SAND2014-17225PE

Better Predictions Trough Betting

Designing Custom Futures Markets to turn Data into Decisions

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2014 Annual Conference of the Prognostics and Health Management Society
September 29 – October 2, 2014
Ft Worth, Texas

2012-6413C

Prediction contracts are simple bets

Binary Contracts

Futures contract

If the Denver Broncos win against the Dallas Cowboys on October 6, 2013, this contract is worth $10. If they lose, the contract is void.

When trading at $7.50,
consensus probability = 0.75

Futures contract

If the Denver Broncos beat the Dallas Cowboys by more than 3 points on October 6, 2013, this contract is worth $10. If they lose, the contract is void.

When trading at $5.00,
consensus probability = 0.50

Derivative Contracts

Futures contract

The hold of this contract will receive $0.10 for every point scored in the game between the Denver Broncos and the Dallas Cowboys on October 6, 2013.

When trading at $9.90,
consensus estimate = 99 total points

Prediction markets exploit “Wisdom of Crowds”

Four qualities that make a crowd smart

1. Diversity (people have different pieces of information)
2. Decentralization (nobody at top is dictating answer)
3. Independence (people focus on own area of expertise)
4. Method* to generate collective opinion (aggregation)

Aggregation method needs to preserve first 3 qualities!

*__Double-auction markets__ are effective at aggregating distributed and dynamic information into a quantitative collective hypothesis evaluation. Prediction contracts are traded just like stocks on the NYSE or commodities on the CME.

Conceptual mapping for future event:

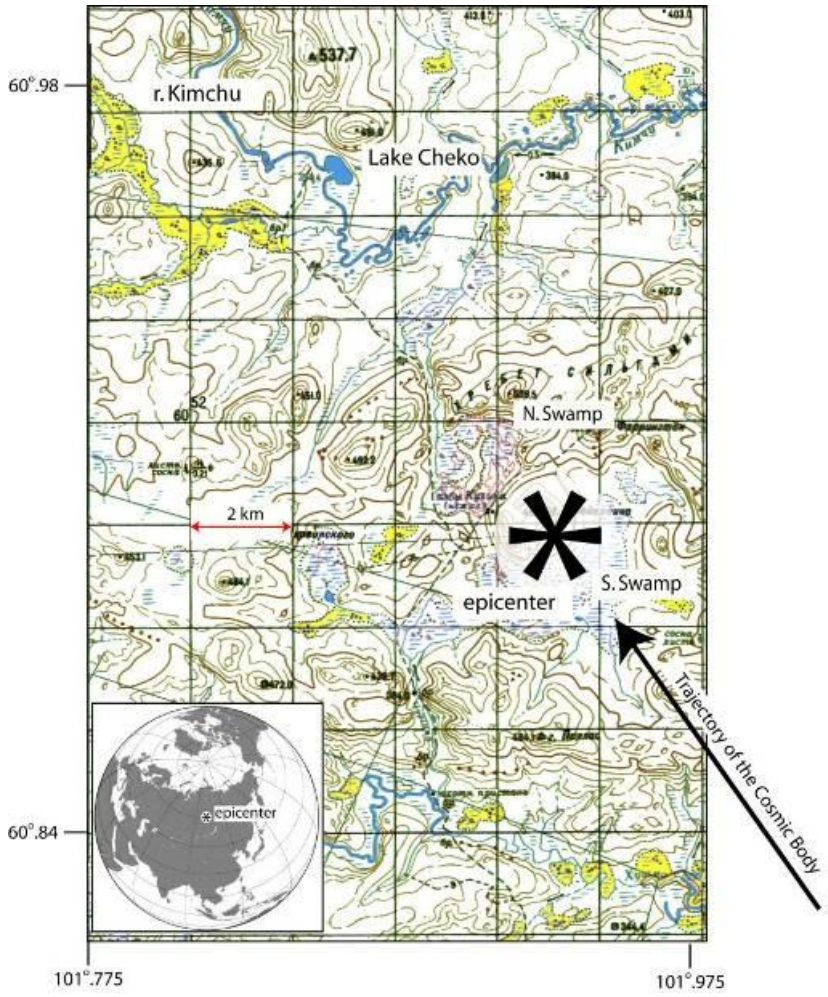
Contract = “Hypothesis” Price = “Probability”

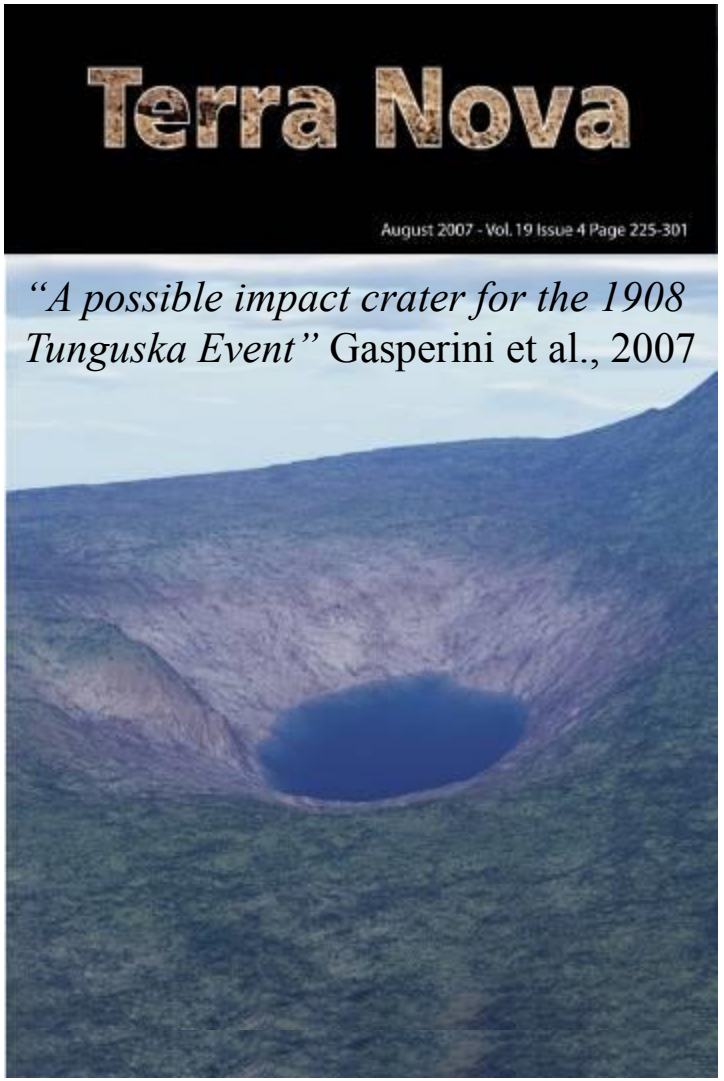
James Surowiecki, “Wisdom of Crowds” (2004).

Examples and potential uses

1. Settling scientific controversies
2. Quantification of scientific consensus
3. Market-based consensus on climate change
4. Intelligence information aggregation
5. Counterintelligence
6. Notification of new information
7. Connecting the dots
8. Objective evaluation of information quality
9. Decision support
10. Funding allocation
11. Global warming and carbon pricing

Example 1: Settling Scientific Controversies





"A possible impact crater for the 1908 Tunguska Event" Gasperini et al., 2007

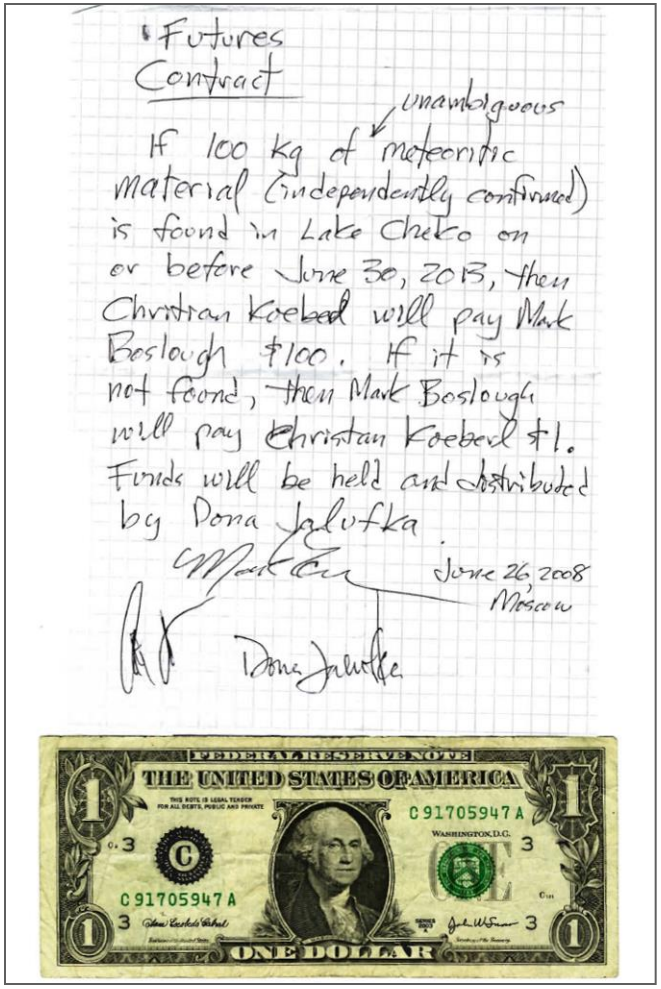
Lake Cheko photography: Discovery Channel

Impact crater or just a lake?

First post-expedition conference: Vanavara

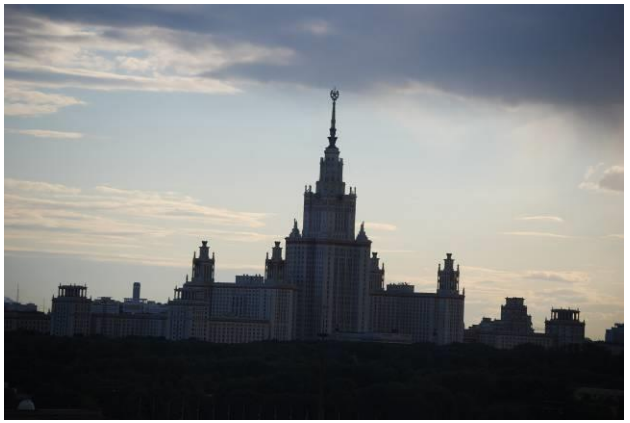
First look: Submersible camera videos!

Scientific bet



Futures contract

If 100 kg of unambiguous meteoritic Material (independently confirmed) is found in Lake Cheko on or before June 30, 2013, then Christian Koeberl will pay Mark Boslough $100. If it is not found, then Mark Boslough will pay Christian Koeberl $1. Funds will be held and distributed by Dona Jalufka.



Scientific futures contract determines consensus probability of hypothesis

Futures contract: .TRUE.

If 100 kg of unambiguous meteoritic Material (independently confirmed) is found in Lake Cheko on or before June 30, 2013, then the holder of this contract collects $101. If it is not found, then the contract is void. Funds will be held and distributed by the World Scientific Hypothesis Exchange.

Buyer pays $1 and gets this contract

Futures contract: .FALSE.

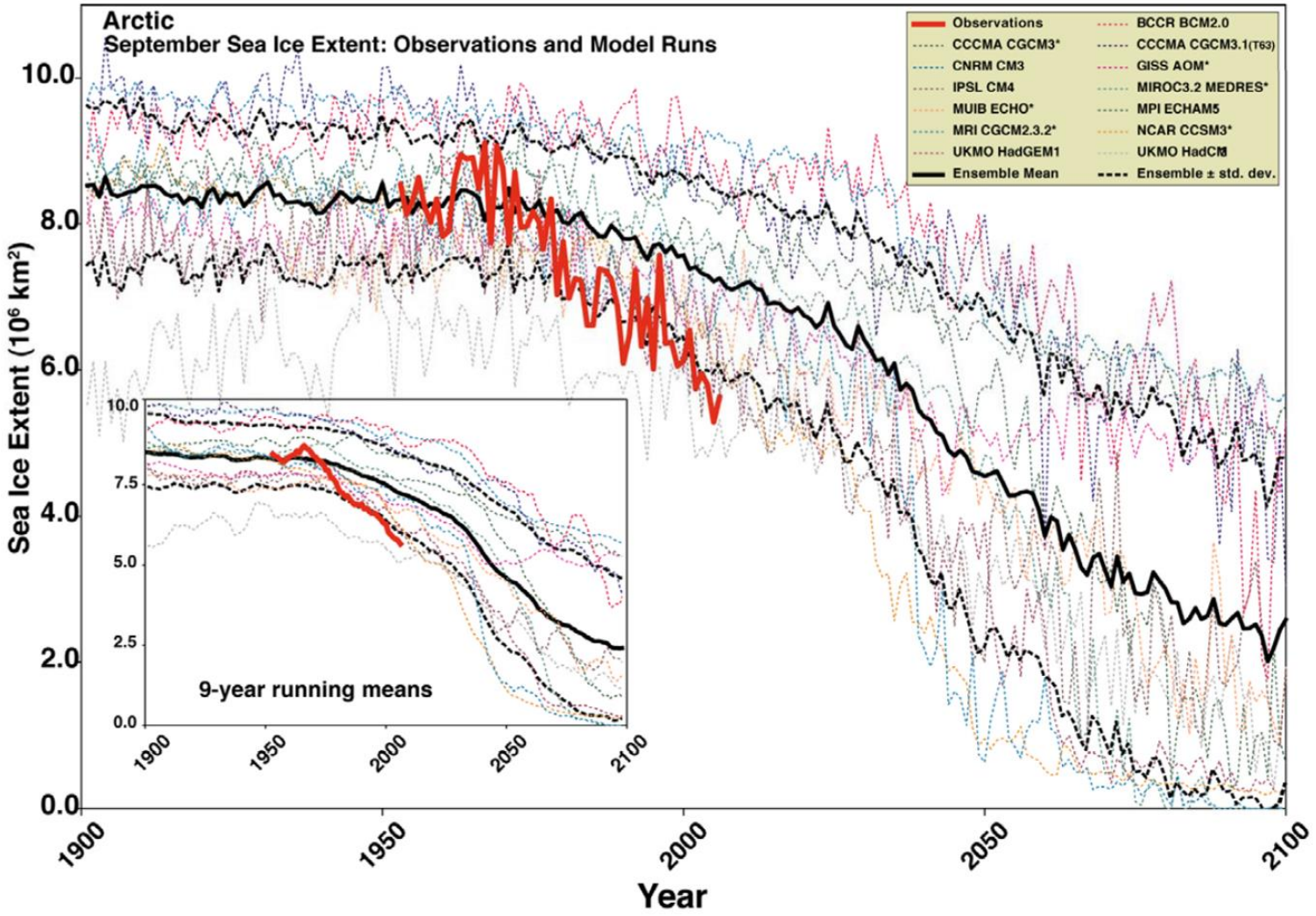
If 100 kg of unambiguous meteoritic Material (independently confirmed) is not found in Lake Cheko on or before June 30, 2013, then the holder of this contract collects $101. If it is found, then the contract is void. Funds will be held and distributed by the World Scientific Hypothesis Exchange.

