Subjective Beliefs and Statistical Forecasts of Financial Risks

The Chief Risk Officer Project

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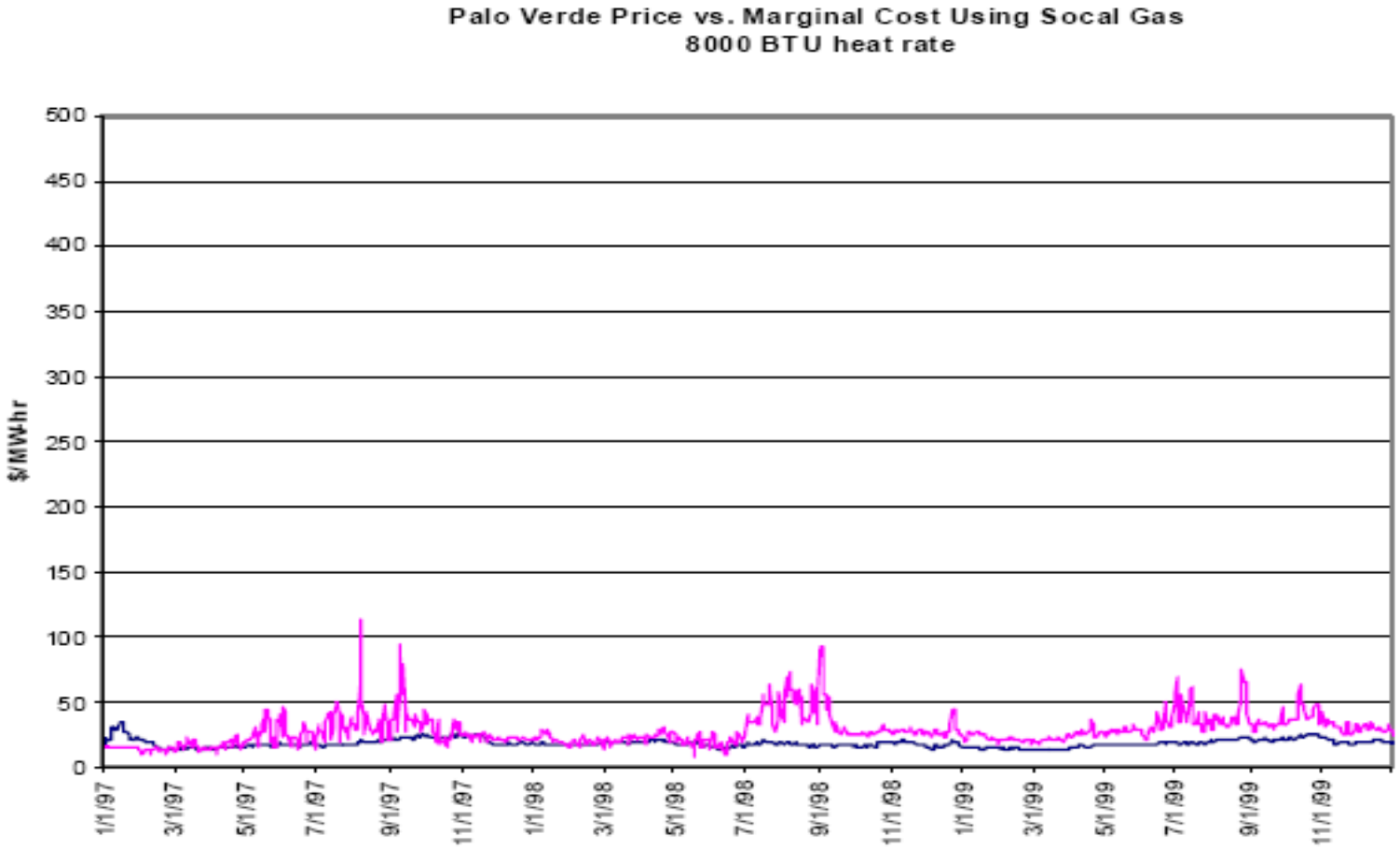
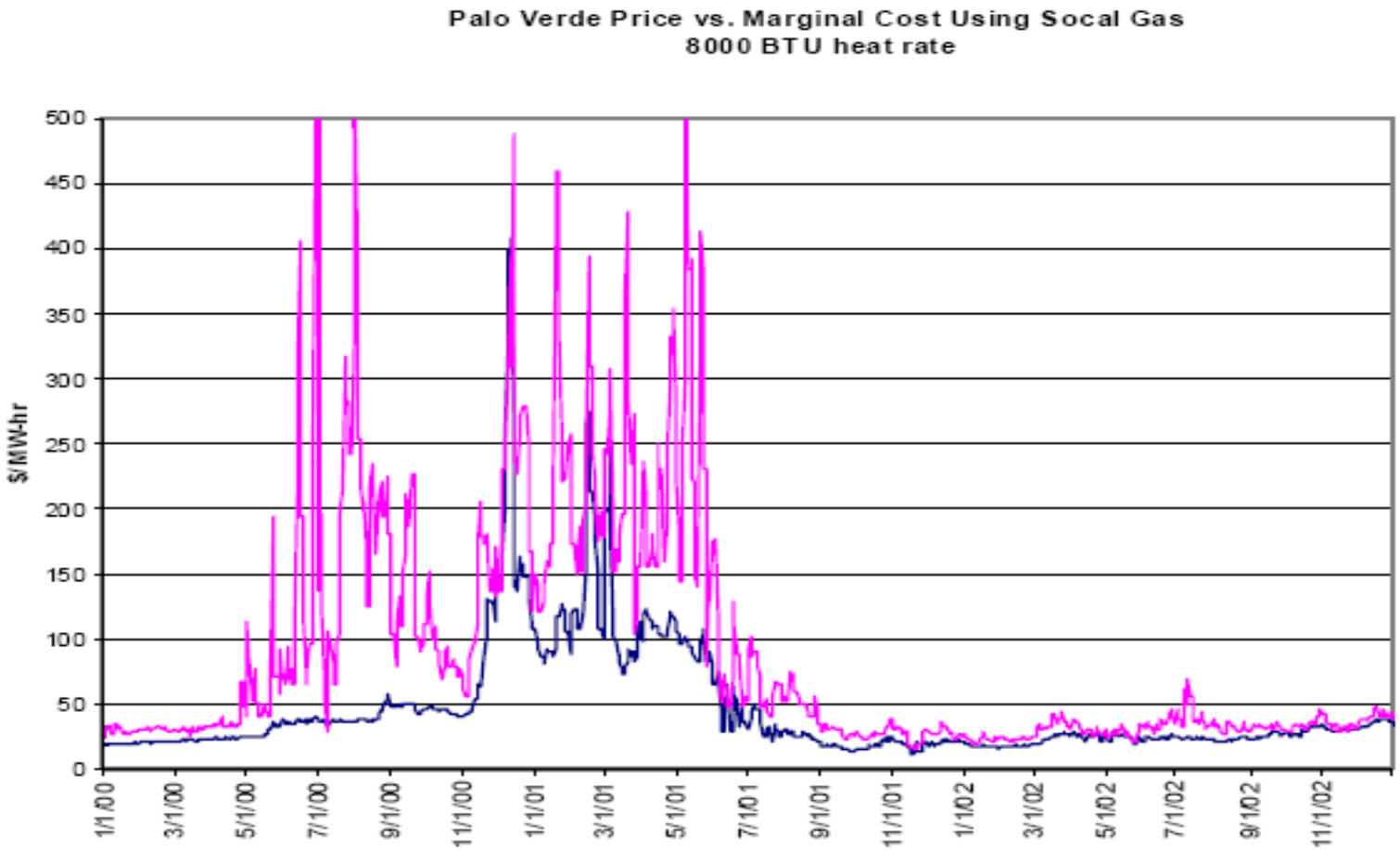
Electric Co. CRO's Problem

