

A series of thin, black, overlapping lines forming various geometric shapes like triangles and polygons, scattered across the upper left portion of the slide.

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Welcome!
Please, have a seat.

Agenda

Intro to Arbitrage

Election Markets

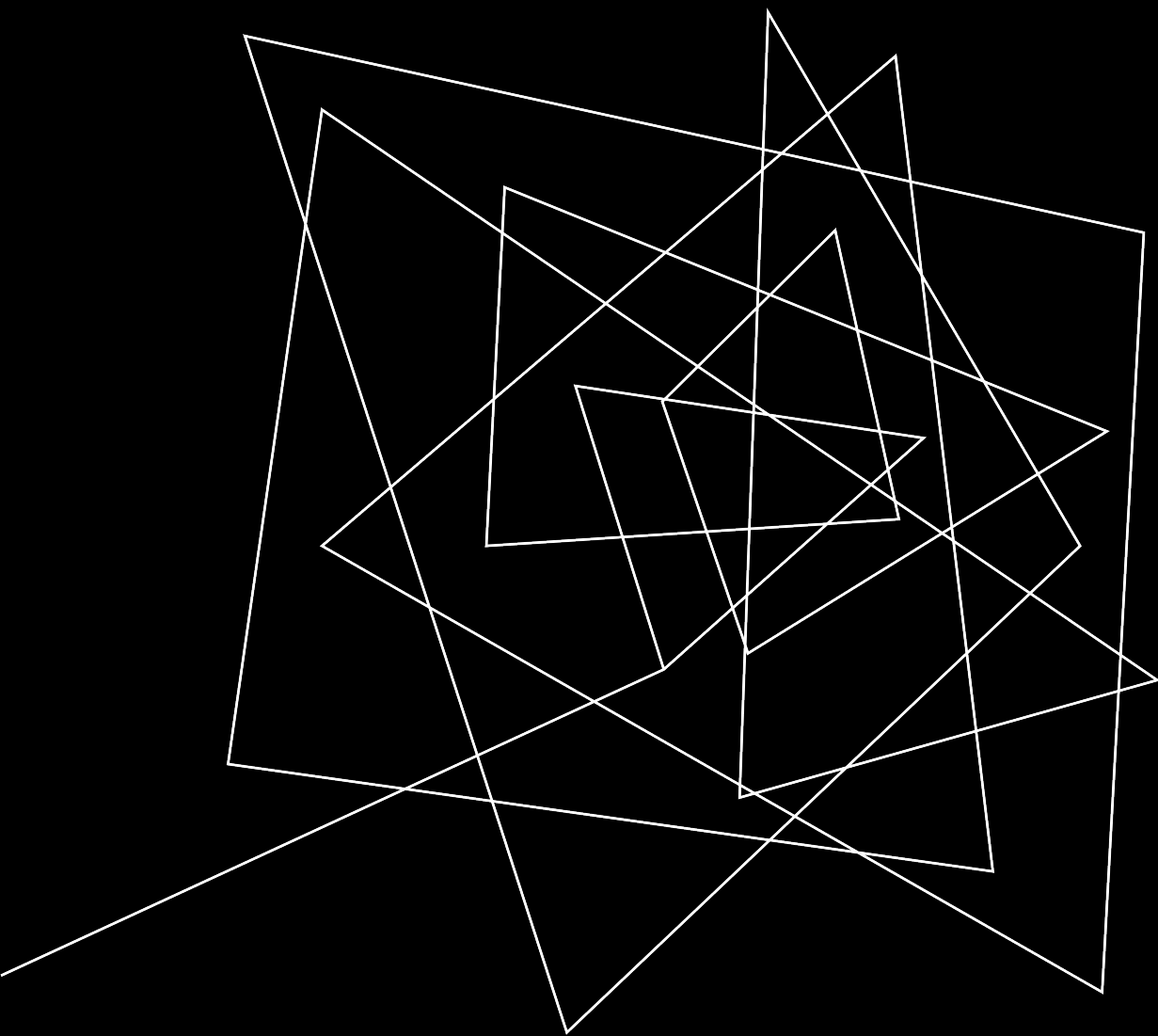
Literature Review

Arbitrage Activity


Attendance | CampusGroups



The first known quantitative trading strategy was developed in the 1970s by mathematician Edward Thorp, who was well known for using statistics to beat the game of Blackjack. He then turned his attention to financial markets and started one of the first quantitative hedge funds: Princeton/Newport Partners. Read more about him [here](#).