Seller pays $100 and gets this contract

Generalized contract allows exchange trading

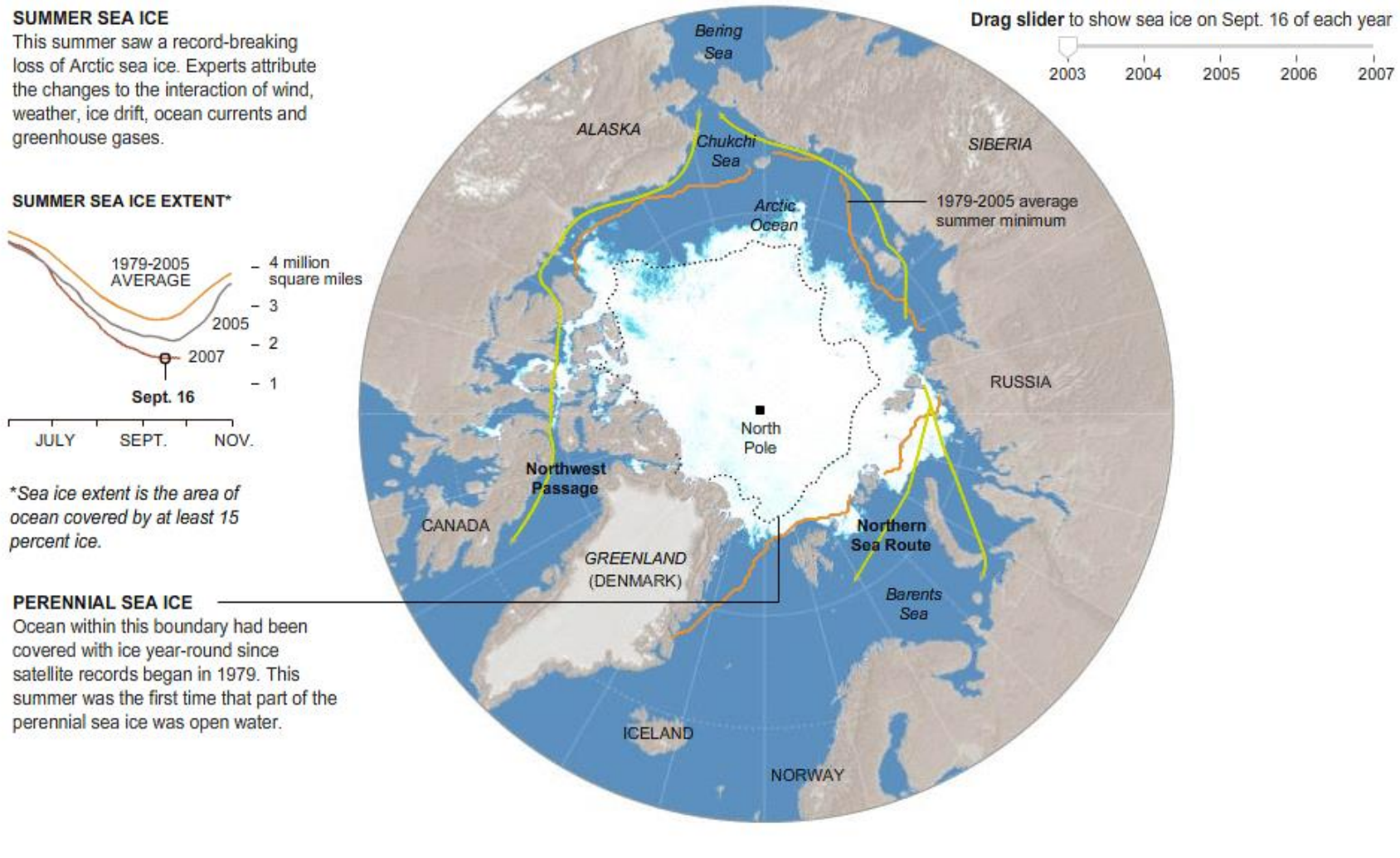
Example 2: Quantification of scientific consensus

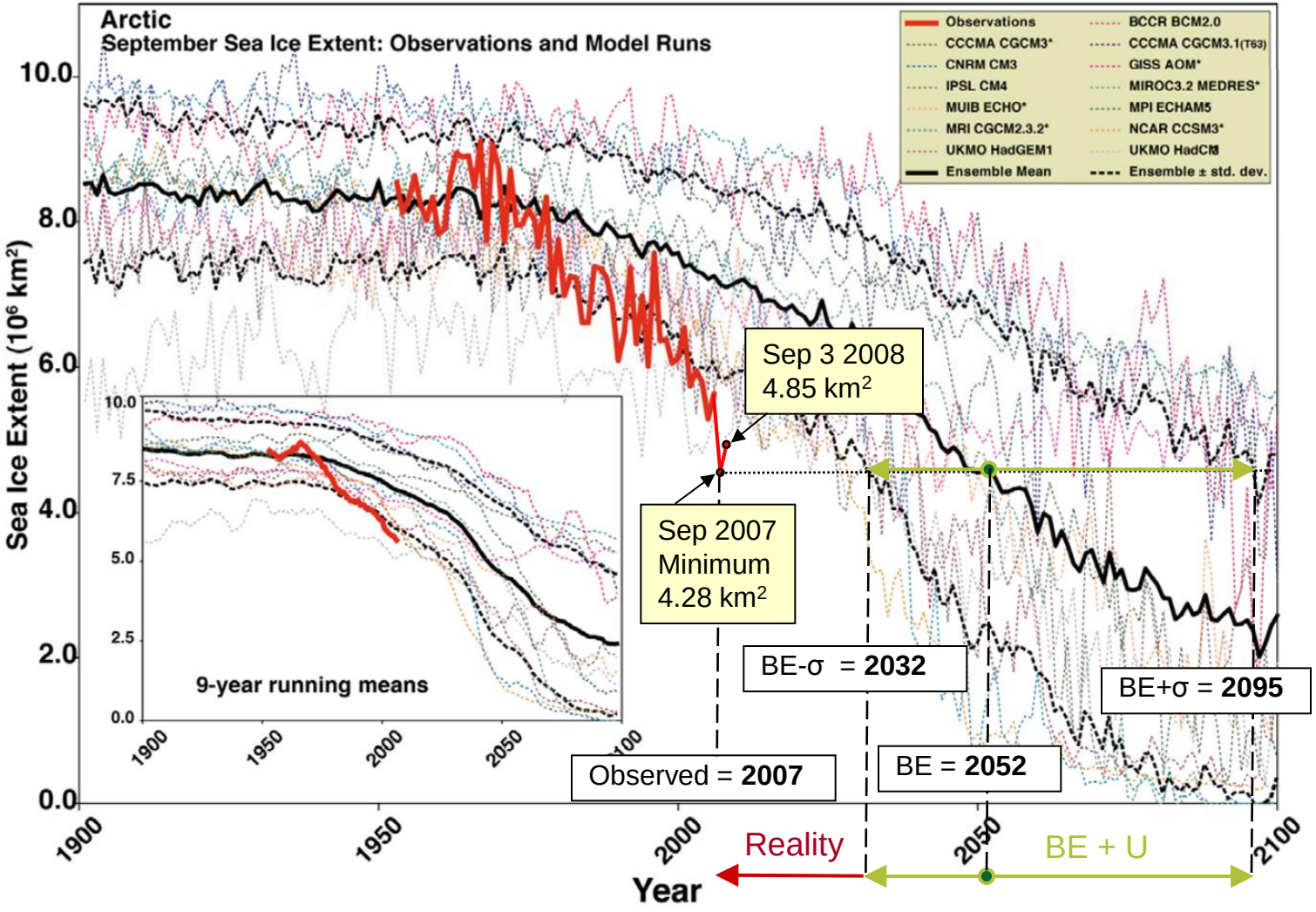
Stroeve et al. (2007) Arctic Sea Ice Decline: Faster than Forecast, GRL



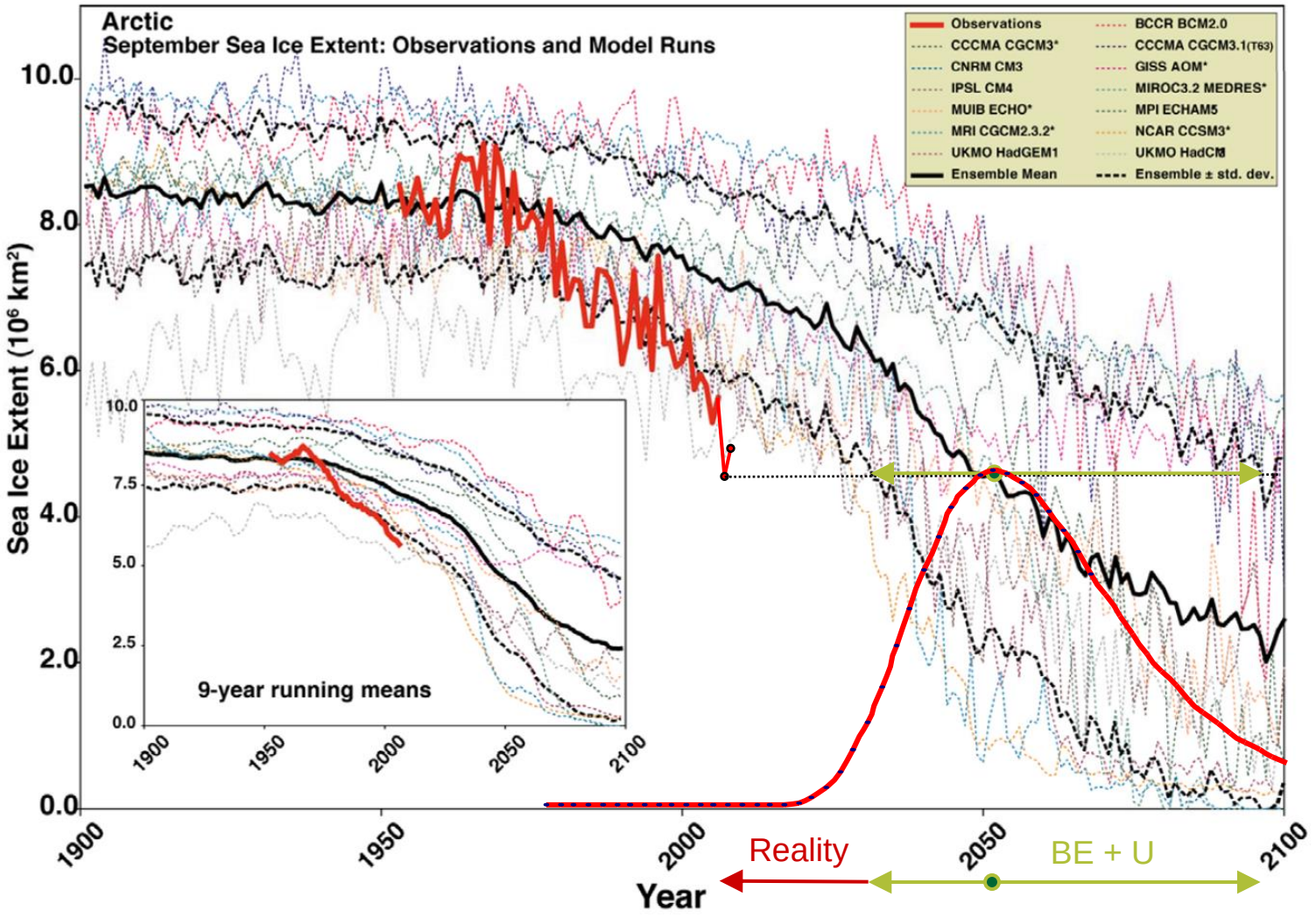
Recent History of Arctic Sea Ice

Hypothesis: Arctic will be ice-free by 2023



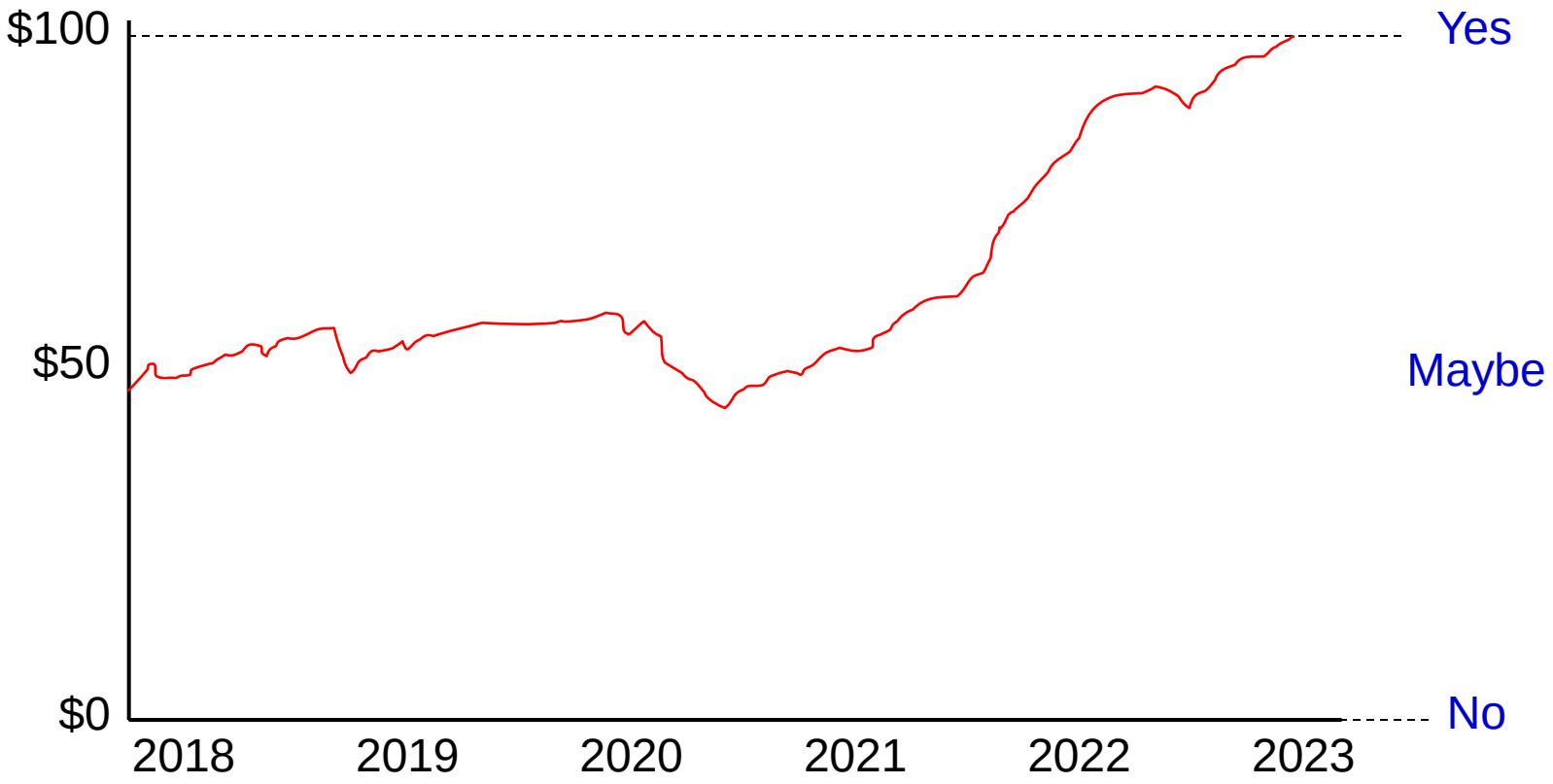


Contracts can be used to determine best estimates and uncertainties



Contracts can be used to build probability density functions

Will Arctic be ice free in September 2023?



Price is the consensus probability of hypothesis being correct…
…but this market would have liquidity because of hedging investments!