Estimate VAR Model for 2000q1 Hedging Program



The CRO's Bigger Problem…..



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What years are these from?

A) 2001 – 2003

B) 2004 – 2006

C) 2007 – 2009

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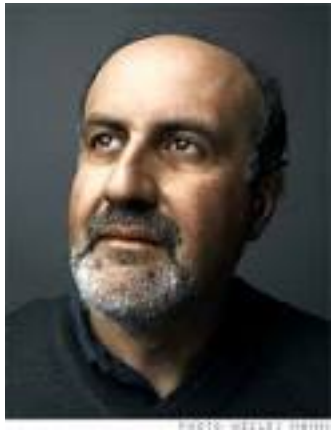
Were these events “predictable”?

“Policies promoting decentralized generation decisions are likely to induce widely fluctuating prices in systems that are not dependent on hydroelectric power.”

Energy Modeling Forum
Stanford University (1998)



For the last 12 years, I have been telling anyone who would listen to me that we are taking huge risks and massive exposure to rare events. … The Black Swan is a philosophy book (epistemology, philosophy of history & philosophy of science), but I used banks as a particularly worrisome case of epistemic arrogance -- and the use of "science" to measure the risk of rare events, making society dependent on very spurious measurements.

Nasim Taleb (2007)

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The Big Three Behavioral Moving Parts

- Risk Attitude
  - Several decompositions
    - Aversion to variability in outcomes
    - Loss aversion (i.e., Prospect Theory)
- Time Preferences
  - The level and shape of the discounting function
  - Additivity of the intertemporal utility function
- Risk Perceptions

Extending the Neo-Classical Model

- Rich array of alternative models are now under development that continue to rely upon the assumption of rationality, e.g.,

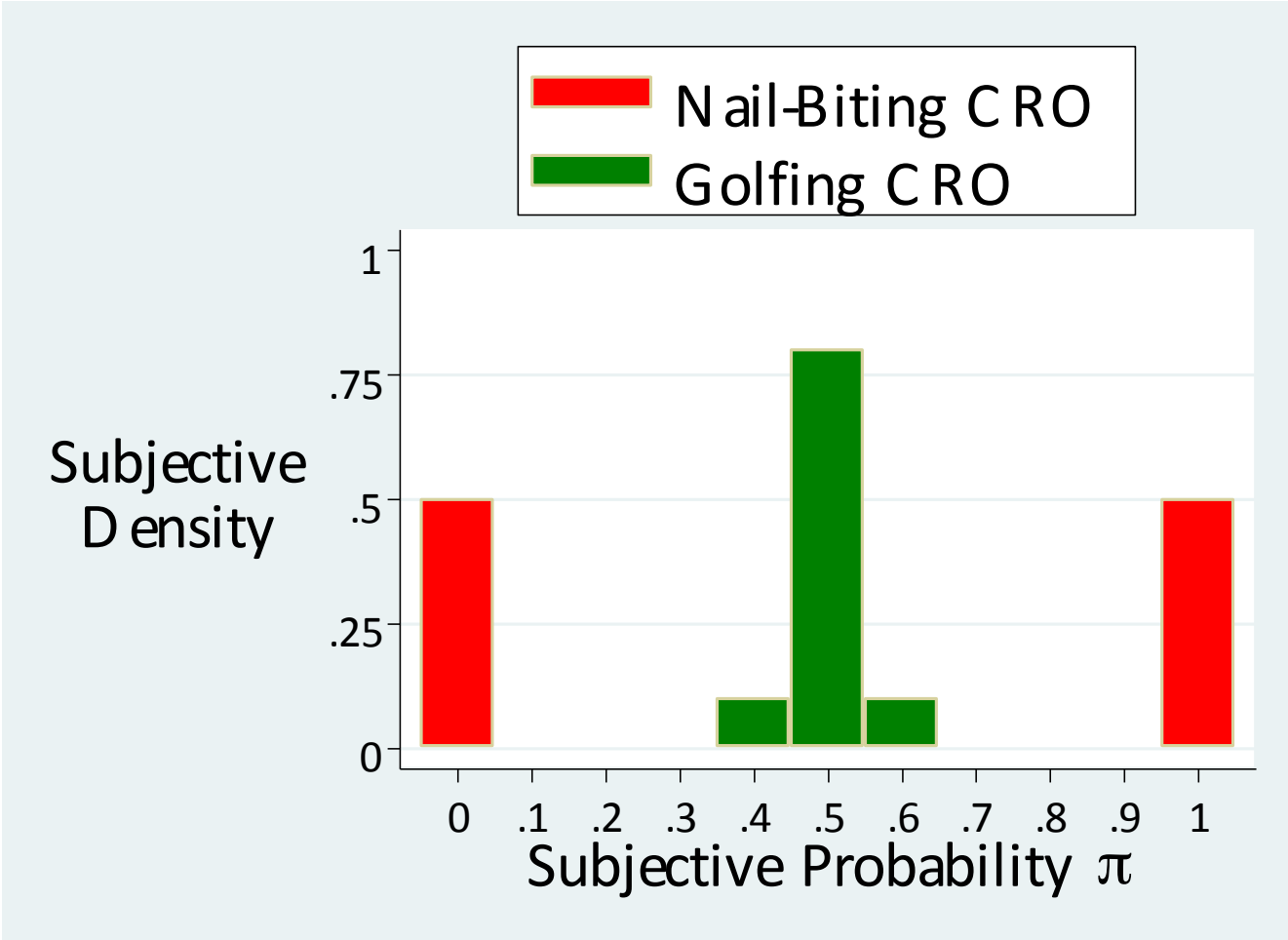
$$\text{Recursive EU} = \sum_j \pi_j V\left[\sum_i p_{ij} U\left[X_i\right]\right]$$