INTRO TO ARBITRAGE

Abstract geometric lines in the top-left corner of the slide, consisting of several thin, dark lines that intersect and form various angles and shapes.

arbitrage (n): the nearly simultaneous purchase and sale of securities of foreign exchange in different markets in order to profit from price discrepancies (Merriam Webster).

Starting with a joke...

I saw this “joke” in three different papers about arbitrage, so I had to repeat it here!

A finance professor and a normal person go on a walk and the normal person sees a \$100 bill lying on the street. When the normal person wants to pick it up, the finance professor says: “Don’t try to do that! It is absolutely impossible that there is a \$100 bill lying on the street. Indeed, if it were lying on the street, somebody else would already have picked it up before you!”

How does this apply to the financial markets?

Buy Low, Sell High

- You've probably heard this saying before
- The idea behind arbitrage is to do both of these at the same time in different markets

But aren't markets efficient?

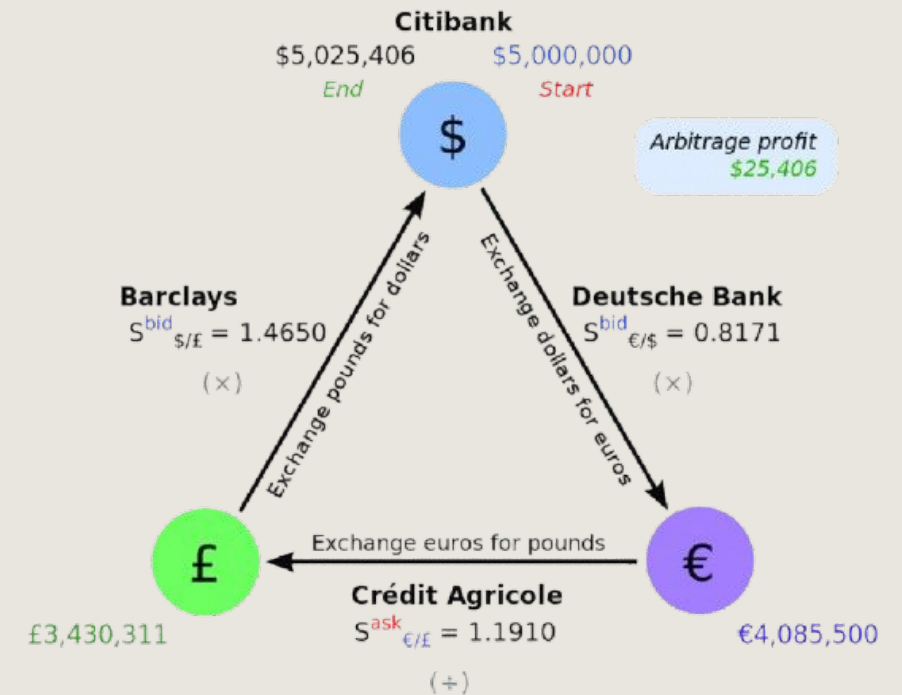
- Markets are efficient under theoretical assumptions that aren't always true in the real world
- In the real world, markets *tend toward* efficiency due to arbitrage opportunities being profitable
- Exploiting arbitrage opportunities brings prices in line with efficiency

Arbitrage...from finance standpoint

Arbitrage is basically free money!*

Assets may be priced differently in markets. This can be exploited!

1. Buy the asset in the market where it is undervalued.
2. Sell the same asset in the market where it is overvalued.
3. The difference between the buying and selling prices represents the arbitrage profit.