Example 3: Market consensus on climate change

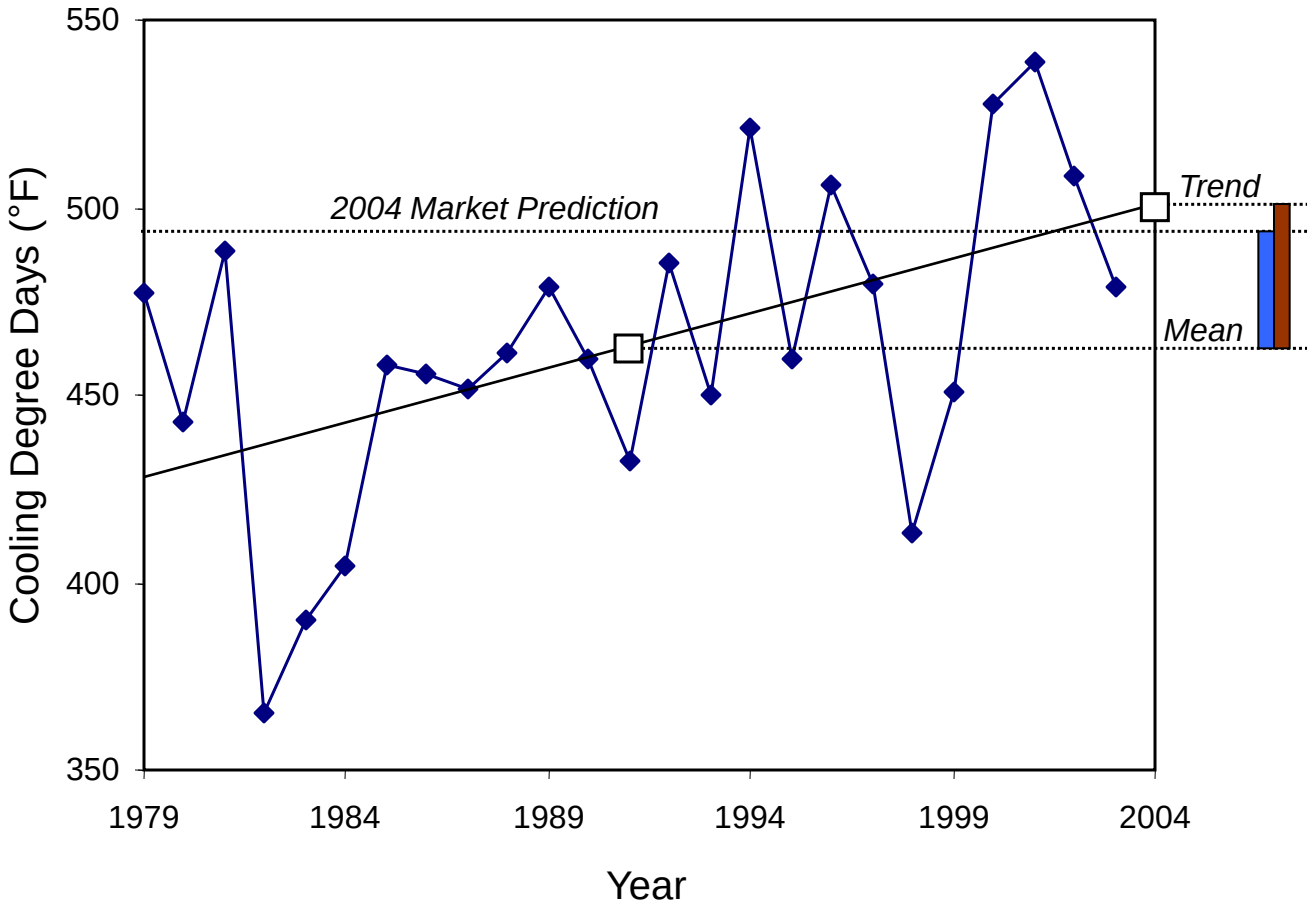
Heating Degree Day (HDD) and Cooling Degree Day (CDD) contracts for various US cities are traded on the Chicago Mercantile Exchange (CME)

$$HDD = \sum \max [0, 65°F - \tfrac{1}{2}(T_{hi} + T_{lo})]$$

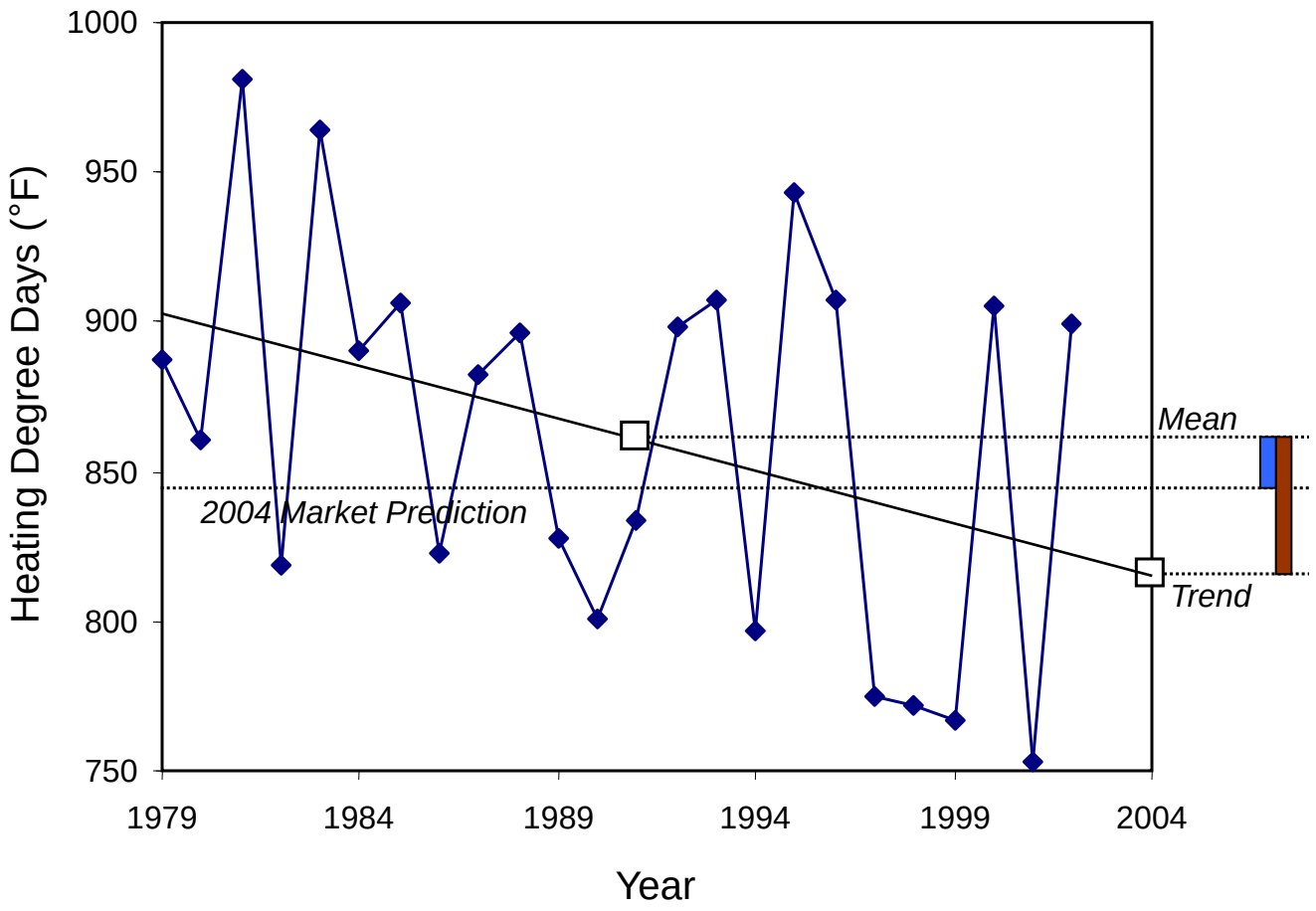
$$CDD = \sum \max [0, \tfrac{1}{2}(T_{hi} + T_{lo}) - 65°F]$$

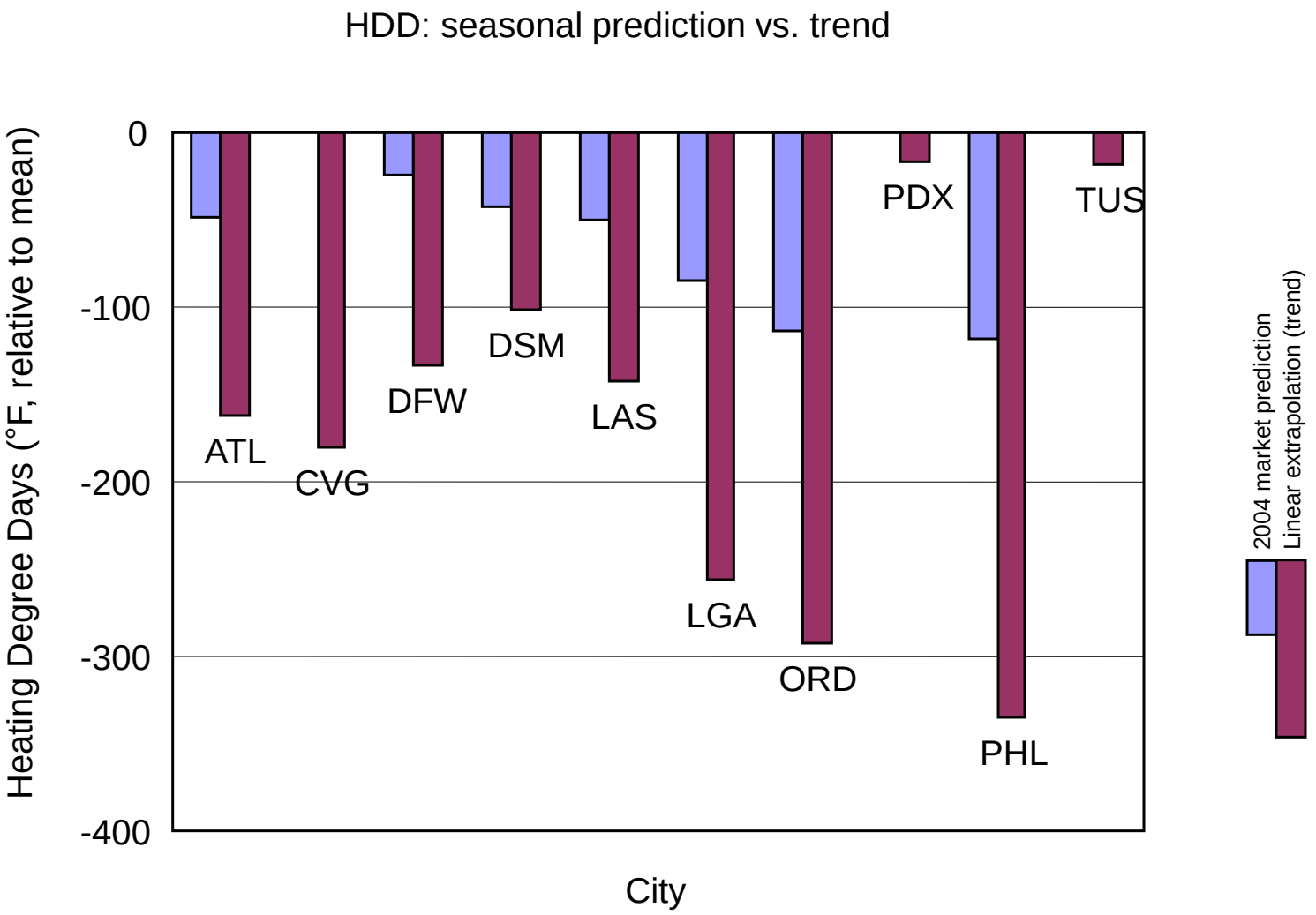
Do predictions represent “market consensus” on climate change?