Subjective Probabilities

Objective Probabilities

- Important insights
  - Risk aversion ≠ Uncertainty aversion
  - Need to do the hard work of evaluating alternative models
  - Do not just assume the model that suits the anecdote

We need to identify underlying beliefs



Why measure subjective beliefs of CROs?

Richard Posner

Little bits of knowledge about the shakiness of the U.S. and global financial systems were widely dispersed among the staffs of banks and other financial institutions and of regulatory bodies, and among academic economists, financial consultants, accountants, actuaries, rating agencies, and business journalists. But there was no financial counterpart to the CIA to aggregate and analyze the information -- to assemble a meaningful mosaic from the scattered pieces. …

Gary Becker

In any event, no effort to determine the probability of financial disaster was made and no contingency plans for dealing with such an event were drawn up. The failure to foresee and prevent the 9/11 terrorist attacks led to efforts to improve national-security intelligence; the failure to foresee and prevent the current financial crisis should lead to efforts to improve financial intelligence.

Were Chief Risk Officers and Chief Actuaries canaries in the cave??

http://www.becker-posner-blog.com/2008/10/the-financial-crisis-why-were-warnings-ignored--posner.html

Alternative methods

- Prediction markets
- Surveys of CRO and CA confidence
- Scoring rules to elicit subjective beliefs
  - Subjective probabilities for a binary event
    - Will the DJIA go up by 5% in the next year?
  - Subjective distributions for a continuous event
    - How much will the DJIA go up by in the next year?

Scoring Rules: The Science

© Journal of the American Statistical Association
December 1971, Volume 66, Number 336
Theory and Methods Section

Elicitation of Personal Probabilities and Expectations

LEONARD J. SAVAGE*

MANAGEMENT SCIENCE
Vol. 22, No. 10, June, 1976
Printed in U.S.A.

SCORING RULES FOR CONTINUOUS PROBABILITY DISTRIBUTIONS*

JAMES E. MATHESON† AND ROBERT L. WINKLER‡§**

Our Contribution to the Science

Available on www.gsucroriskindex.org/about/white-papers/

Scoring Rules for Subjective Probability Distributions

by

Glenn W. Harrison, Jimmy Martínez-Correa, J. Todd Swarthout and Eric R. Ulm †

February 2013

Subjective Beliefs and Statistical Forecasts of Financial Risks: The Chief Risk Officer Project

by

Glenn W. Harrison and Richard D. Phillips †

March 2013

Incentivized scoring rule for probabilities

- Start with elicitation for binary events and assume SEU
- Logic to incentivize truthful response
  - Report r, the probability of state X occurring instead of ~X
  - Score in state X: $A - B(\mathbf{1} - r)^2$
  - Score in state ~X: $A - B(\mathbf{0} - r)^2$
  - Penalize for deviations from what a **clairvoyant** would respond
- Induces truthful reports if individual is…
  - Risk neutral: a risk averse agent is sucked towards 0.5 report
  - Agent does not integrating earnings with existing endowments