Case Study - SBF

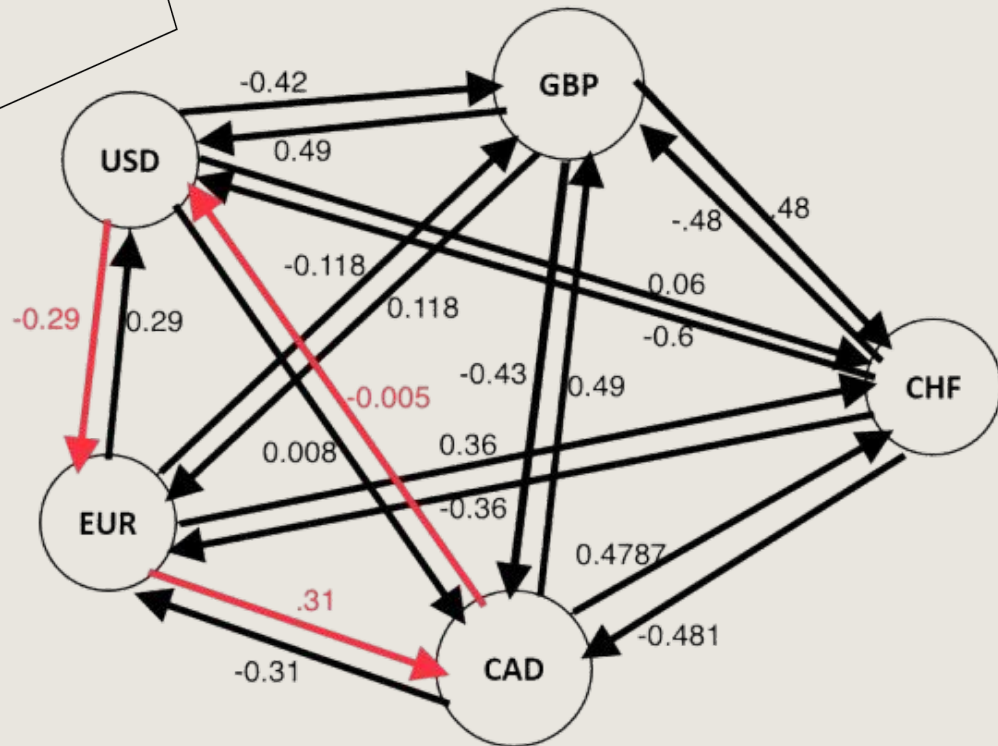
Arbitrage Opportunities in Cryptocurrency Markets

- While Bitcoin was pricing at \$10,000 in the US, it traded for \$15,000 in Korean Won on Korean exchanges. (“The Kimchi Premium”)
- While Bitcoin was pricing at \$10,000 in the US, it traded for \$11,500 in Japanese Yen on Japanese exchanges.