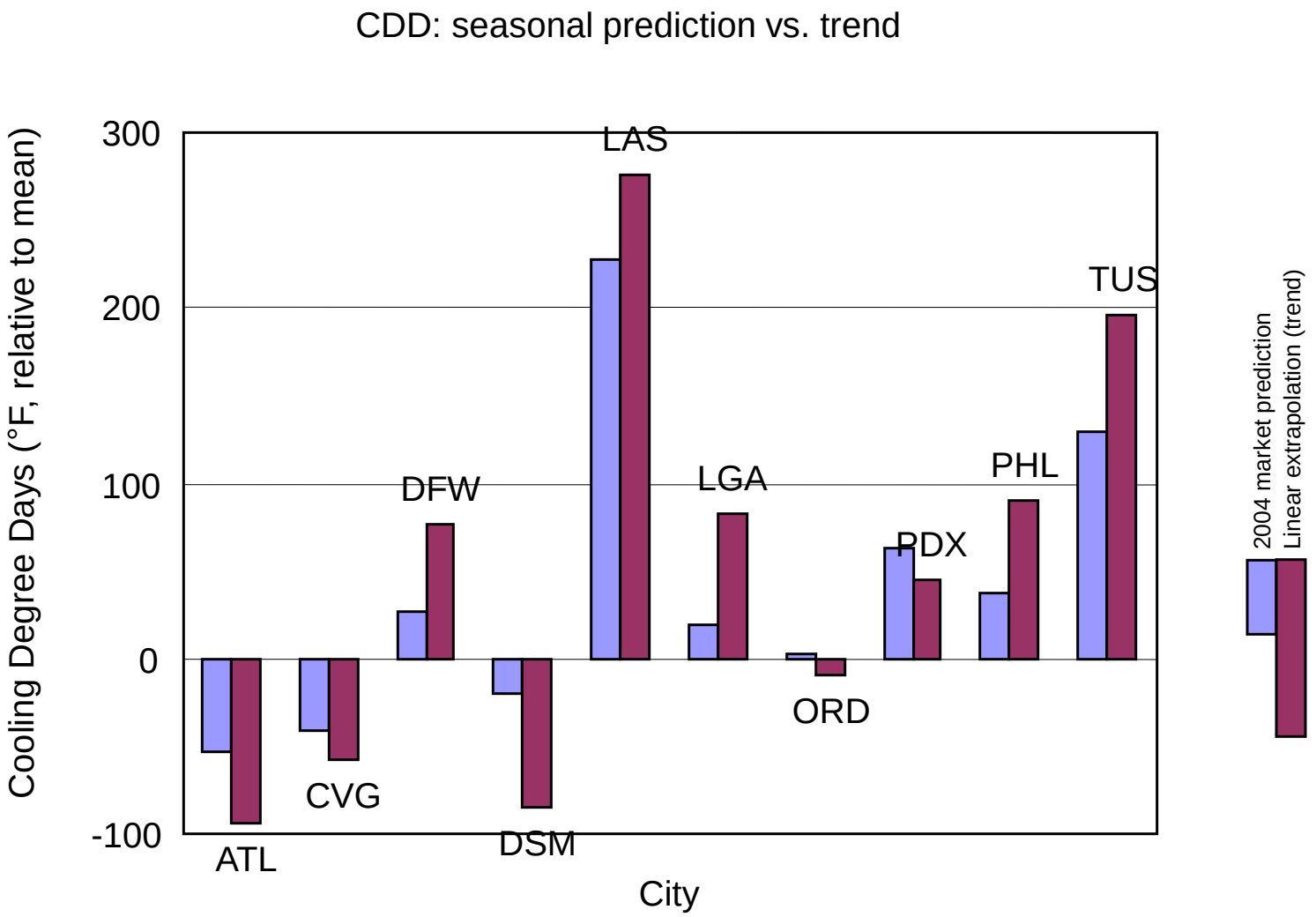
CDD: Las Vegas summer season

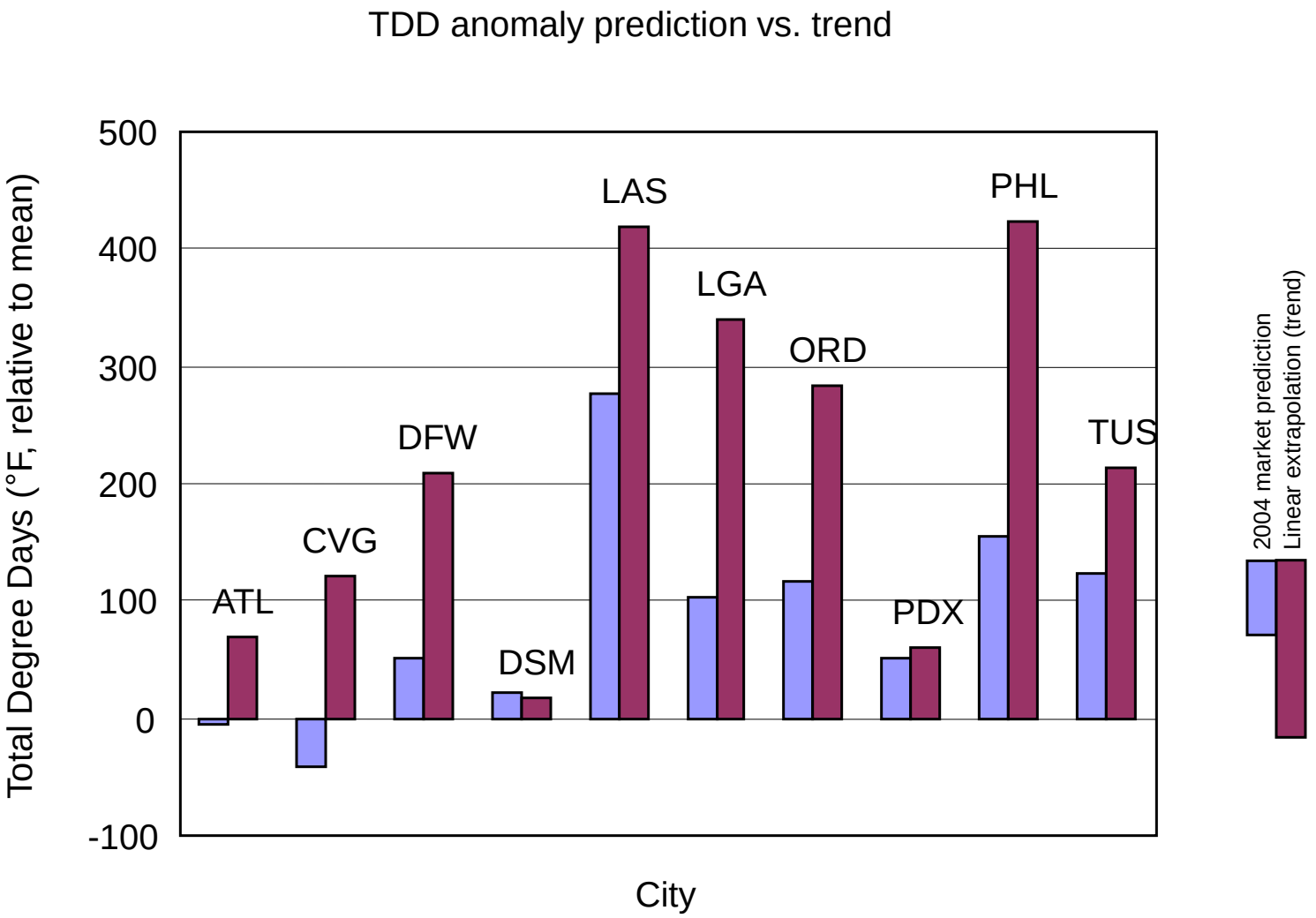


HDD: Chicago winter season

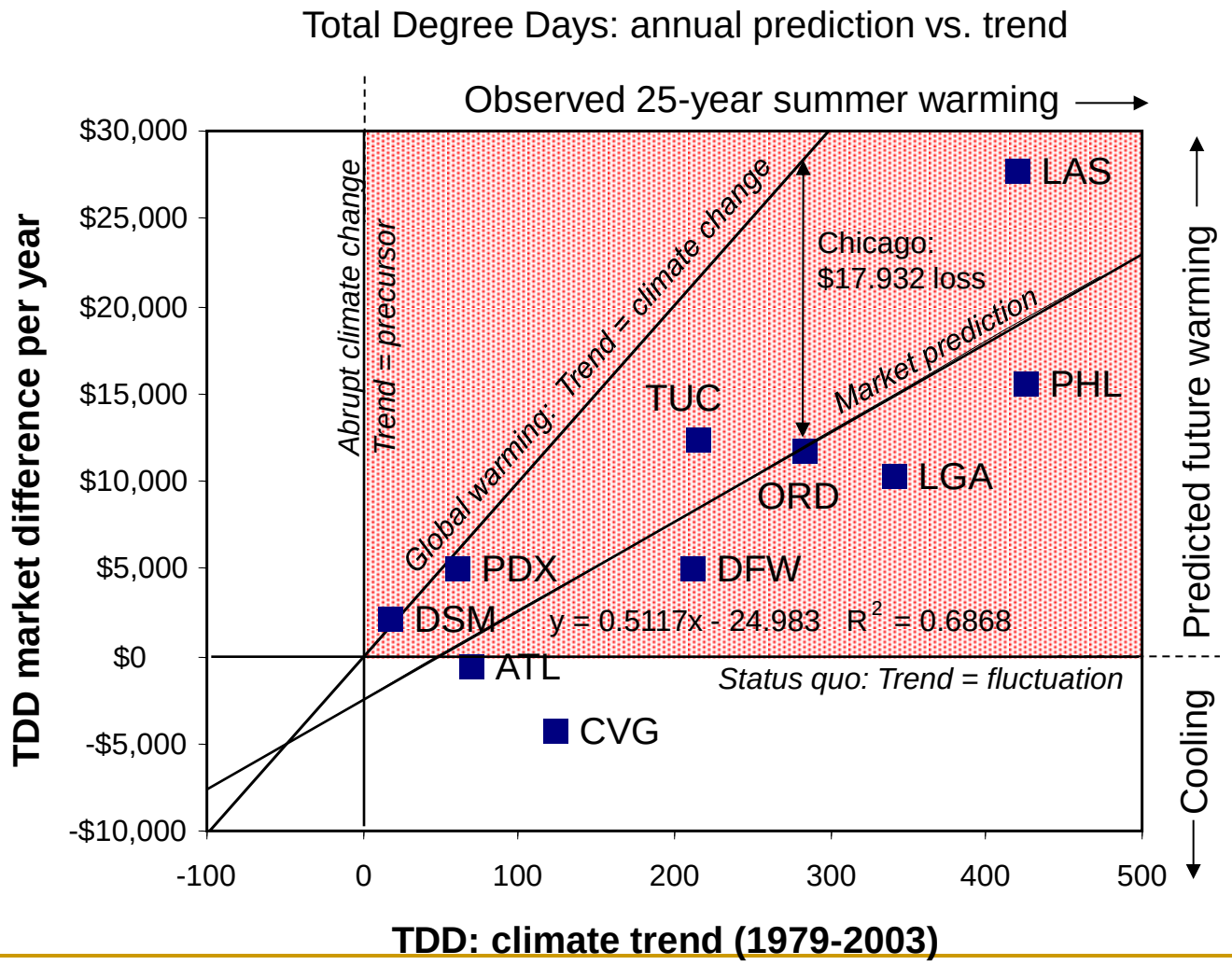



HDD: seasonal prediction vs. trend
Heating Degree Days (°F, relative to mean)
0
-100
-200
-300
-400
ATL
CVG
DFW
DSM
LAS
LGA
ORD
PHL
PDX
TUS
City
2004 market prediction
Linear extrapolation (trend)


CDD: seasonal prediction vs. trend
Cooling Degree Days (°F, relative to mean)
300
200
100
0
-100
ATL
CVG
DFW
DSM
LAS
LGA
ORD
PDX
PHL
TUS
City
2004 market prediction
Linear extrapolation (trend)


TDD anomaly prediction vs. trend
Total Degree Days (°F, relative to mean)
500
400
300
200
100
0
-100
ATL
CVG
DFW
DSM
LAS
LGA
ORD
PDX
PHL
TUS
City
2004 market prediction
Linear extrapolation (trend)

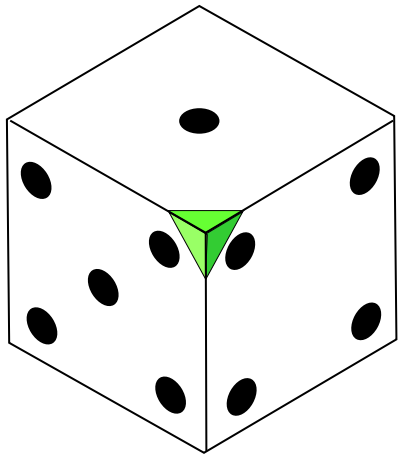
Markets: 51% of total warming trend is climate change



Example 5: Intelligence information aggregation

Possibility sets can be aggregated

State space Ω



True state = ω_{154}

$P_A = \{\omega_{154}, \omega_{564}, \omega_{624}, \omega_{214}\}$

$P_B = \{\omega_{142}, \omega_{154}\}$

$P_C = \{\omega_{415}, \omega_{154}, \omega_{541}\}$

$P_{Aggregate} = \{\omega_{154}\}$

Example 6: Counterintelligence

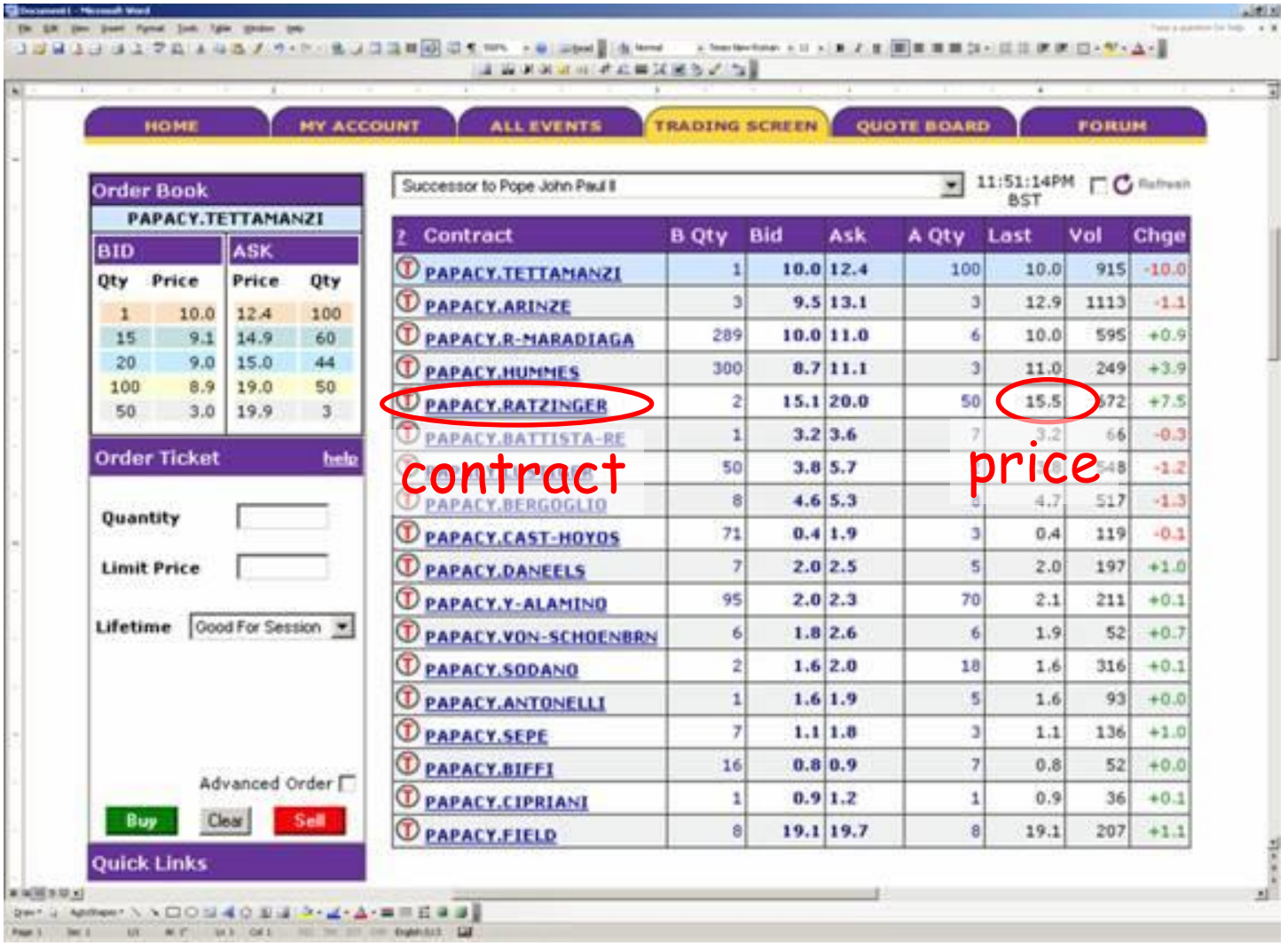
Vatican on lookout for eavesdroppers

Spies may be out to penetrate secret conclave of cardinals

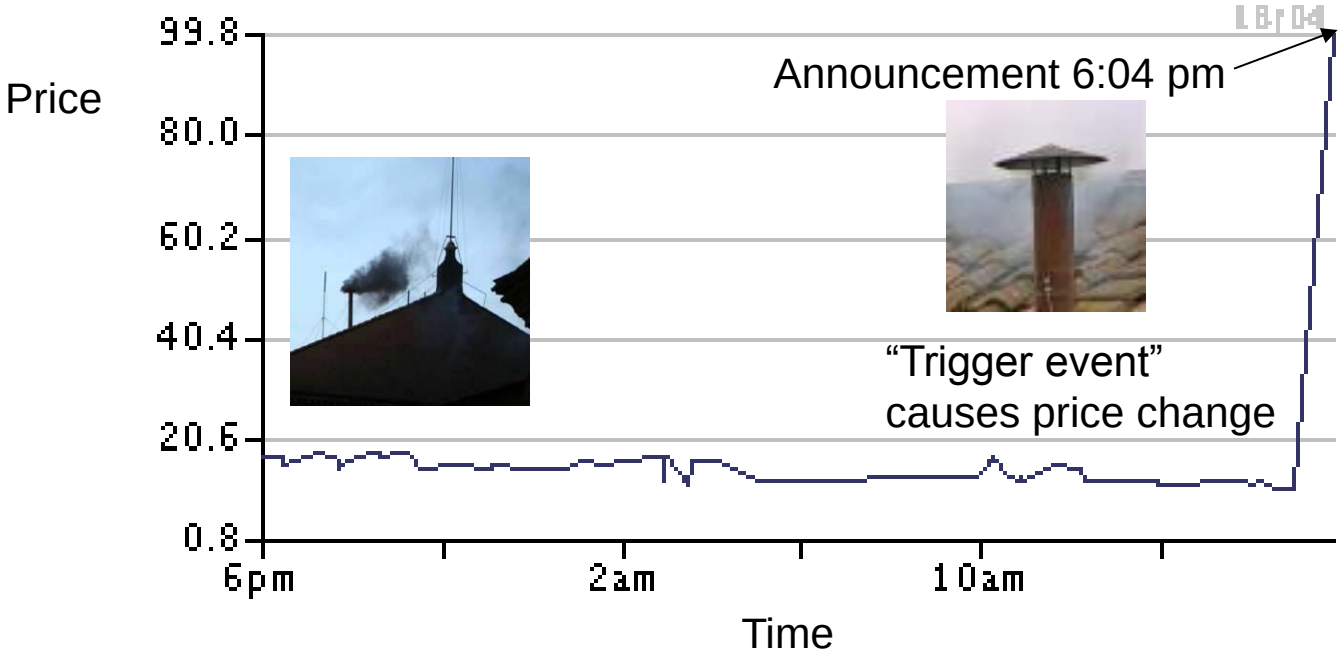
Friday, April 15, 2005

VATICAN CITY (CNN):
"Surely many intelligence agencies in the world are trying to penetrate inside the Holy See. They will do with special aircraft, for example, spy planes with… lasers." **Andrea Margelletti,** of the Center for International Studies in Rome.