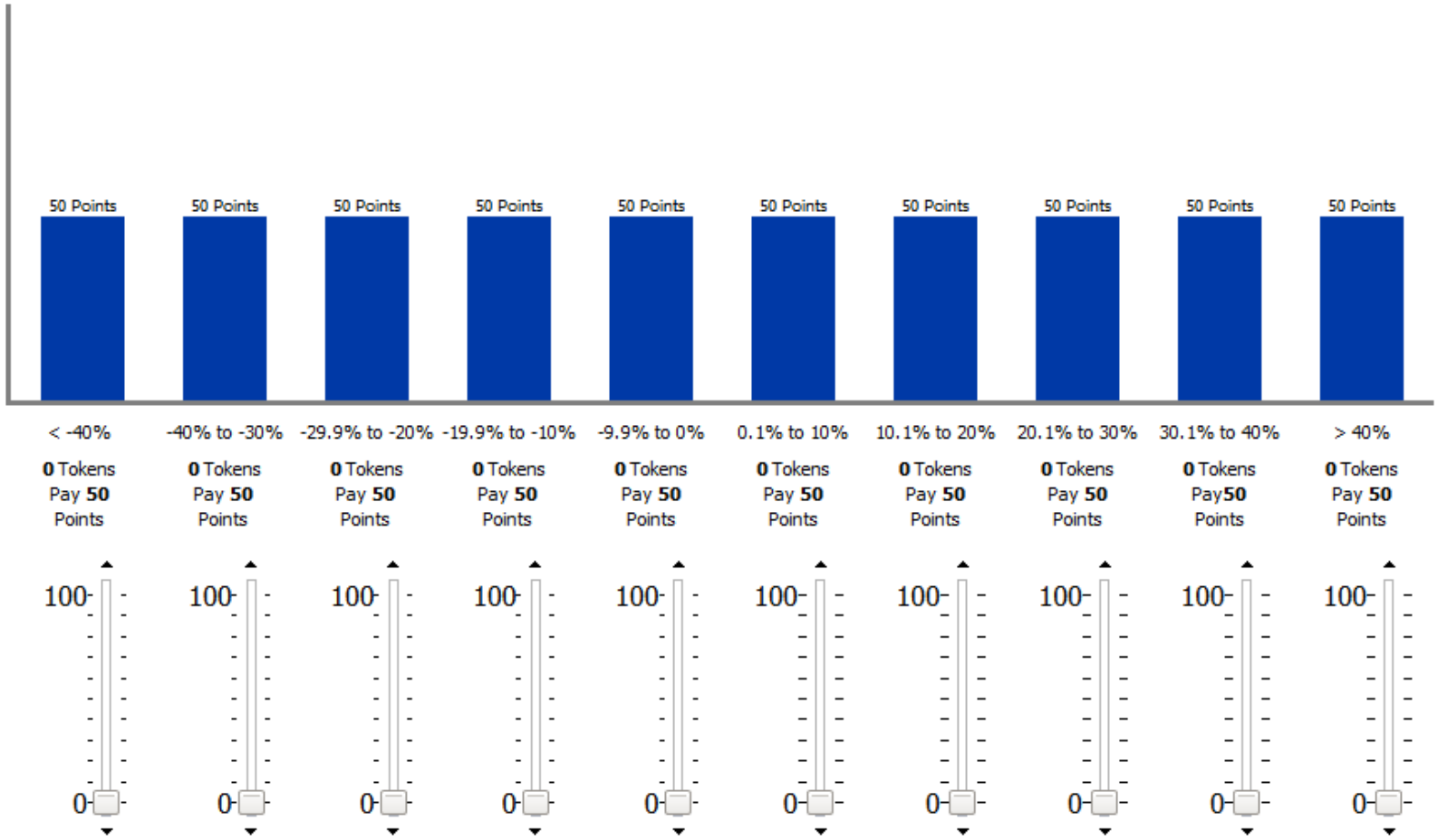
Choice 1 of 11

What will the Standard and Poor's 500 index be at the end of August 2014? You can respond in annual percent change or in levels.

Latest
12 Month Low
12 Month Hi
12 Month Range
Uniform
Previous Allocation
Clear

Show Levels

Video Instructions



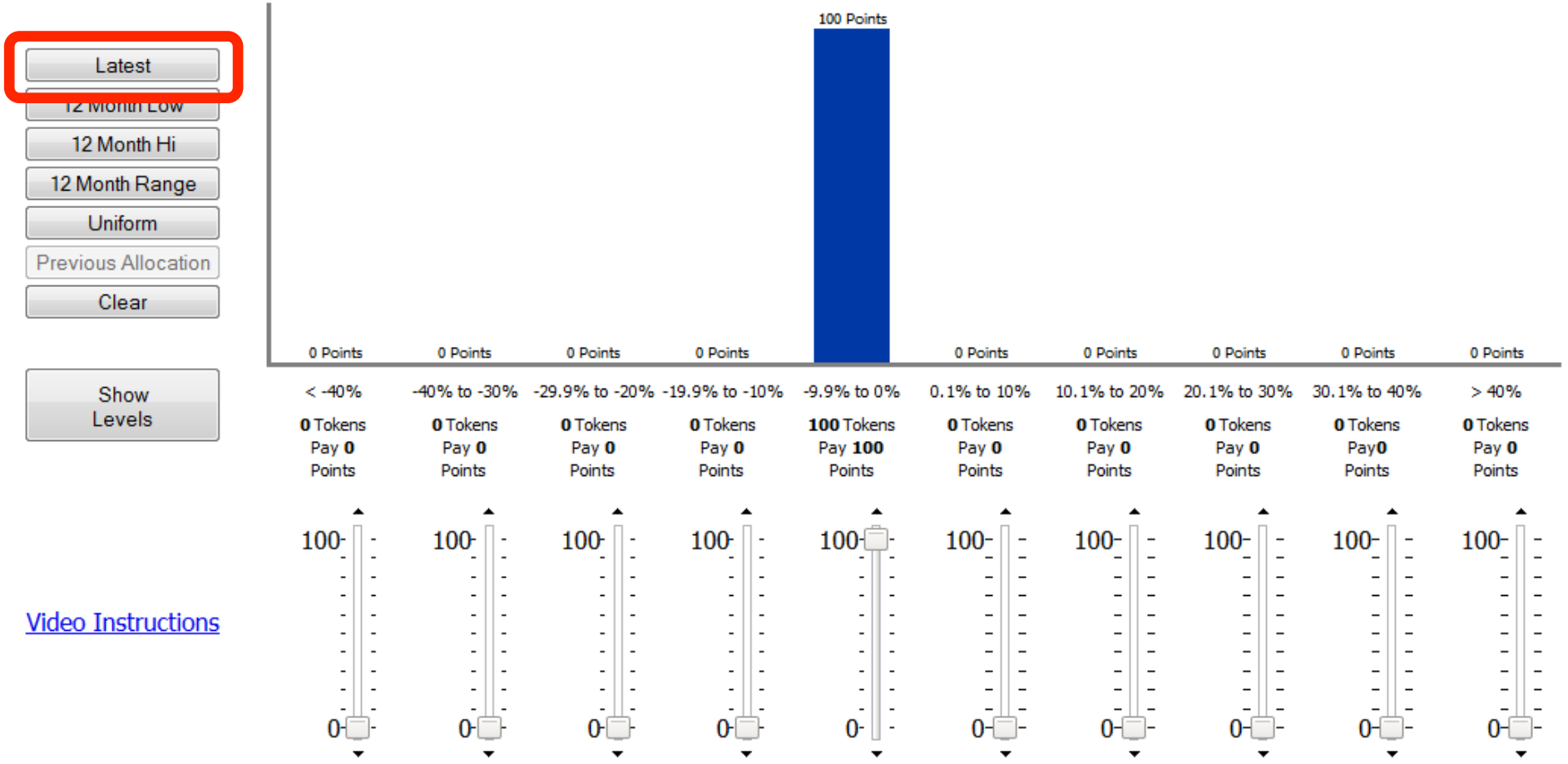
Comments: (optional)

You still have 100 tokens left to allocate.

