the order of days or at most a few weeks, it needs to be massively liquid and refer to real world questions people have natural exposures to, to create participation. It ties up cash and doesn't offer the rush of a good gamble. No one wants to bet on an obscure outcome years from now.
 - If your market is unlikely to resolve, participants will find other uses for their time and money.
 - If your market has potential hidden information, that is a tax on everyone who participates, who are prey to adverse selection.
 - If your market doesn't draw natural interest and offer disagreement, to create a foundation of participation and liquidity, there's no foundation or interest.
 - In addition to these threats, such markets face regulatory and legal hurdles, and face various ethical concerns. If you offer one market that seems to mimic a regulated trade, such as an option on a stock, or that sounds distasteful, such as the so-called 'assassination markets,' that can be all anyone will see when they look at your offerings.
 - Active curation needed to deal with many issues, and to provide simple ease of use and ease of finding what one is looking for and would be interested in.

²⁵ <https://www.lesswrong.com/posts/a4jRN9nbD79PAhWTB/prediction-markets-when-do-they-work>

Subsidizing Prediction Markets²⁶

- Subsidization is an option for satisfying the fifth requirement: Sources of Disagreement and Interest, also known as Suckers At The Table. The ultimate sucker is an explicit, intentional one.
- One might want to create a subsidized prediction market to get a good estimate for the probability distribution of an event, and to do so without paying more than necessary. Secondary goals might include building up interest and a marketplace for this and future prediction markets, and getting a transparently robust result, so others or even the media are more likely to take the outcome seriously.
- To get a thriving prediction market, you need five things:
 1. Well-defined outcome (The most cost-efficient subsidy for a market is to ensure that the market is well defined. If you're going to subsidize a market, step one is to write good careful rules, make sure people understand them, and to commit to making it right for everyone if something goes wrong, if necessary by paying multiple sides as if they had won).
 2. Quick resolution (pay the winners quickly — people care more about this than you may imagine).
 3. Probable resolution (Make sure that if money gets tied up for months or years, that it won't be for nothing).
 4. Limited hidden information (Make inside information public and work to keep everyone informed. When you can't fix this through action and disclosure, give that money to the outsiders who were essentially scammed).
 5. Disagreement and interest (You are paying a subsidy, so you're the sucker. Let everyone know that and why they are being paid to express their opinions).
- Best ways/options for subsidizing
 1. Cover Your Basics:
 - Choose a market people want to participate in to begin with. Ensure there are carefully written rules with no ambiguity, that any problems there are covered. Make sure you'll get things resolved and paid quickly, that capital won't be tied up one minute longer than necessary. When possible, disclose all the relevant information, on all levels. If things don't resolve, compensate people for their time and capital.
 - Make sure everyone is confident the winners will be paid! Nothing kills a market like worrying you can't collect if you win. That's often as or more important even than providing strong, reliable liquidity.
 - Improve your interface, usability, accessibility, user's tax liability. If market design is poor, such as having the wrong tick size, make sure to fix that. Tick sizes that are too small discourage the providing of liquidity, and are in my experience a bigger and more common mistake than ticks that are too big.
 - Waive the fees. All of them. Deposit fees, withdraw fees, trading fees, you name it. At most, there should be a fee when taking liquidity that is paid entirely to the trader providing liquidity. People hate paying fees a lot more than they like getting subsidies. They won't cancel out.
 - With that out of the way, what are your options for the main subsidy?
 2. Be a Market Maker and Provide Liquidity Directly:
 - One strategy is to take periodically liquidity in both directions.
 - Directly subsidize people to aggressively provide liquidity.
 3. Subsidize Trading / Give Free Money:

²⁶ <https://www.lesswrong.com/posts/AeKS2m6uLM8RYfvND/subsidizing-prediction-markets>

- Make it sufficiently difficult to do wash trading or sign up for tons of copies of the bonuses and then give users a puzzle worth maximizing (from their perspective) and effectively rent their labor to see what they think of it.
- 4. Subsidize Market Making:
 - You can also subsidize market making activity, as an alternative to doing the job yourself and butchering it.
 - Paying people who provide rather than take liquidity is good, and often paying for real two-sided market making activity is better.
- 5. Advertising:
 - People can't trade what they aren't thinking about or don't know about.
- Putting it all together
 - It's expensive to change or clarify your rules and conditions once trading has begun, so invest in doing that first.
 - Use subsidy to take away bad experiences and barriers first.
 - The best subsidy is paying to produce reliable, safe and easy to use software, getting ironclad rules in place, being ready to handle deposits, withdrawals, evaluation of results and other hassles.
 - Make sure people can find your markets and set up the markets people want to find.
 - Next best is to avoid fees. People hate fees more than they love subsidies. At a minimum, you shouldn't be charging fees for deposits or withdrawals, or for providing liquidity in the market.
 - Make trades cost net zero fees. Either charge nothing to provide or to take liquidity, or charge a fee to take liquidity but pay it to those who provide.
 - If that's still not good enough, provide liquidity. Either pay someone else to be a market maker, or provide the service yourself.
 - As the market matures, you'll want to transition to something smarter. Thin markets want obviously dumb providers.
 - Give away Free Money. Give people some cash in exchange for participating in the market at all, or trading a minimum amount. Or give people bonuses on deposited funds so long as they use them to trade, or similar.
 - Watch for abuse. If you can respond to abuse by changing the system, it's fine to be vulnerable to abuse in theory, and even allow small amounts of it.
 - Taking liquidity seems less likely to motivate the average potential participant, and costs you weirdness points, but does provide a strong incentive for the right type of trader. The best reason I can think of to use such a strategy is that it is robust to abuse. That's a big game if you can't respond dynamically to unfriendly players.
 - At the end of the day, biggest barriers are that people's attention is limited, complexity is bad, opportunity cost is high and people don't do things.
 - Subsidy can get people excited and make markets work that wouldn't otherwise get off the ground. What I think they can't do at reasonable cost is fix fundamental problems.
 - If you don't have a great product behind the subsidy, it's going to be orders of magnitude more expensive to motivate participation.

The Use of Knowledge in Society²⁷

- Relevant information exists as dispersed bits of incomplete and frequently contradictory knowledge which all separate individuals possess.
- Everyone has relevant information.
- Economic problem of society is a problem of the utilization of knowledge.
- Scientific knowledge is not all knowledge — there is beyond question a body of very important but unorganized knowledge which cannot possibly be called scientific in the sense of knowledge of general rules: the knowledge of particular circumstances of time and place.
- Practically every individual has some advantage over all others in that he possesses unique information of which beneficial use might be made, but of which use can be made only if the decisions depending on it are left to him or are made with his active cooperation.
- All knowledge should be readily at the command of everybody, and the reproach of irrationality leveled against the existing economic order is frequently based on the fact that it is not so available.
- Ultimate decisions must be left to the people who are familiar with circumstances, who know directly of relevant changes and of the resources immediately available to meet them. Decentralization is required.
- Decentralization is needed because only then can we ensure that the knowledge of the particular circumstances of time and place will be promptly used.
- We must look at the price system as such a mechanism for communicating information if we want to understand its real function — a function which, of course, it fulfills less perfectly as prices grow more rigid.
- In arguing against centralized economic planning by a small body of experts, “the practical problem [of promoting economic rationality] arises precisely because [the relevant] facts are never so given to a single mind, and because, in consequence, it is necessary that in the solution of the problem knowledge should be used that is dispersed among many people.”
- Useful knowledge is possessed by “practically every individual.”

²⁷ https://www.kysq.org/docs/Hayek_45.pdf