www.tradesports.com

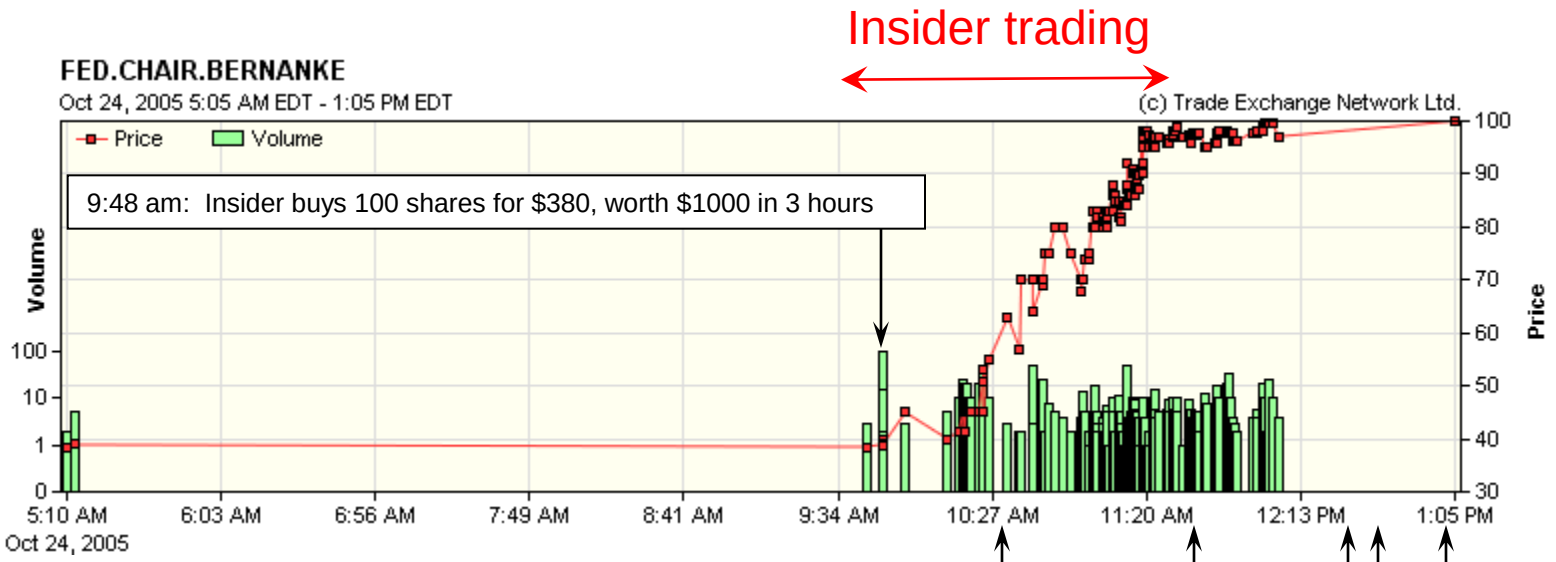


Pope contract ticker confirms no leaks



Cardinal Ratzinger contract "ticker"

Fed chair contract ticker reveals leaks



10:30 am: (Drudge) FLASH: New Fed chairman will be announced at 1PM ET... Developing…

11:36 am: (Drudge) WSJ: President Bush to name Ben Bernanke, the current chairman of his Council of Economic Advisers, to succeed Alan Greenspan as chairman of the Federal Reserve... Developing…

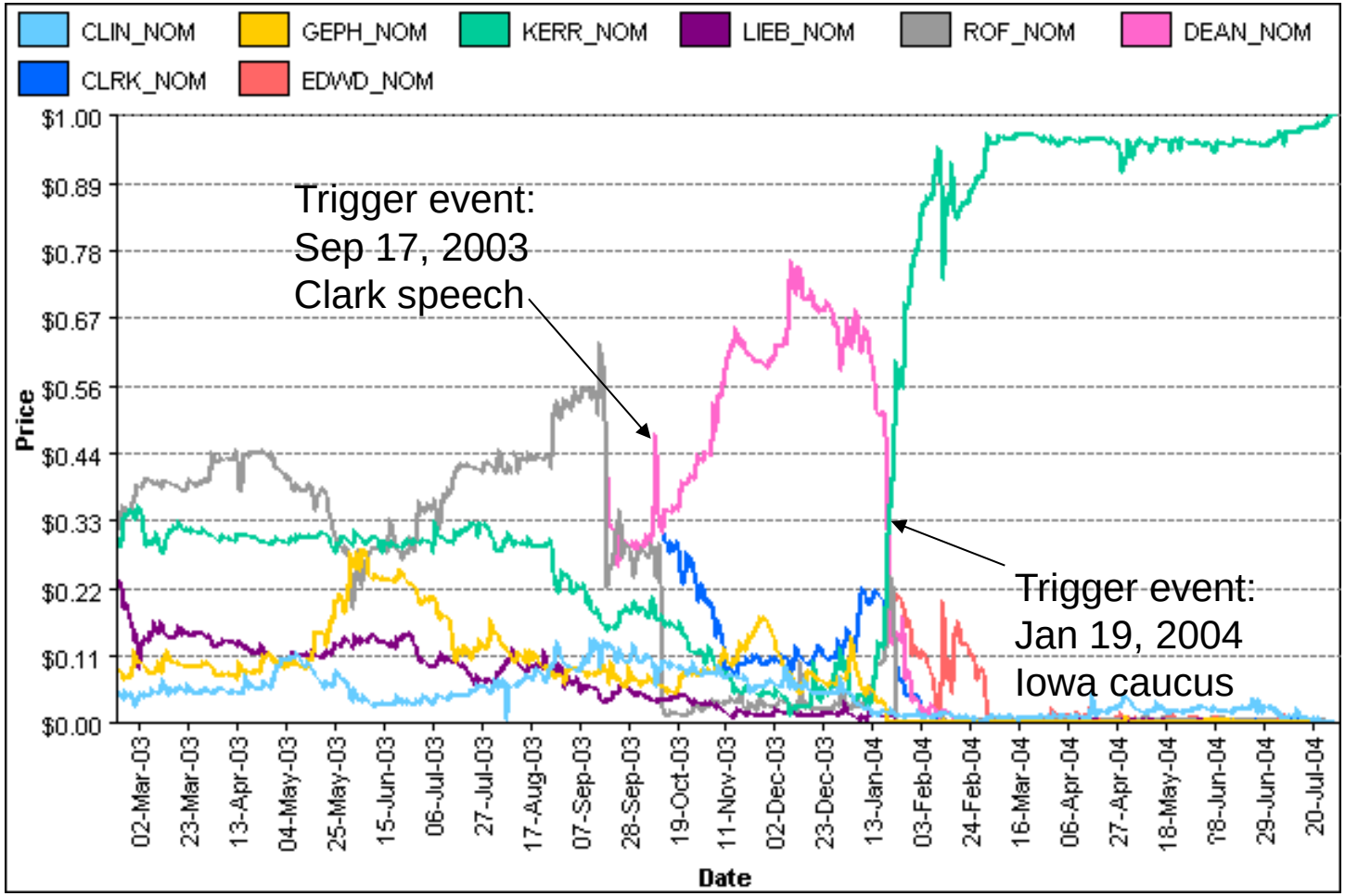
12:29 pm (CNN): President Bush was expected to announce Monday that he has picked top economic adviser Ben Bernanke..

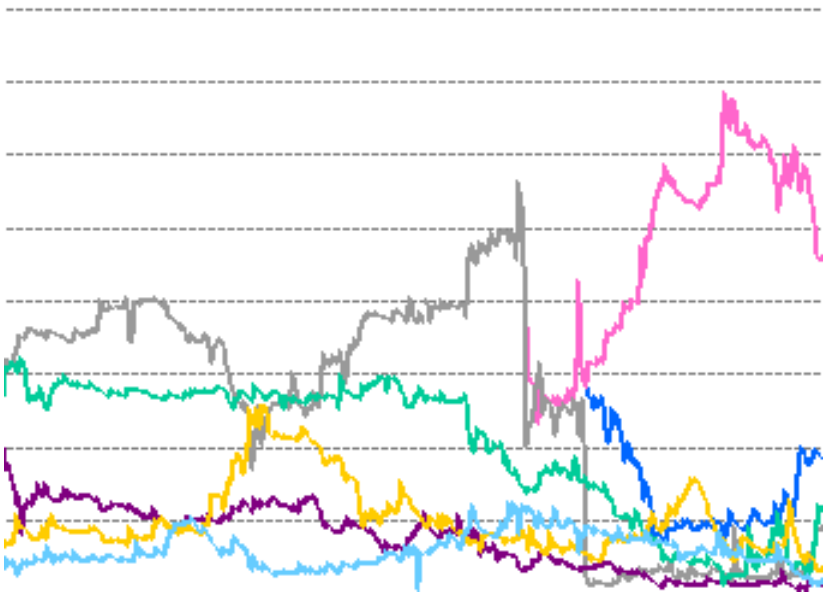
12:29 pm (Drudge): Bush picks Bernanke to Replace Greenspan…

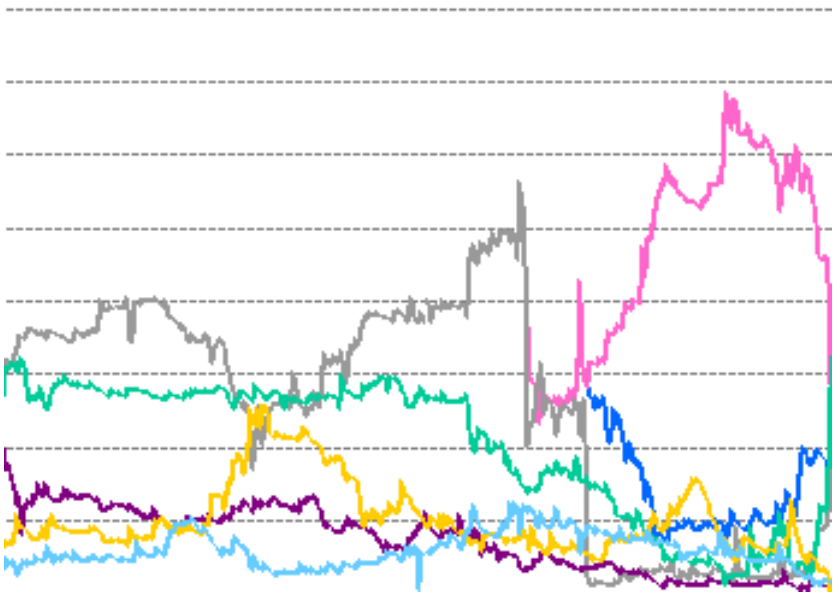
(White House) President Appoints Dr. Ben Bernanke for Chairman of the Federal Reserve

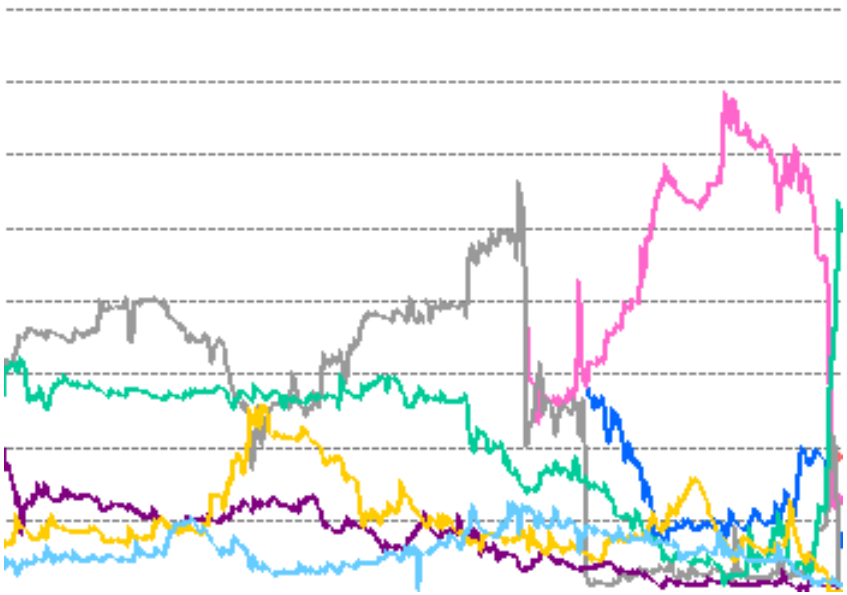
Example 6: Notification of new information