Submit

Choice 1 of 11

What will the Standard and Poor's 500 index be at the end of August 2014? You can respond in annual percent change or in levels.



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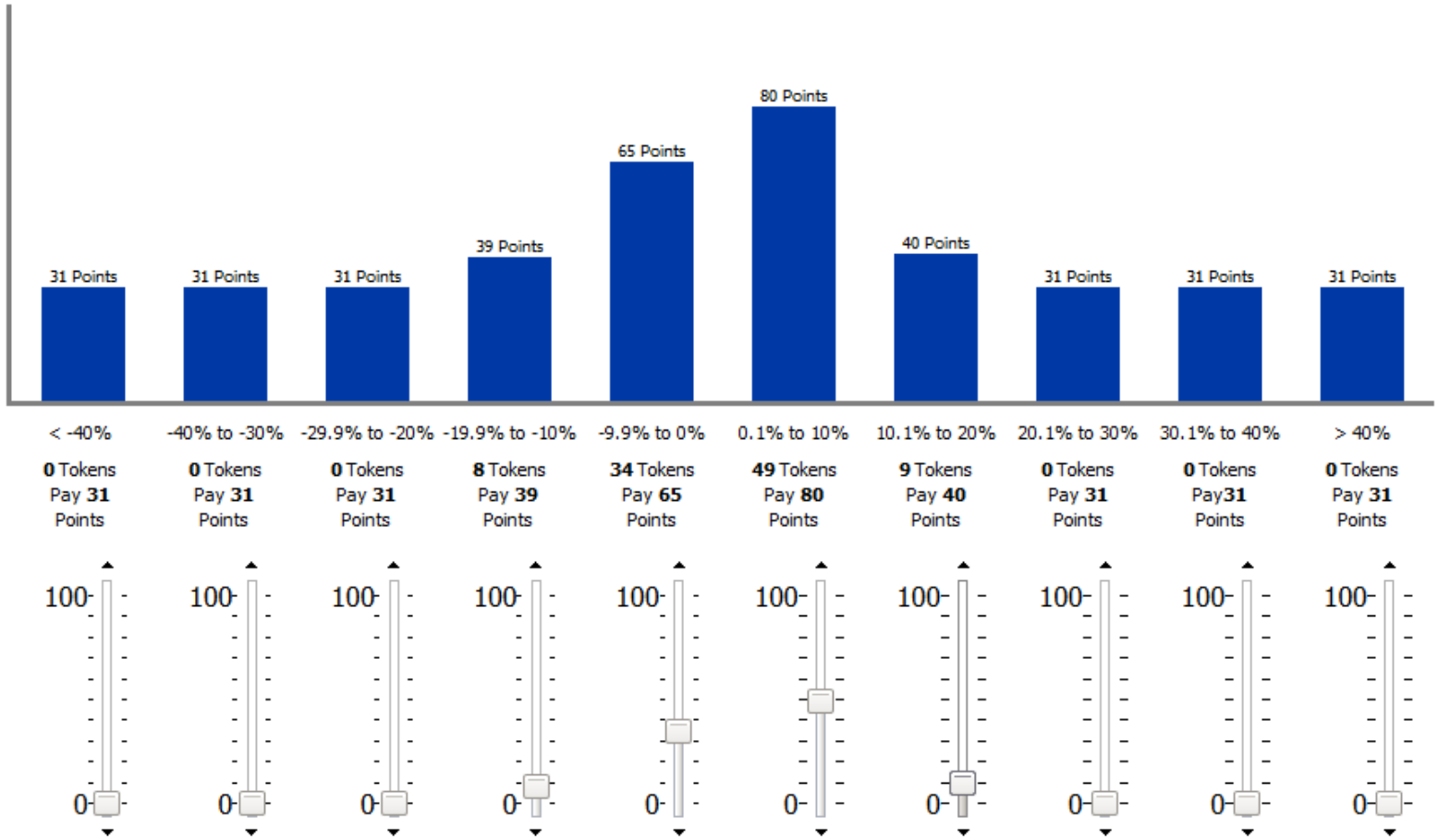