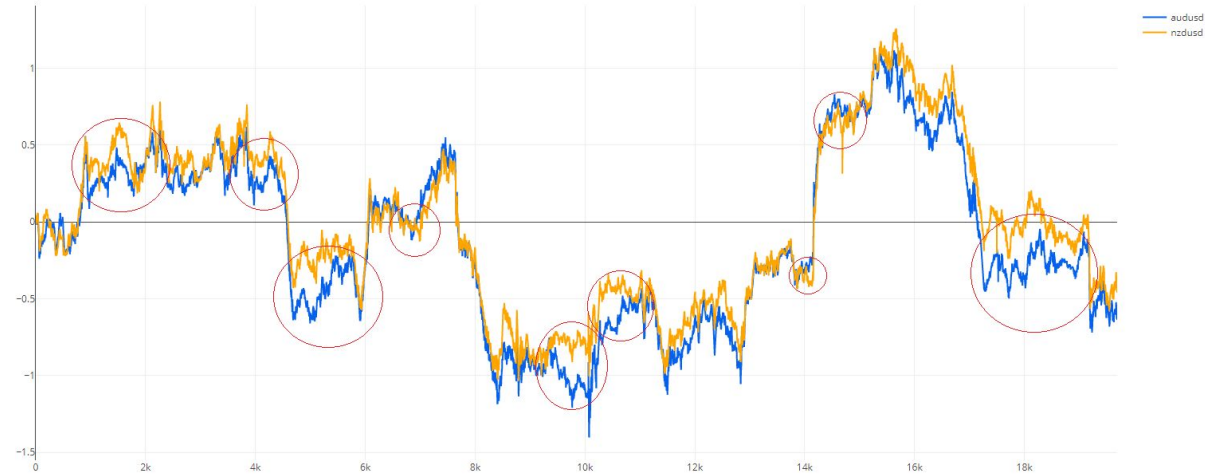


Sidenote...arbitrage using Bellman-Ford

- The Bellman-Ford algorithm is a graph algorithm used to find the shortest paths from a single source vertex to all other vertices in a weighted graph.
- It is particularly useful for graphs with negative weight edges, which Dijkstra's algorithm cannot handle.
- Additionally, it can detect if there is a negative weight cycle in the graph (a cycle whose sum of edge weights is negative), in which case no solution exists.
- If the algorithm finds a negative cycle, it indicates the presence of an arbitrage opportunity. The negative cycle represents a sequence of currency conversions that results in a net gain.