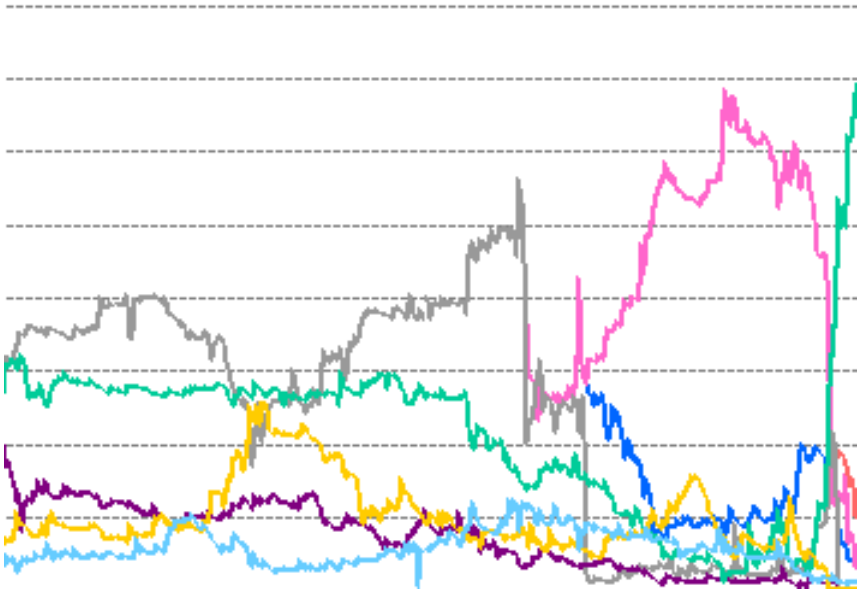
Iowa Electronic Market data

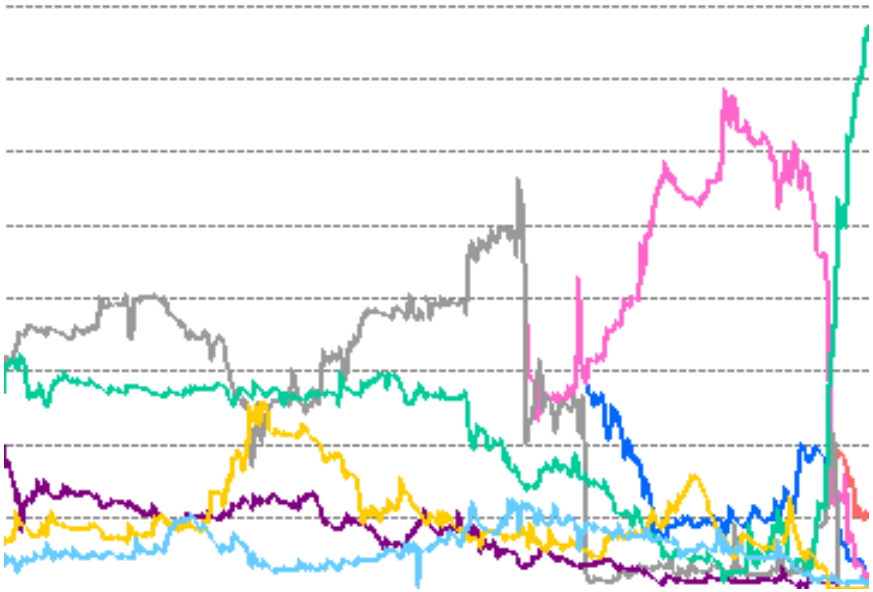


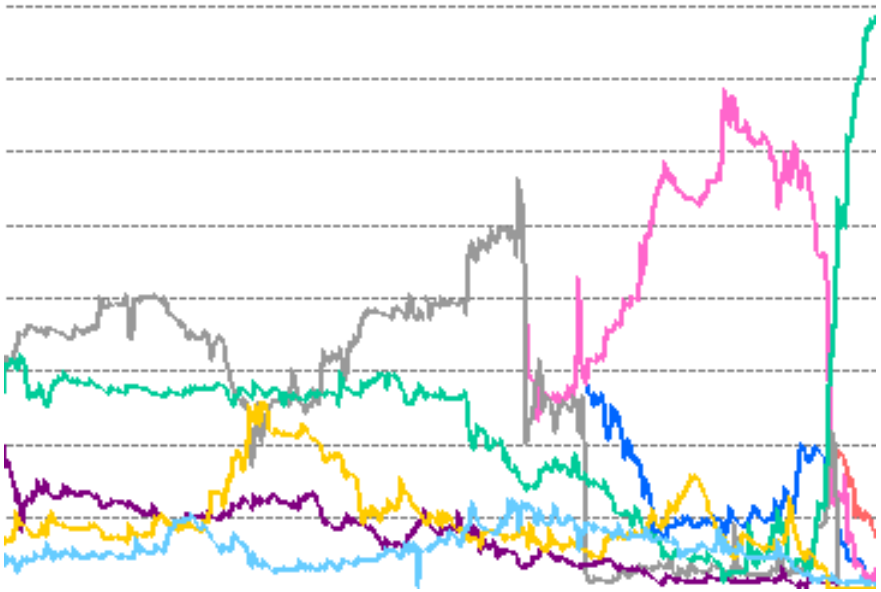


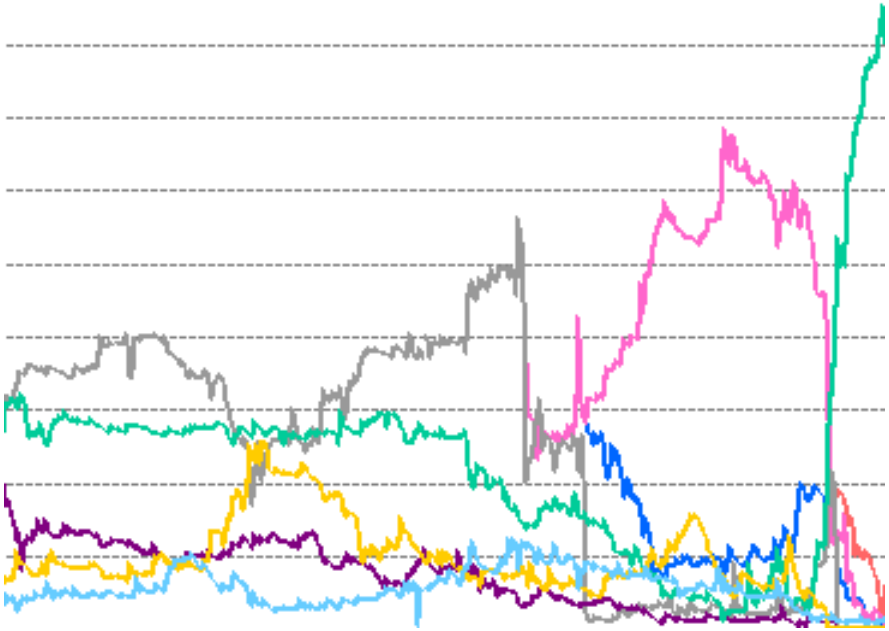


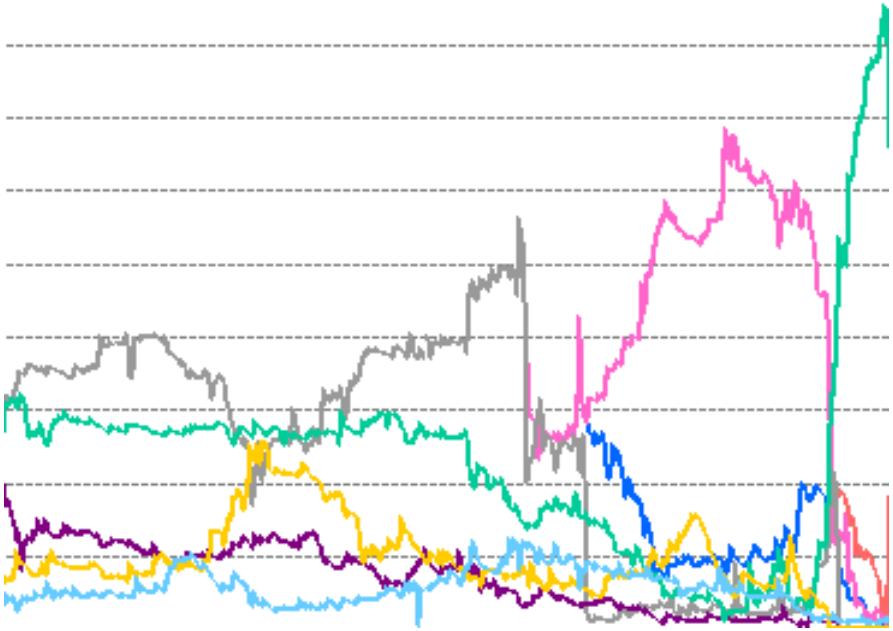


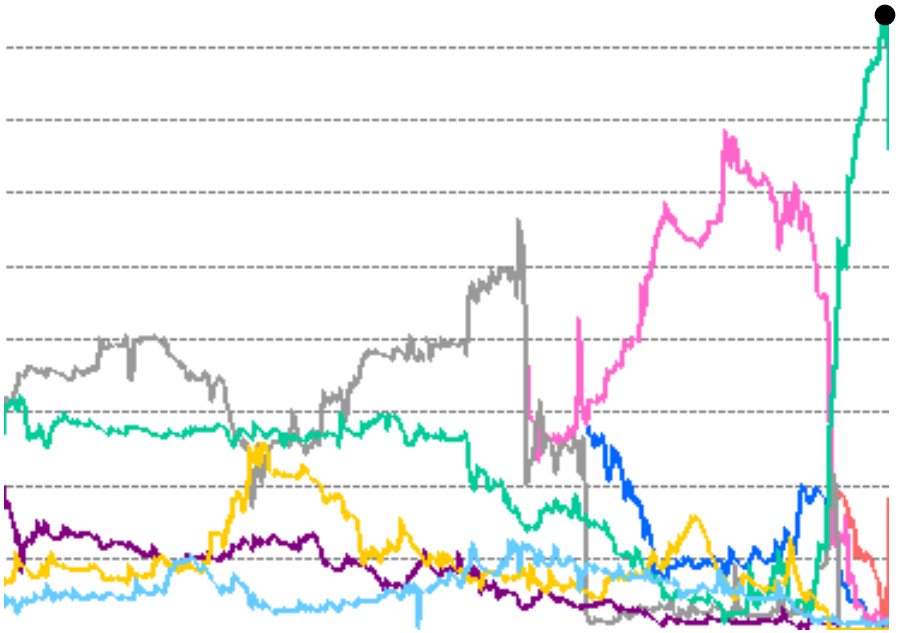






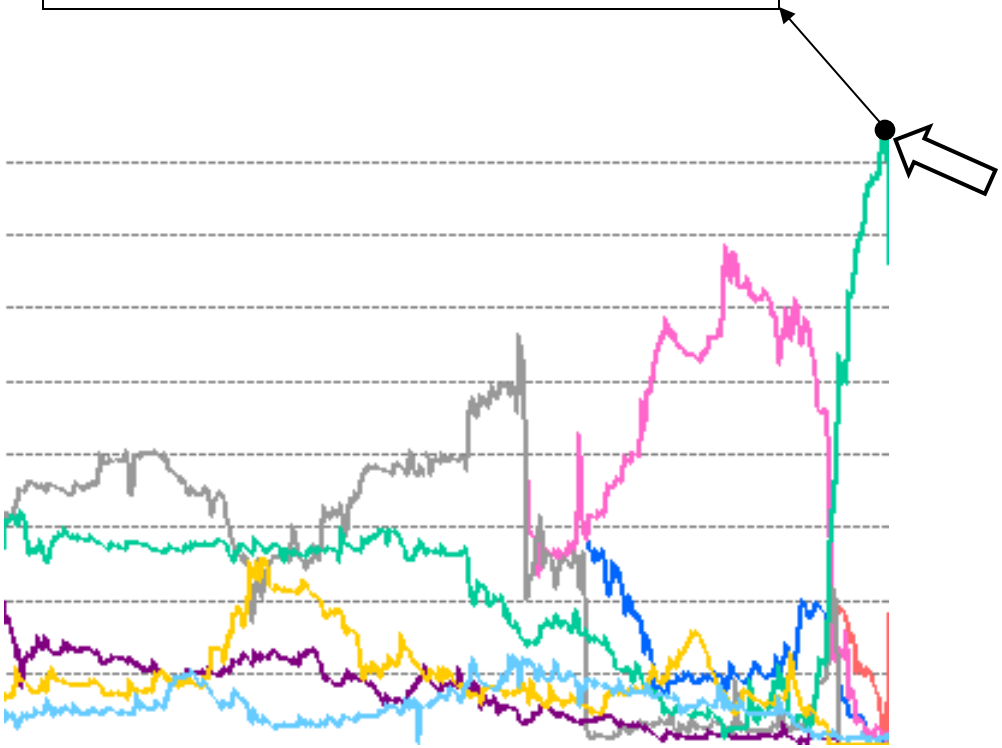




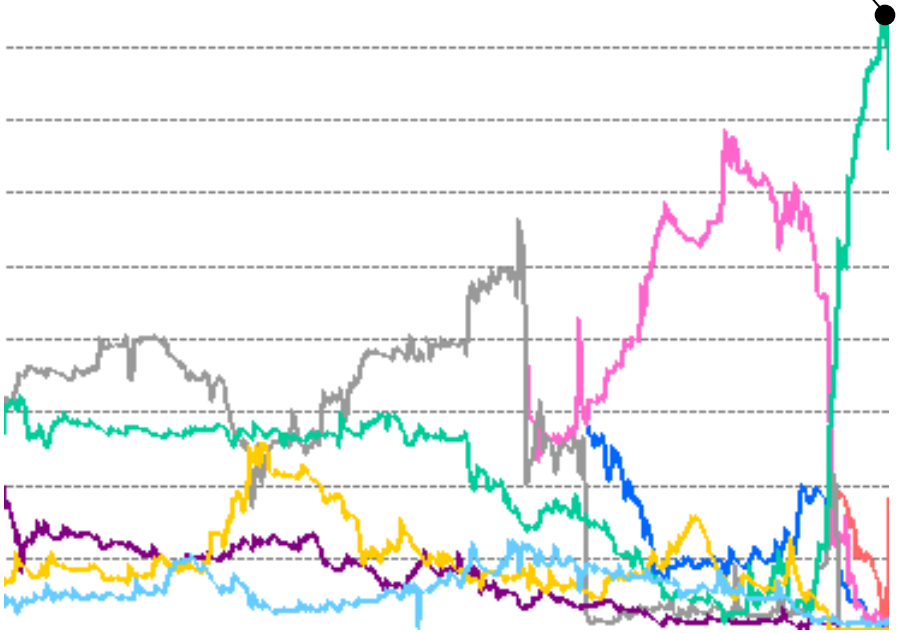


Trigger event:
Feb. 12, 2004
18:26:16

http://www.drudgereportarchives.com/data/2004/02/12/20040212_182616.htm



http://www.drudgereportarchives.com/data/2004/02/12/20040212_182616.htm



A frantic behind-the-scenes drama is unfolding around Sen. John Kerry and his quest to lockup the Democratic nomination for president, the DRUDGE REPORT can reveal...

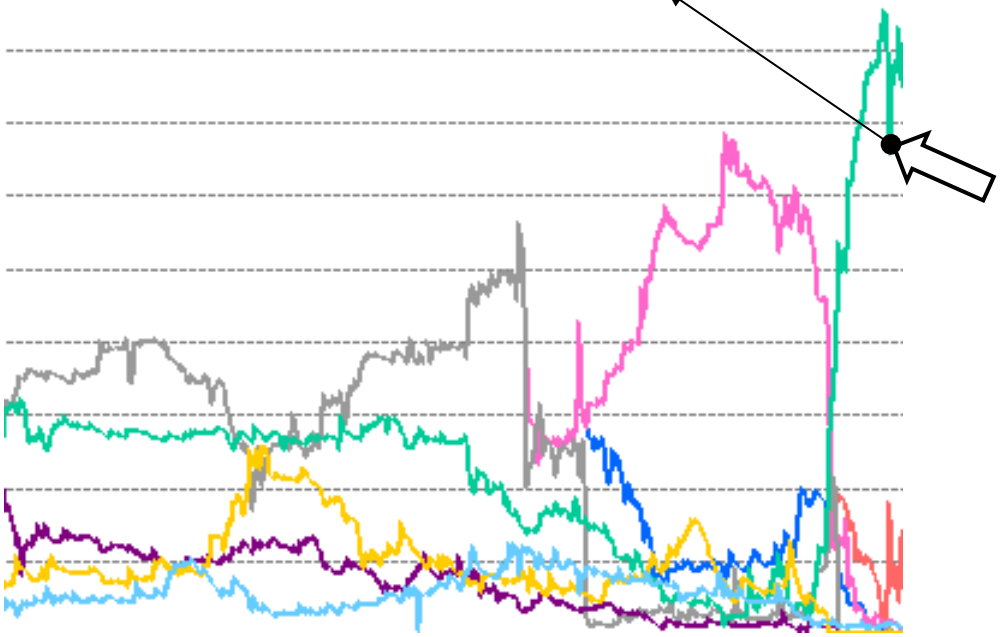
CAMPAIGN DRAMA ROCKS DEMOCRATS: KERRY FIGHTS OFF MEDIA PROBE OF RECENT ALLEGED INFIDELITY, RIVALS PREDICT RUIN