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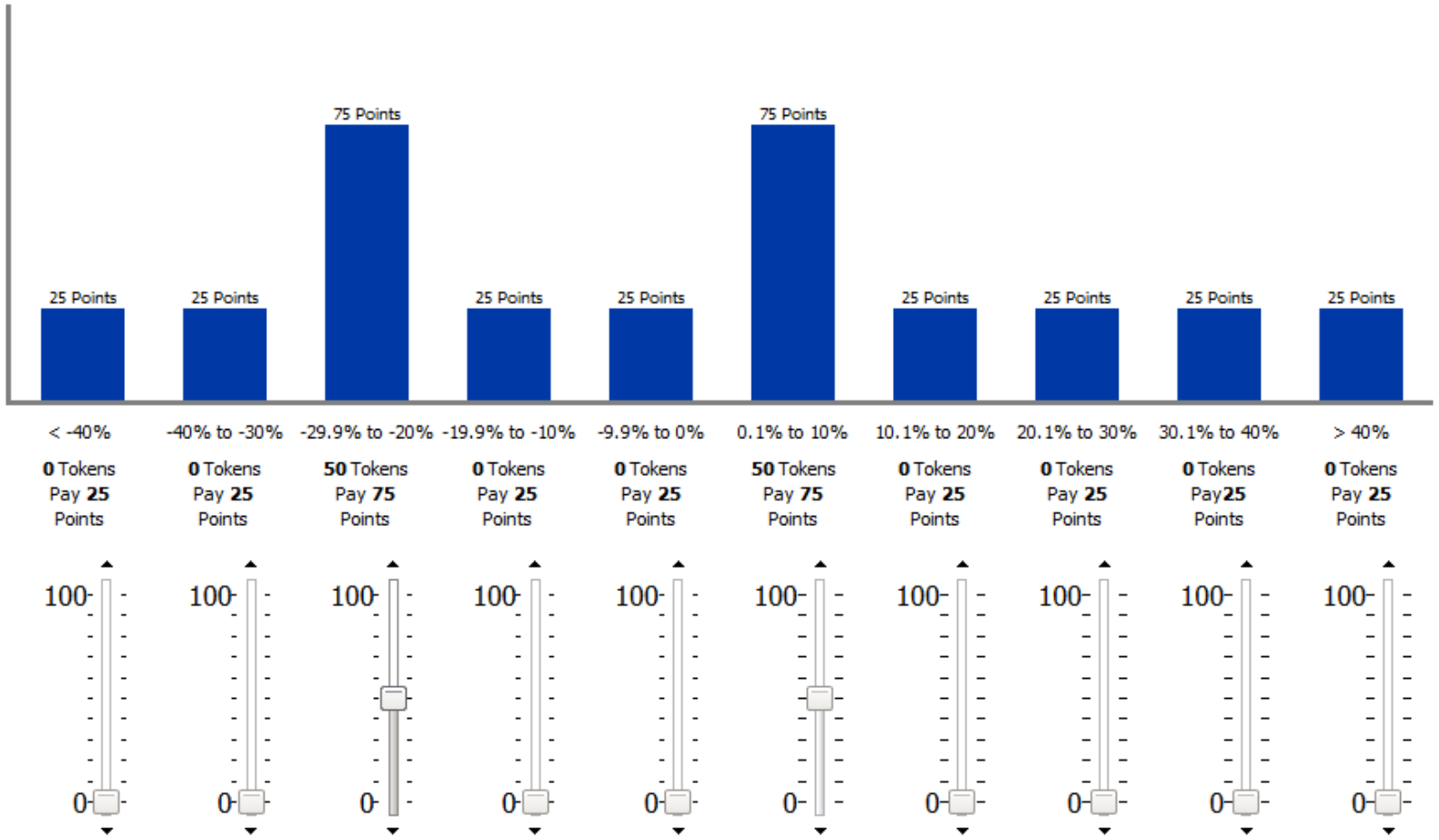

Goals of the GSU CRO Risk Index Project

- Aggregate the subjective beliefs of senior risk professionals
- Produce an early warning indicator of different important individual markets
- Subjective information elicited from CROs can directly **supplement** existing financial risk management models
- Produce a baseline historical data driven model with which to compare the outcomes

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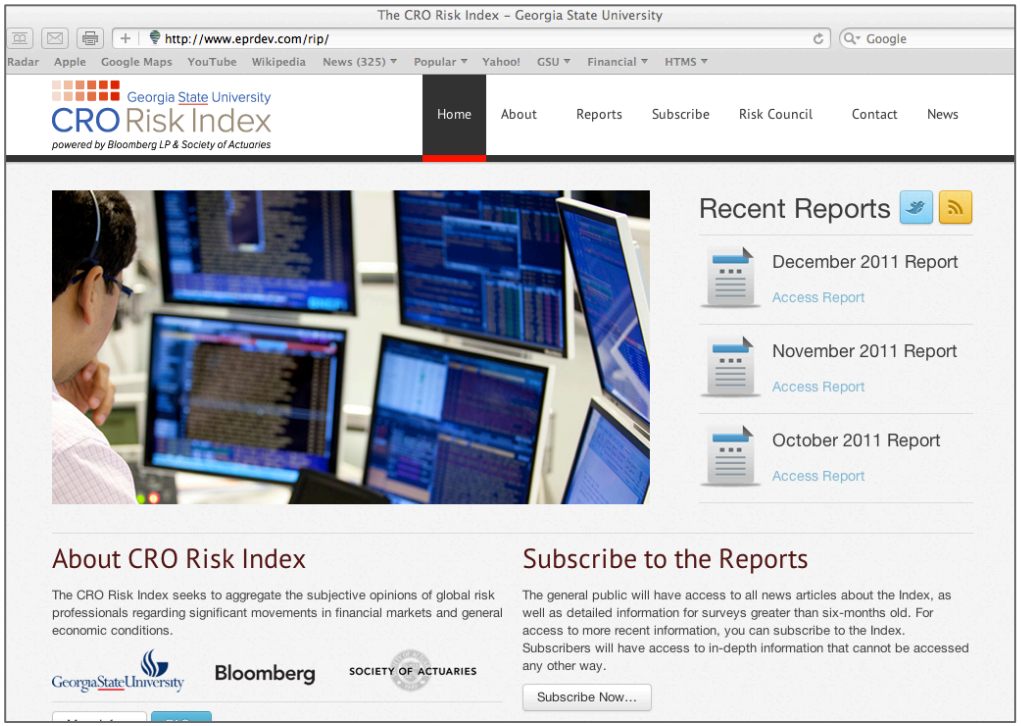
The Elicitation Instrument

- Follow 11 core financial risk indices monthly
- Respondents are CROs and Chief Actuaries
- Initial training can be done self-directed in 15 minutes
- Responses requested every month
  - Web interface to minimize time cost
  - Designed to take no more than 10-15 minutes of time
- Compare results to “objective” risk indices
- Informative when they disagree and they agree
- Results published monthly online at www.gsucroriskindex.org



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CRO Risk Council

(As of March 1, 2014)

Georgia State University
CRO Risk Index
powered by Bloomberg LP & Society of Actuaries