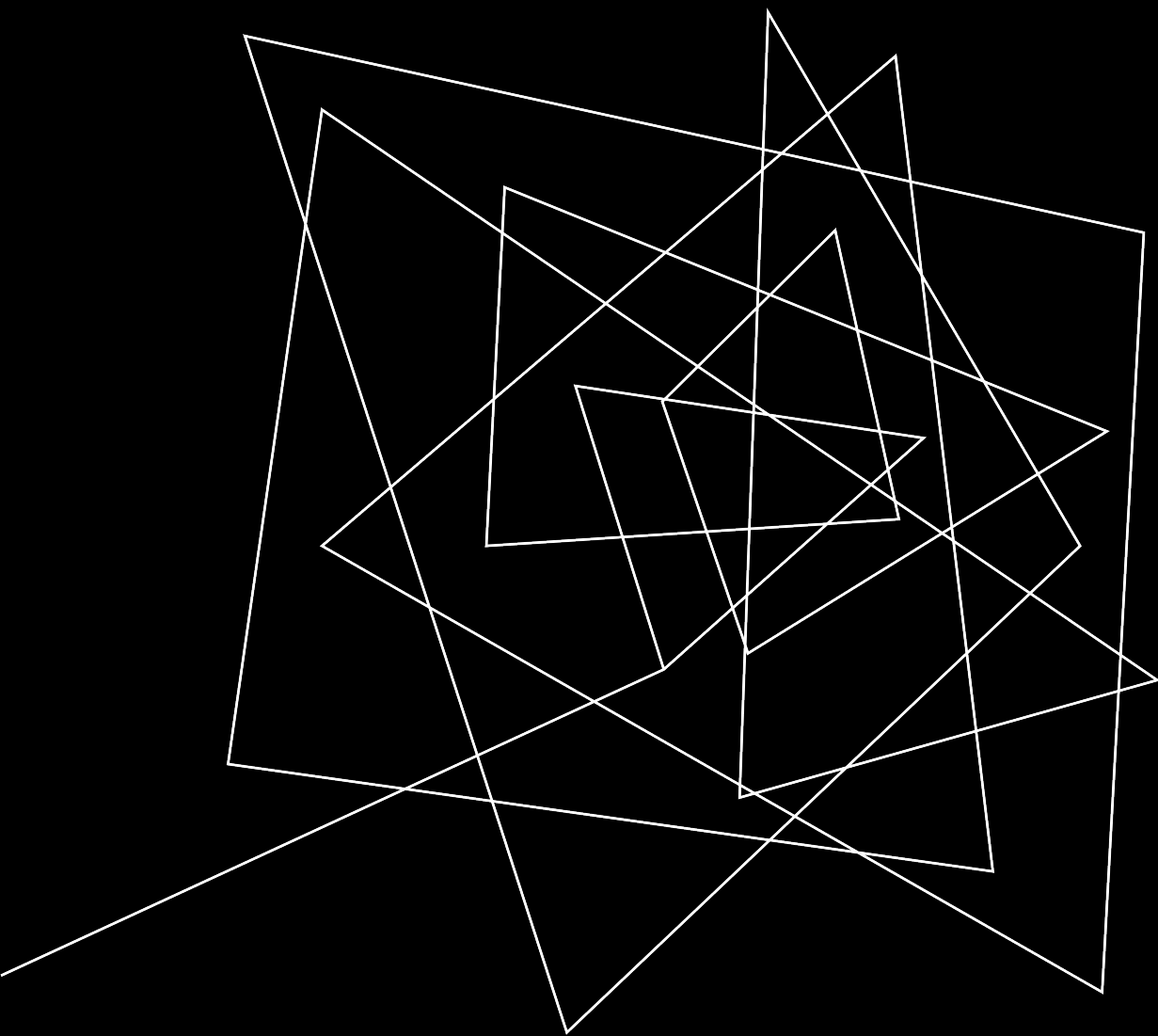


Statistical Arbitrage



Highly technical and computational approach to arb

- Instead of the same security being traded on different markets, two or more highly correlated securities are traded on the same market to take advantage of inefficient relative pricing while maintaining market neutrality
- The strategy relies on mean reversion - it assumes that price divergence between the assets will tend toward 0 instead of further expanding
- In practice, these price divergences might only last for small fractions of a second - that's where HFT comes into play