DRUDGE REPORT

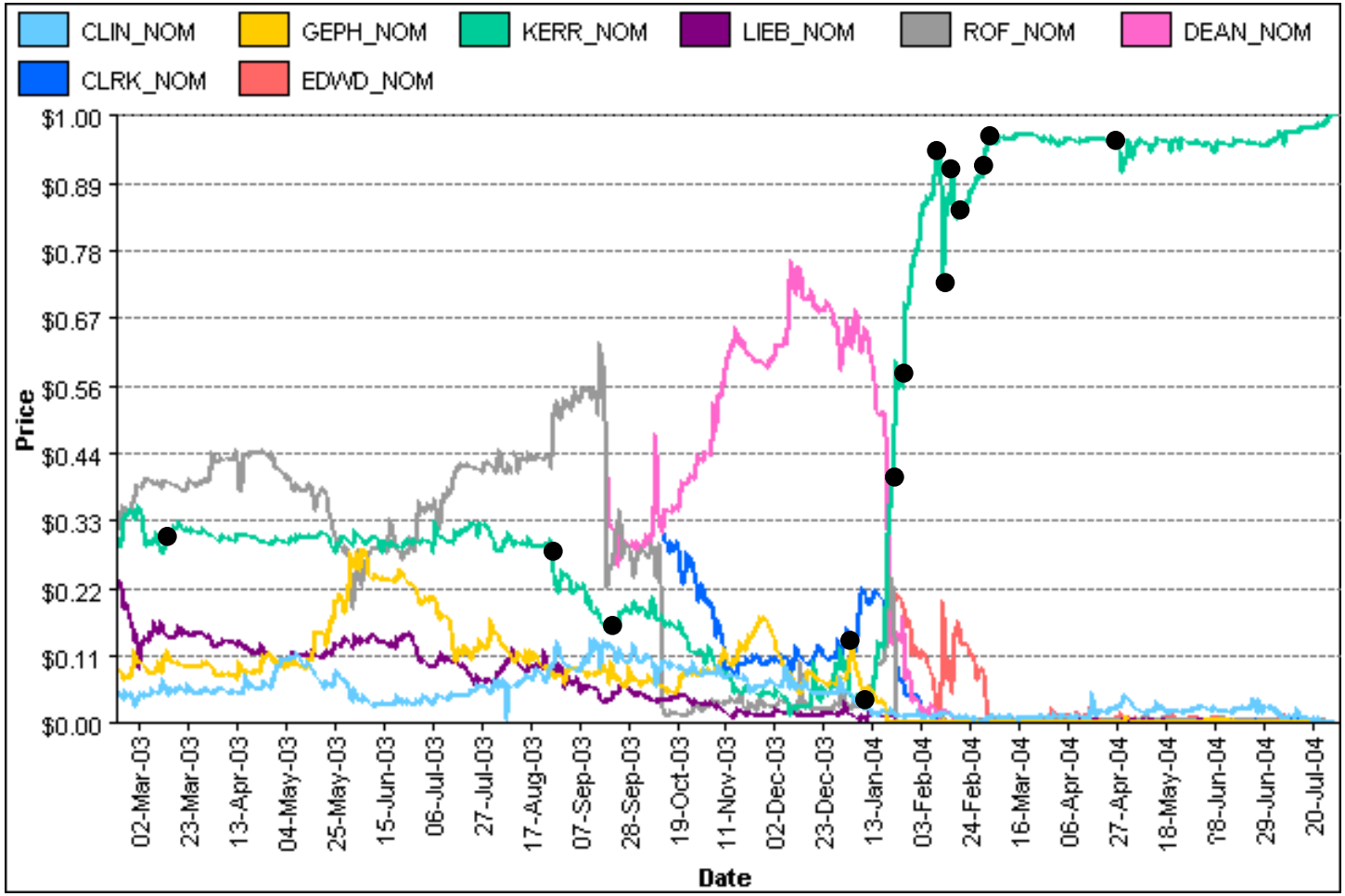
http://www.drudgereportarchives.com/data/2004/02/12/20040212_182616.htm

Statement from woman and parents about rumors linking her to Sen. John Kerry
The Associated Press
Monday, February 16, 2004

http://sfgate.com/cgibin/article.cgi?file=/news/archive/2004/02/16/politics1300EST0543.DTL

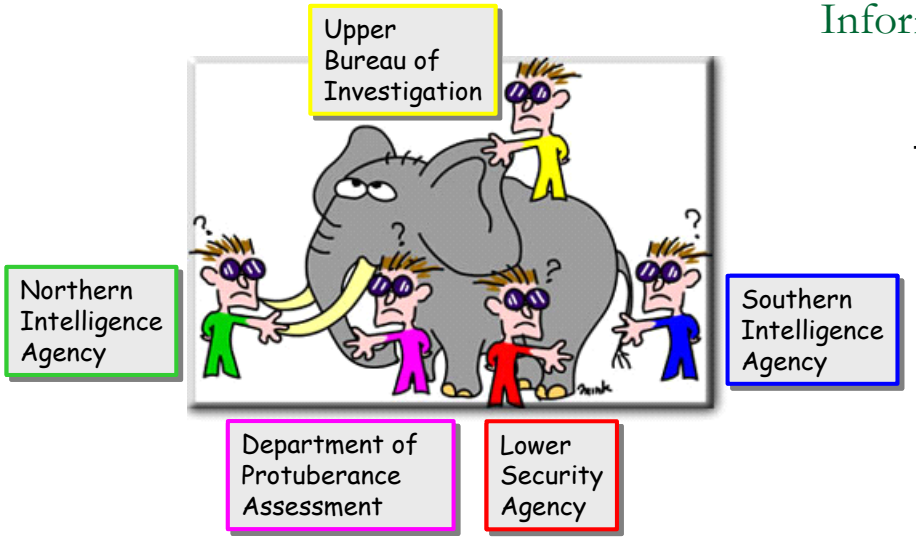


Annotated ticker can provide a self-organized dynamic data structure



Example 7: “Connecting the dots”

How markets aggregate information

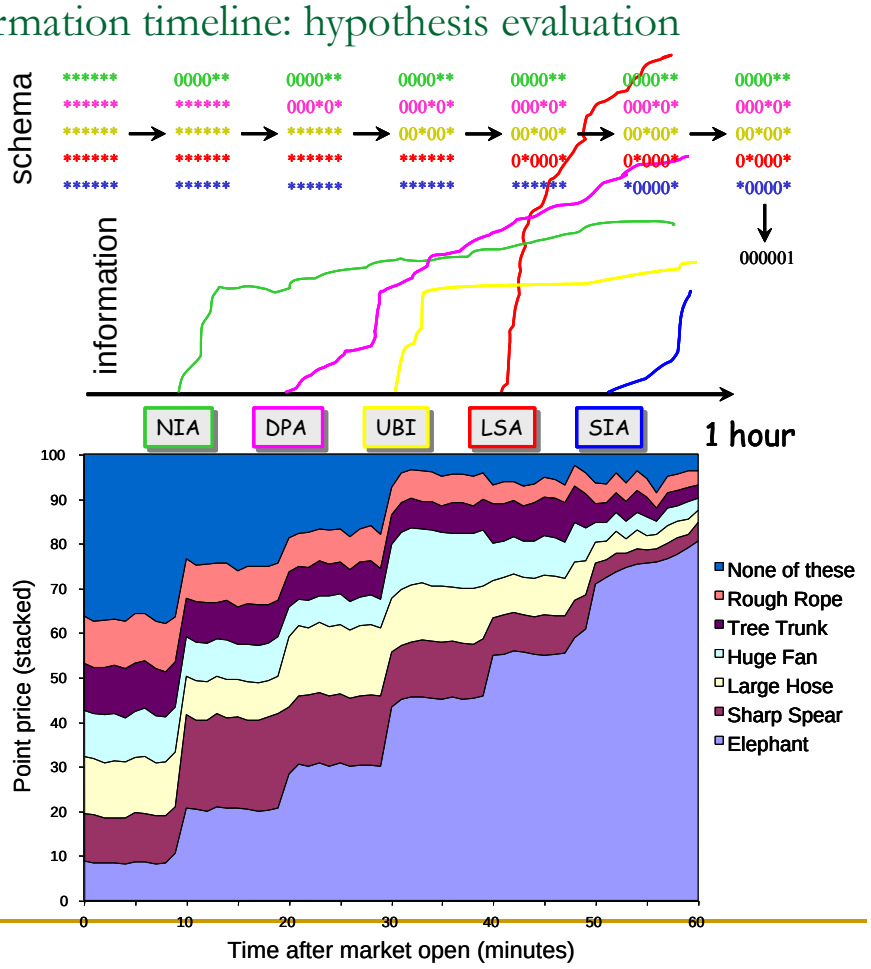


IAM contract

The lights will be turned on at 1:00 pm. If a(n) **Sharp Spear** is seen, this contract is redeemable for 100 tokens. Otherwise, it is void. Sold at **51 minutes** for **9** tokens.

IAM contract

The lights will be turned on at 1:00 pm. If a(n) **Elephant** is seen, this contract is redeemable for 100 tokens. Otherwise, it is void. Sold at **51 minutes** for **61** tokens.

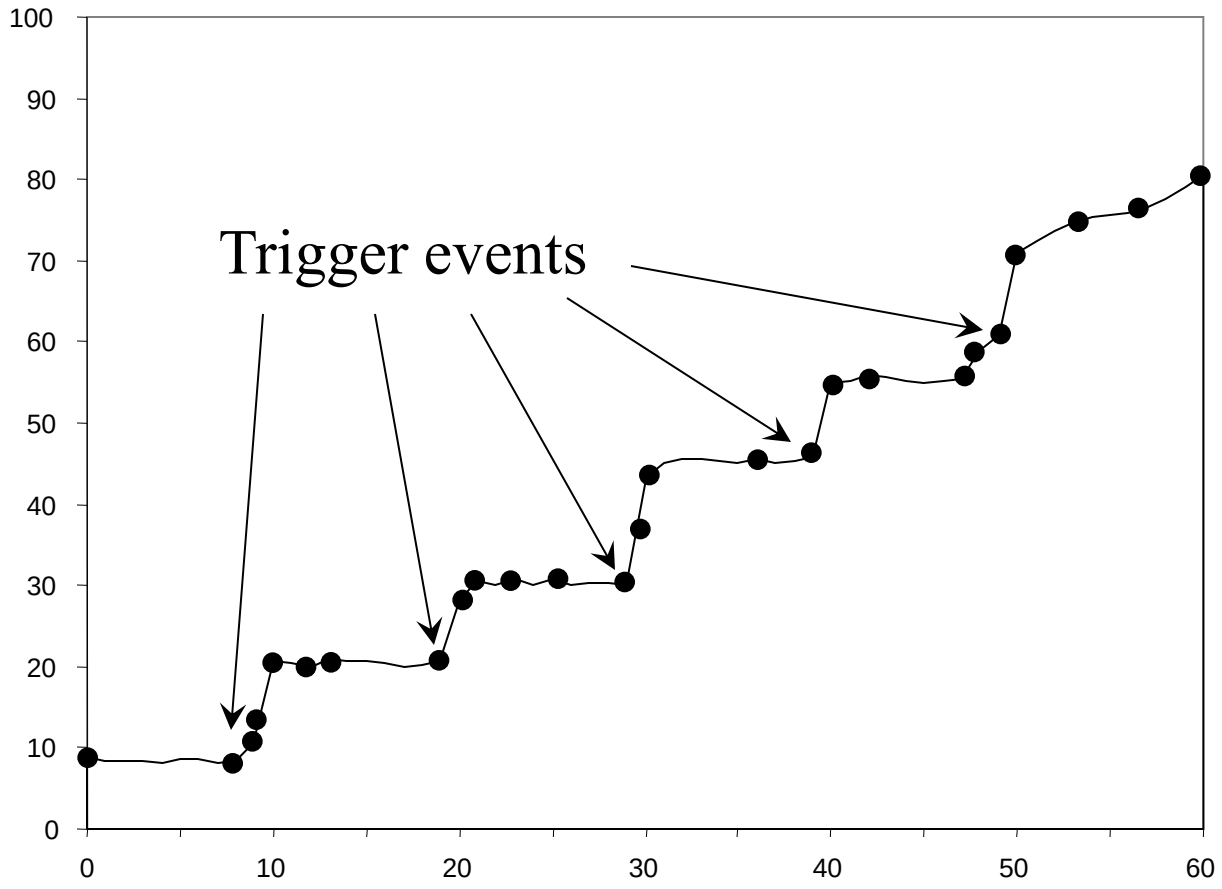


Closed Market Institution

- Traders can have eligibility requirements (e.g. analysts only)
- Traders can have security requirements (clearance level)
- Tracking points can be proxy for money
- Protocol for information disclosure can be implemented