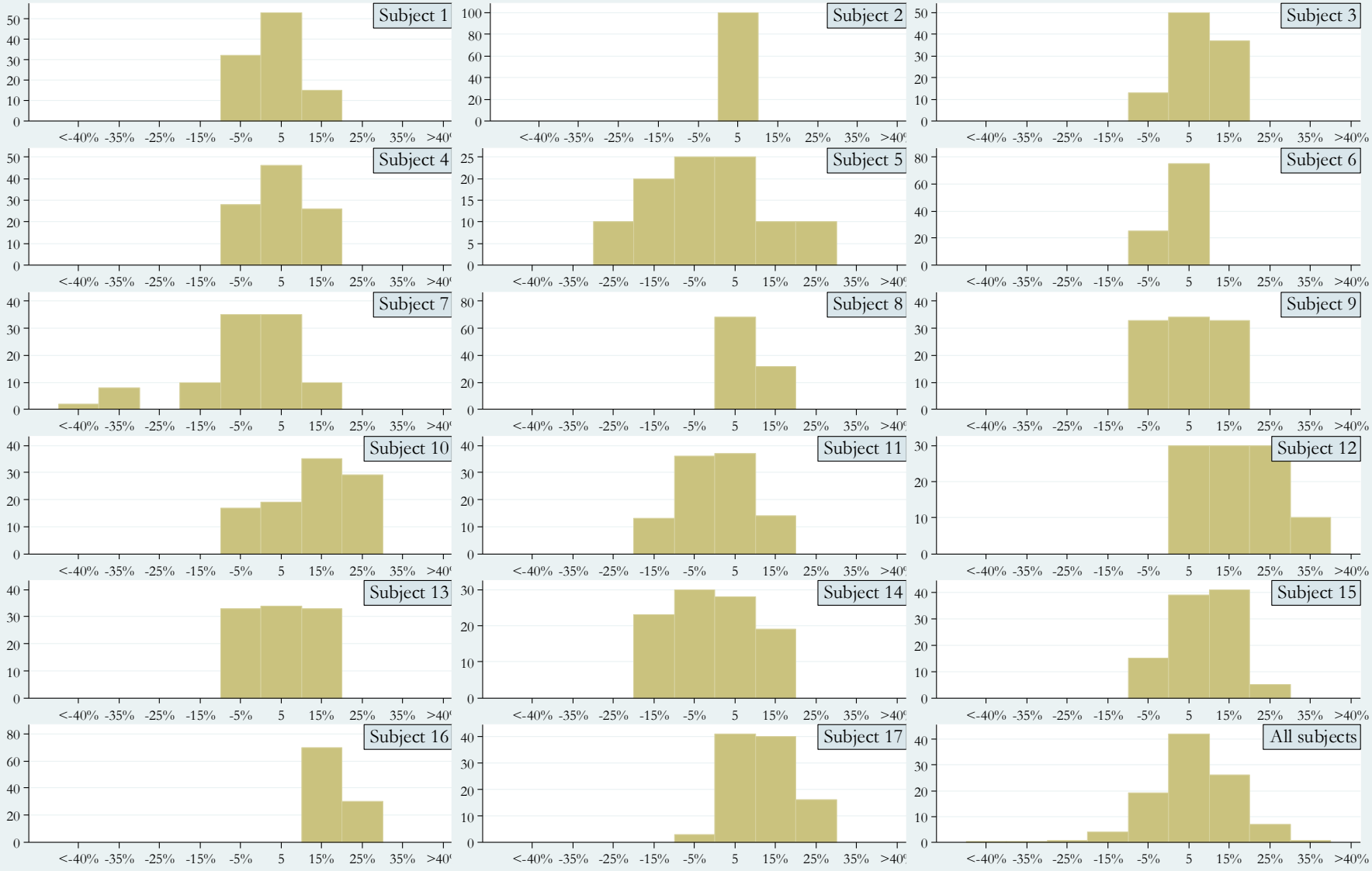
	Bank/Asset Manager	Insurer	Total
North American	9	9	18
European	0	2	2
Pan Asian	1	0	1
Total	10	11	21