ELECTION MARKETS

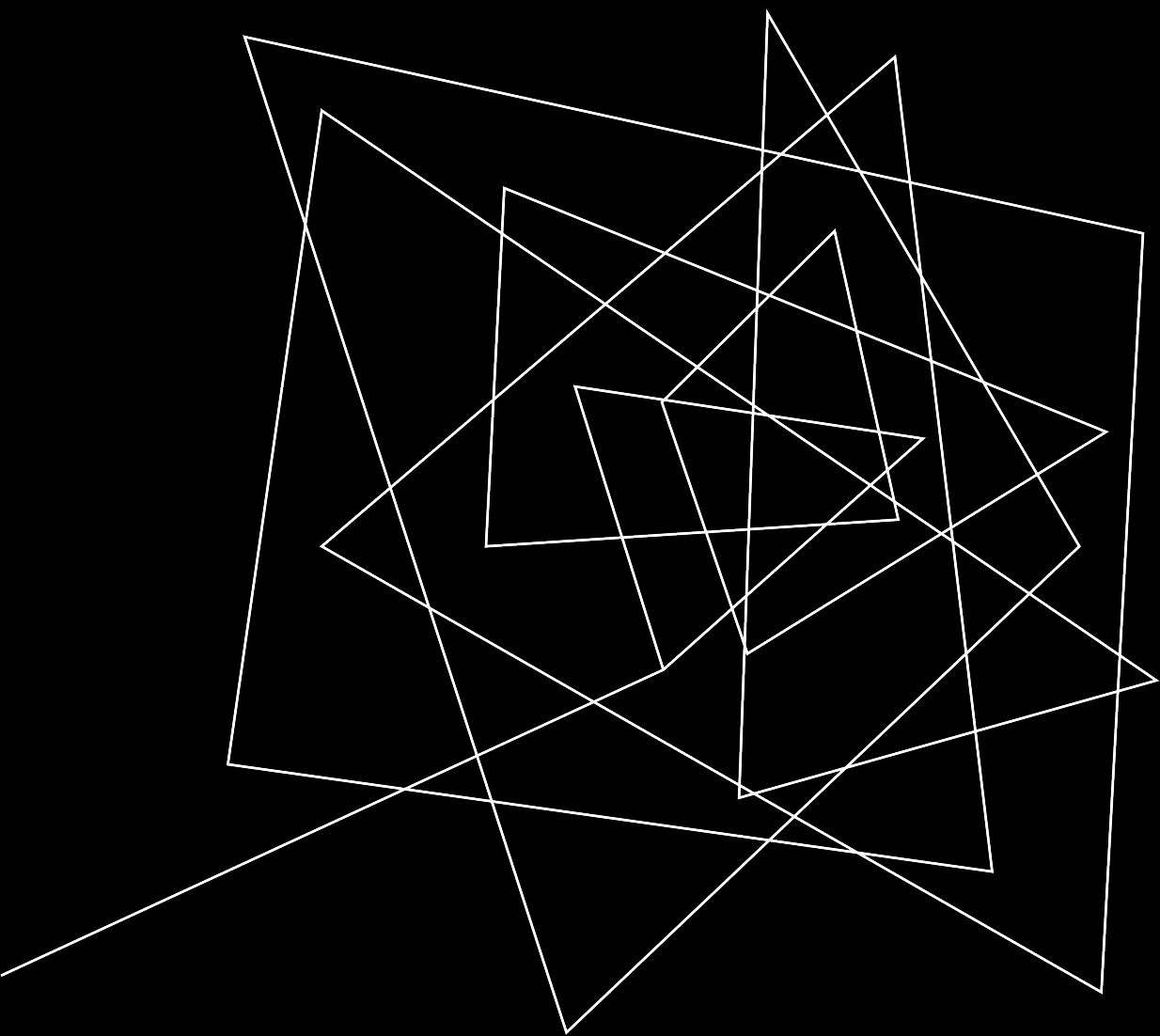
Introduction

How do they work?

- Traders buy shares of an event
- Shares are priced between 1 cent and 99 cents, where the price represents a probability of the event happening
- At the end of their lifetimes, shares expire and pay out one dollar each if their associated event happened or zero dollars otherwise

Why are we interested?

- Not only are election markets far less efficient than the more familiar financial markets, but evidence suggests that they seem to be getting less efficient over time due to their increased popularity with retail
- The conditions for an arb opportunity are easier to understand and detect



LITERATURE REVIEW

Literature Review

Even though shares in election prediction markets are futures contracts in essence, they can be modeled as option contracts where the “price” represents a prediction probability of the share’s event

Notation:

Y_0	the observed estimated proportion of votes expressed in $[0, 1]$ at time t_0 . These can be either popular or electoral votes, so long as one treats them with consistency.
T	period when the irrevocable final election outcome Y_T is revealed, or expiration.
t_0	present evaluation period, hence $T - t_0$ is the time until the final election, expressed in years.
s	annualized volatility of Y , or uncertainty attending outcomes for Y in the remaining time until expiration. We assume s is constant without any loss of generality –but it could be time dependent.
$B(\cdot)$	“forecast probability”, or estimated continuous-time arbitrage evaluation of the election results, establishing arbitrage bounds between $B(\cdot)$, Y_0 and the volatility s .

$$B(Y_0, \sigma, t_0, T) = \frac{1}{2} \operatorname{erfc} \left(\frac{l - \operatorname{erf}^{-1}(2Y_0 - 1)e^{\sigma^2(T-t_0)}}{\sqrt{e^{2\sigma^2(T-t_0)} - 1}} \right), \quad (1)$$

where

$$\sigma \approx \frac{\sqrt{\log(2\pi s^2 e^{2\operatorname{erf}^{-1}(2Y_0-1)^2} + 1)}}{\sqrt{2}\sqrt{T-t_0}}, \quad (2)$$

$$dS = \left(\frac{1}{2} \sigma^2 \frac{\partial^2 S}{\partial x^2} + X \sigma^2 \frac{\partial S}{\partial x} \right) dt + \sigma \frac{\partial S}{\partial x} dW$$