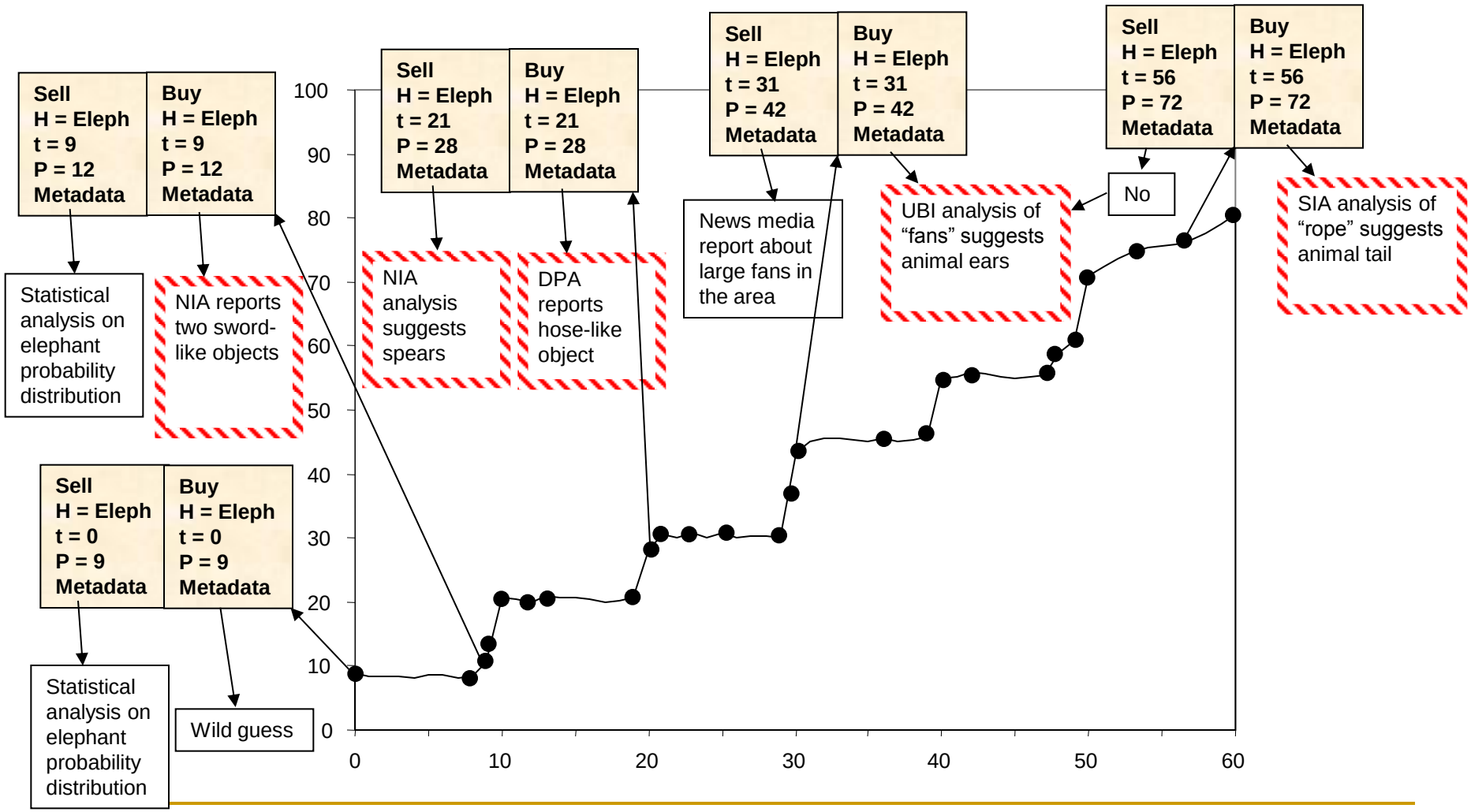
Innovation: linked metadata

Market trading creates the dots



Innovation: linked metadata

Disclosure rule connects the dots



Example 8: Objective evaluation of information quality

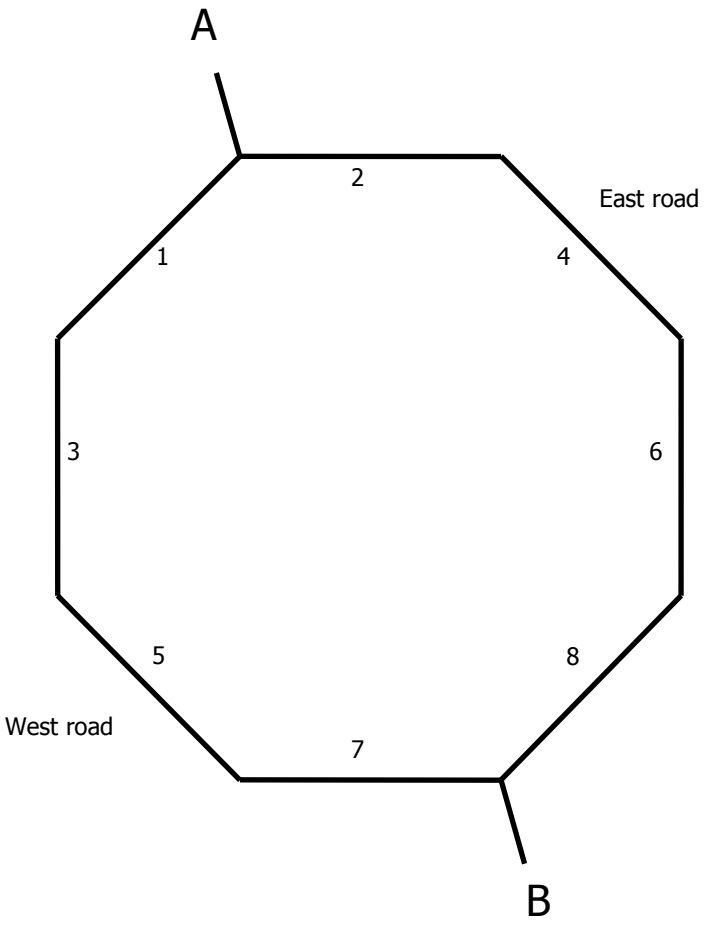
Simulated IED field test

Eight-way aggregation market
(one contract for each road segment)

Futures contract

The contract will expire at midnight. If the mock IED is found on segment 4 this contract is redeemable for 100 points.

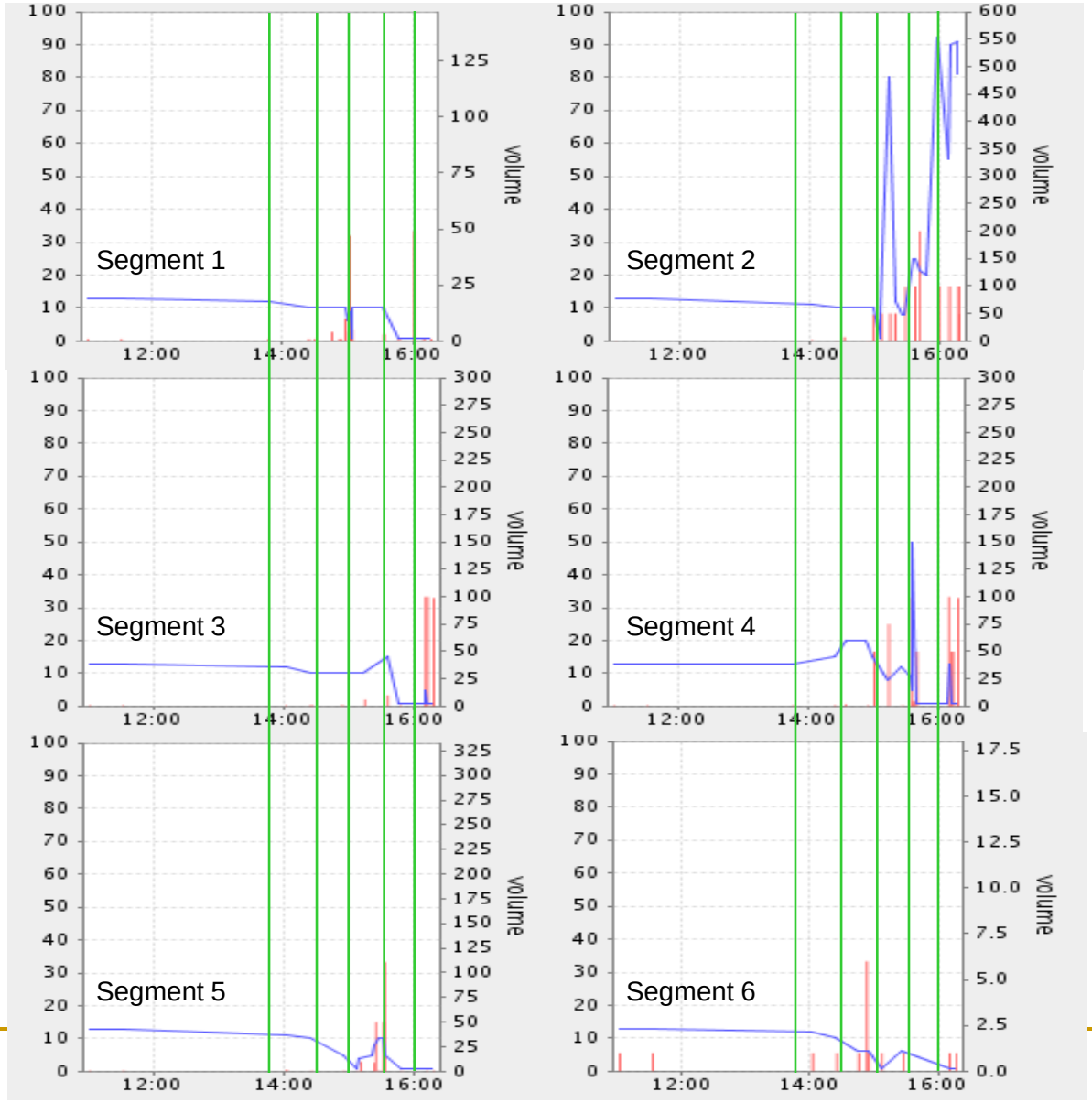
Otherwise, it is void.



Seven technologies ranked by market

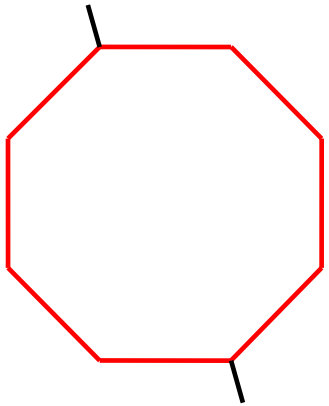
	False pos. rate	False neg. rate	Round 1 t=13:45	Round 2 t=14:31	Round 3 t=15:00	Round 4 t=15:32	Round 5 T=15:57	Win (Loss)
NUT	0%	0%	7 0	6 0	4 0	2 1	7 0	$489
JIG	3.125%	6.25%	8 0	5 0	2 1	5 0	7 0	$144
BAT	6.25%	12.5%	8 0	1 0	8 0	1 0	5 0	($8)
LOG	6.25%	25%	1 0	2 1	3 0	4 0	5 0	$32
OAK	6.25%	50%	8 0	3 0	4 0	1 0	1 0	$1
CAT	12.5%	12.5%	7 0	8 0	1 1	4 1	3 0	($7)
FIR	12.5%	25%	4 1	4 1	3 1	6 0	5 0	($649)

Time-resolved tickers for six segments

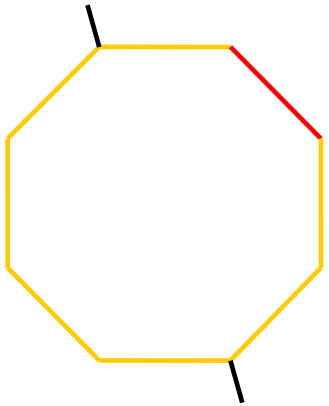


Example 9: Decision support

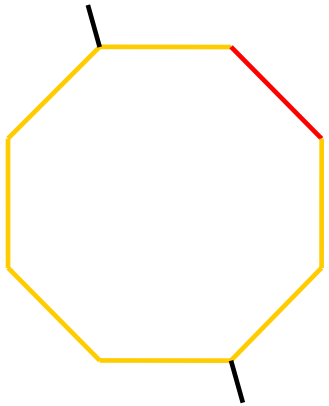
Information can be distilled to its essence for decision makers



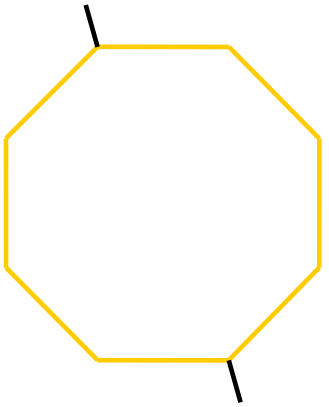
Initial state



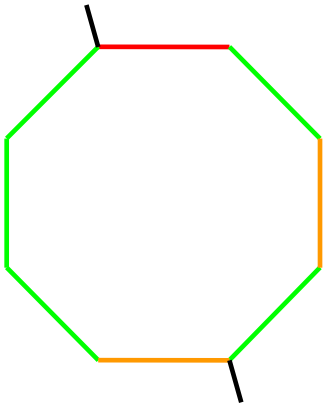
Round 1



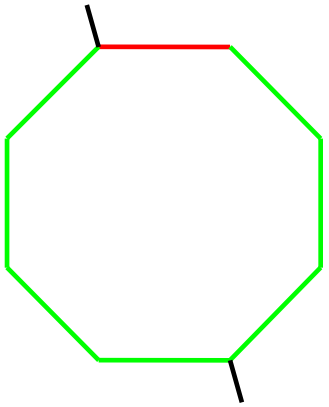
Round 2



Round 3



Round 4



Round 5

Example 10: Funding allocation

	False pos. rate	False neg. rate	Round 1 t=13:45	Round 2 t=14:31	Round 3 t=15:00	Round 4 t=15:32	Round 5 T=15:57	Win (Loss)
NUT	0%	0%	7 0	6 0	4 0	2 1	7 0	$489
JIG	3.125%	6.25%	8 0	5 0	2 1	5 0	7 0	$144
BAT	6.25%	12.5%	8 0	1 0	8 0	1 0	5 0	($8)
LOG	6.25%	25%	1 0	2 1	3 0	4 0	5 0	$32
OAK	6.25%	50%	8 0	3 0	4 0	1 0	1 0	$1
CAT	12.5%	12.5%	7 0	8 0	1 1	4 1	3 0	($7)
FIR	12.5%	25%	4 1	4 1	3 1	6 0	5 0	($649)

Increase Funding

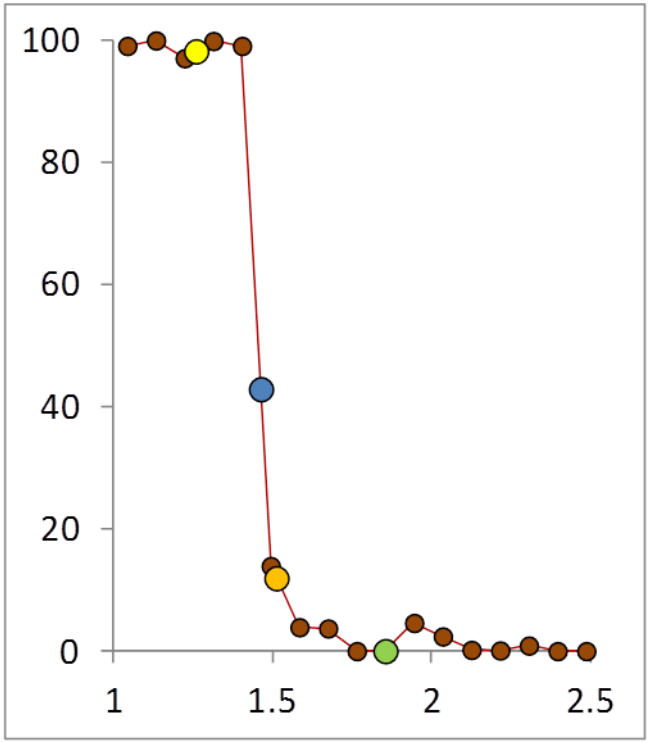
Reduce Funding

Eliminate

Example 11: Global Warming and Carbon Pricing

? Contract	B Qty	Bid	Ask	A Qty	Last	Vol	Chge
Trade 2012.TEMP.ANOMOLY.0.30+	0	-	-	0	99.0	1	0
Trade 2012.TEMP.ANOMOLY.0.35+	4	80.0	-	0	99.9	38	0
Trade 2012.TEMP.ANOMOLY.0.40+	4	80.0	-	0	99.5	84	0
Trade 2012.TEMP.ANOMOLY.0.45+	4	80.0	-	0	99.5	599	0
Trade 2012.TEMP.ANOMOLY.0.50+	1	95.1	99.9	100	99.5	1084	0
Trade 2012.TEMP.ANOMOLY.0.55+	16	6.0	26.5	3	27.9	621	0
Trade 2012.TEMP.ANOMOLY.0.60+	100	0.1	4.0	4	0.3	215	0
Trade 2012.TEMP.ANOMOLY.0.65+	0	-	8.5	3	0.2	24	0
Trade 2012.TEMP.ANOMOLY.0.70+	0	-	-	0	0.1	12	0
Trade 2012.TEMP.ANOMOLY.0.75+	0	-	-	0	0.1	2	0
Trade 2012.TEMP.ANOMOLY.0.80+	0	-	-	0	4.7	2	0
Trade 2012.TEMP.ANOMOLY.0.85+	0	-	-	0	2.5	1	0
Trade 2012.TEMP.ANOMOLY.0.90+	0	-	-	0	0.3	4	0
Trade 2012.TEMP.ANOMOLY.0.95+	0	-	-	0	0.2	1	0
Trade 2012.TEMP.ANOMOLY.1.00+	0	-	-	0	1.0	1	0
Trade 2012.TEMP.ANOMOLY.1.05+	0	-	-	0	0.1	1	0
Trade 2012.TEMP.ANOMOLY.1.10+	0	-	-	0	0.1	1	0

Trading page for 2012 global temp anomaly, Nov. 30, 2012



Nov. 30, 2012 contract prices can be used to construct probability density function (anomaly in Fahrenheit relative to 1880).

Climate derivative markets could be used to price carbon dumping fee!

Summary: Intelligence aggregation method

- Overcomes horizontal information barrier (stovepipe effect)
- Overcomes vertical information barrier due to hierarchy and inertia
- Promotes (rather than *inhibits*) information exchange through competition
- Preserves compartmentalization of classified information
- Evolutionary method rewards accurate, relevant and consistent knowledge
- Exhibits rapid time response
- Allows asynchronous information exchange
- Insulates against politics and turf battles
- Insulates against agenda-driven false information (e.g. climate denial)
- Yields self-assembly of information structures
- Is scalable (massively parallel people and data distribution)

QUESTIONS?