$$\mathbb{E}(X, T) = X_0 e^{\sigma^2(T-t_0)},$$

$$\mathbb{V}(X, T) = \frac{e^{2\sigma^2(T-t_0)} - 1}{2}$$

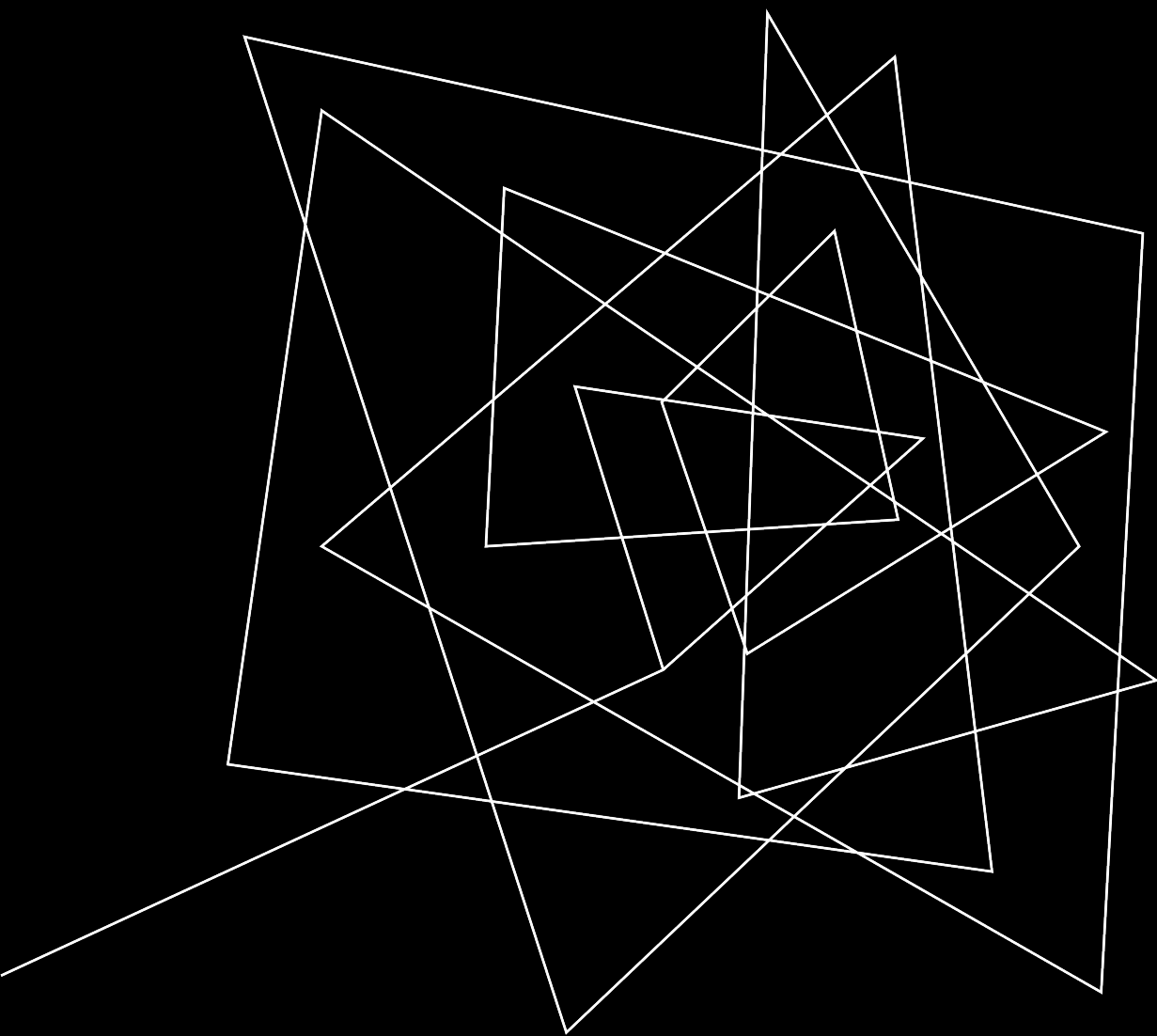
Favorite-Longshot Bias

Betting markets have been shown to exhibit FLB (systemic bias toward underdogs and underpricing of favorites), and the same goes for election markets

Vlastakis et al. (2009)	2009	Inter-market arbitrage and betting biases	There exist limited but highly profitable arbitrage opportunities, as well as the favorite-longshot bias (FLB) and an "away-favorite" bias.	Bet365, Internet1x2, Interwetten, Sportingbet, and William Hill (2002–2004)
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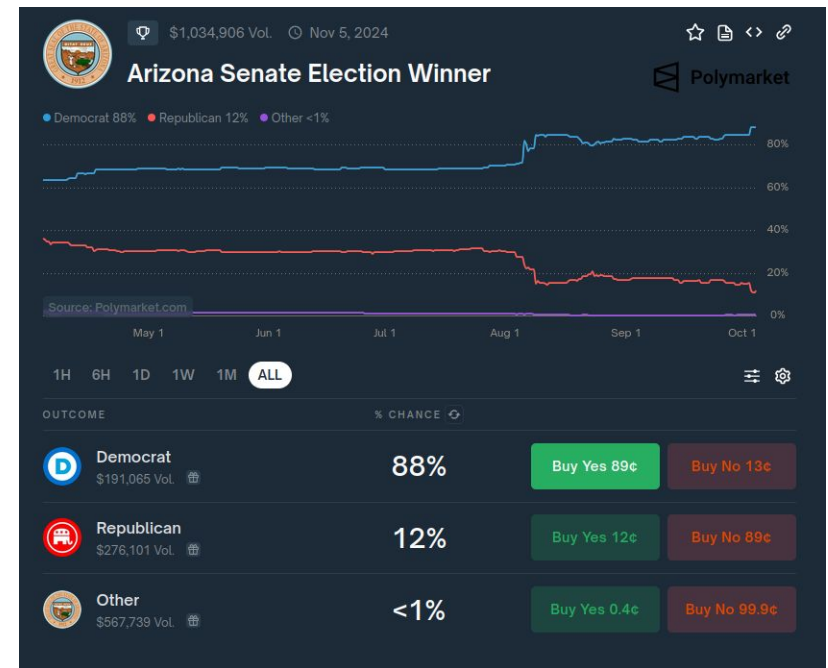
Page (2012)	2012	Favorite-longshot bias (FLB)	Market exhibits FLB.	Tradesports.com (2006–2007)
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Restocchi et al. (2019)	2019	Favorite-longshot bias (FLB)	Markets exhibit FLB, and the level of FLB decreases with duration of the market.	PredictIt (2014–2016)
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ARBITRAGE ACTIVITY




Arbitrage Opportunities: AZ Senate



PredictIt Markets Leaderboards Support Login Sign Up



Presidency Congress Donald Trump Kamala Harris

Which party will win the 2024 US Senate election in Arizona?







Contract	Latest Yes Price	Best Offer	Best Offer
 Democratic	81¢ 1¢↑	81¢ Buy Yes Buy No	20¢
 Republican	22¢ NC	22¢ Buy Yes Buy No	79¢
 Independent	1¢ NC	1¢ Buy Yes Buy No	N/A

Another Example: WI Presidency

PredictIt:

Which party will win Wisconsin in the 2024 presidential election?					
Contract		Latest Yes Price	Best Offer		Best Offer
	Democratic	63¢ <small>1¢↑</small>	63¢	Buy Yes	Buy No 38¢
	Republican	41¢ <small>NC</small>	41¢	Buy Yes	Buy No 60¢

PolyMarket:



OUTCOME		% CHANCE 		
	Democrat \$1,360,273 Vol. 	52%	Buy Yes 53¢	Buy No 49¢
	Republican \$921,483 Vol. 	48%	Buy Yes 49¢	Buy No 53¢
View more 				

Obstacles to Arbitrage

- Trade size limits on major exchanges (ex. \$850 cap on investments per trader per question on PredictIt)
- Illiquidity
- Slippage
- Commissions and fees

All of this puts a constraint on the minimum size of a viable arb trade (ex. a 1 or 2 cent profit trade is generally never viable)

Which party will win Georgia in the 2024 presidential election?

Contract	Latest Yes Price	Best Offer	Best Offer
 Republican	61¢ 1¢↓	62¢	Buy Yes Buy No 39¢
 Democratic	42¢ NC	43¢	Buy Yes Buy No 58¢



Activity (10m)

Try it!

- Break into groups of 3-4 students
- Introduce yourself to teammates
- Go to the given prediction market websites
- Find your own arbitrage opportunities
- Create payoff tables to see your profit

Sites:

<https://www.predictit.org/>

<https://polymarket.com/>

<https://kalshi.com/> (newer)

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QUESTIONS AND ANSWERS

Contact us!

Email: quants@case.edu

Instagram: [@cwruquants](https://www.instagram.com/cwruquants)

Attendance