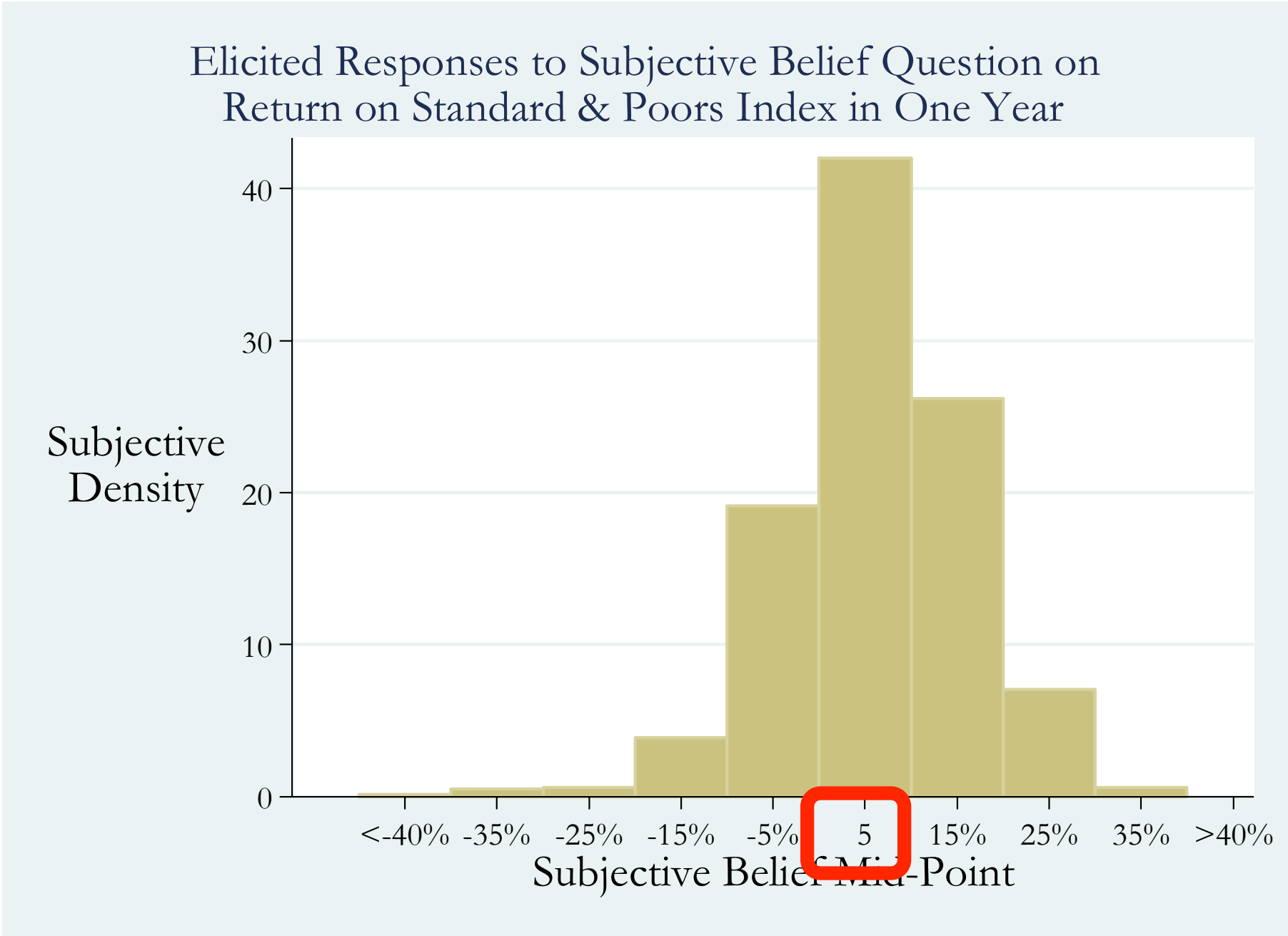
SunTrust
BlackRock
Janus Capital Group
The Hartford
Allianz
T. Rowe Price — Invest With Confidence
Mutual of Omaha
Guardian
First Horizon
Daiwa Capital Markets
FHLBank Atlanta — A Federal Home Loan Bank
RGA
commonfund
Mitsubishi UFJ Securities (USA) — MUFG
BB&T
John Hancock
hannover re®
AXA
Northwestern Mutual

Variables of Interest

Equities	Interest Rates	Credit	Foreign Currency	Commodity
S&P 500	10 Year U.S. Treasury Bond Yield	Markit CDX North American Investment Grade Index	Euro/USD Exchange Rate	Price of a Barrel of Brent Crude Oil
Euro Stoxx 50	10 Year German Bund Rate	Markit iTraxx European Crossover Index		Gold Spot Price 1 oz.
MSCI All Country Asia Ex-Japan	10 Year Japanese Government Bond Yield			

Elicited Responses of Each Subject to Subjective Beliefs on Return on Standard & Poors Index in One Year




Elicited Responses to Subjective Belief Question on
Return on Standard & Poors Index in One Year
Subjective
Density
0
10
20
30
40
<-40%
-35%
-25%
-15%
-5%
5
15%
25%
35%
>40%
Subjective Belief Mid-Point

CRO Concordance

- **ρ_c - Concordance Correlation Coefficient**
  evaluates the degree to which pairs of random draws from two separate distributions agree with one another by falling along a 45° line drawn through the origin.

$$\rho_c = \rho C_b$$

- ρ - **measure of precision**
  Standard Pearson Linear Correlation. Use to measures how far each observation pair deviates from the best-fit line.

- C_b - **bias correction factor**
  Measures how far the best-fit line deviates from the 45° line drawn through the origin.

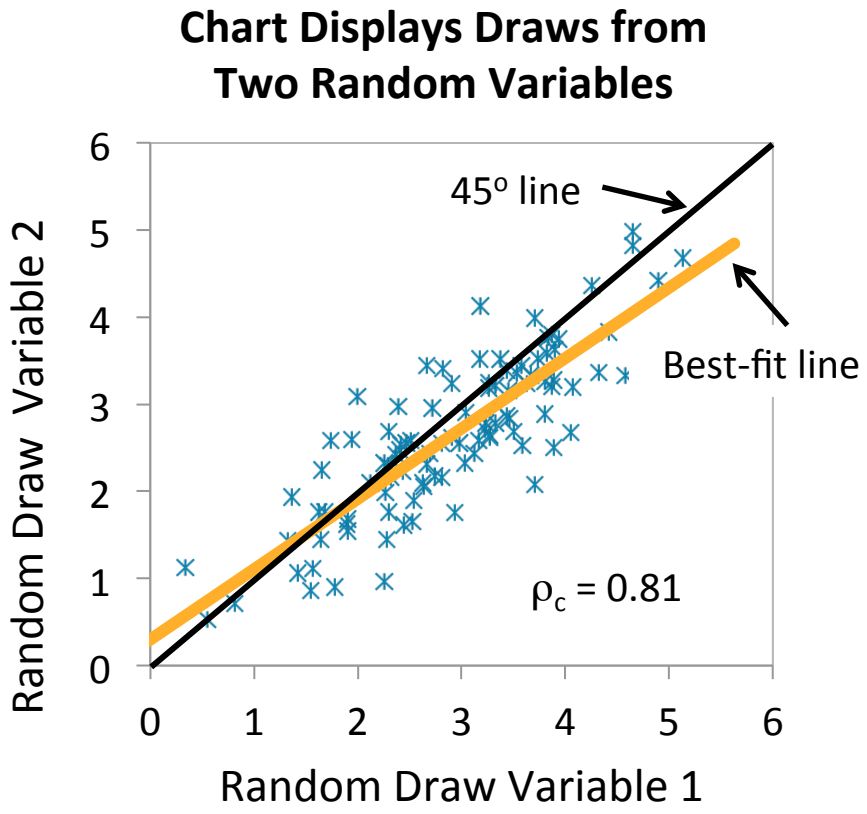
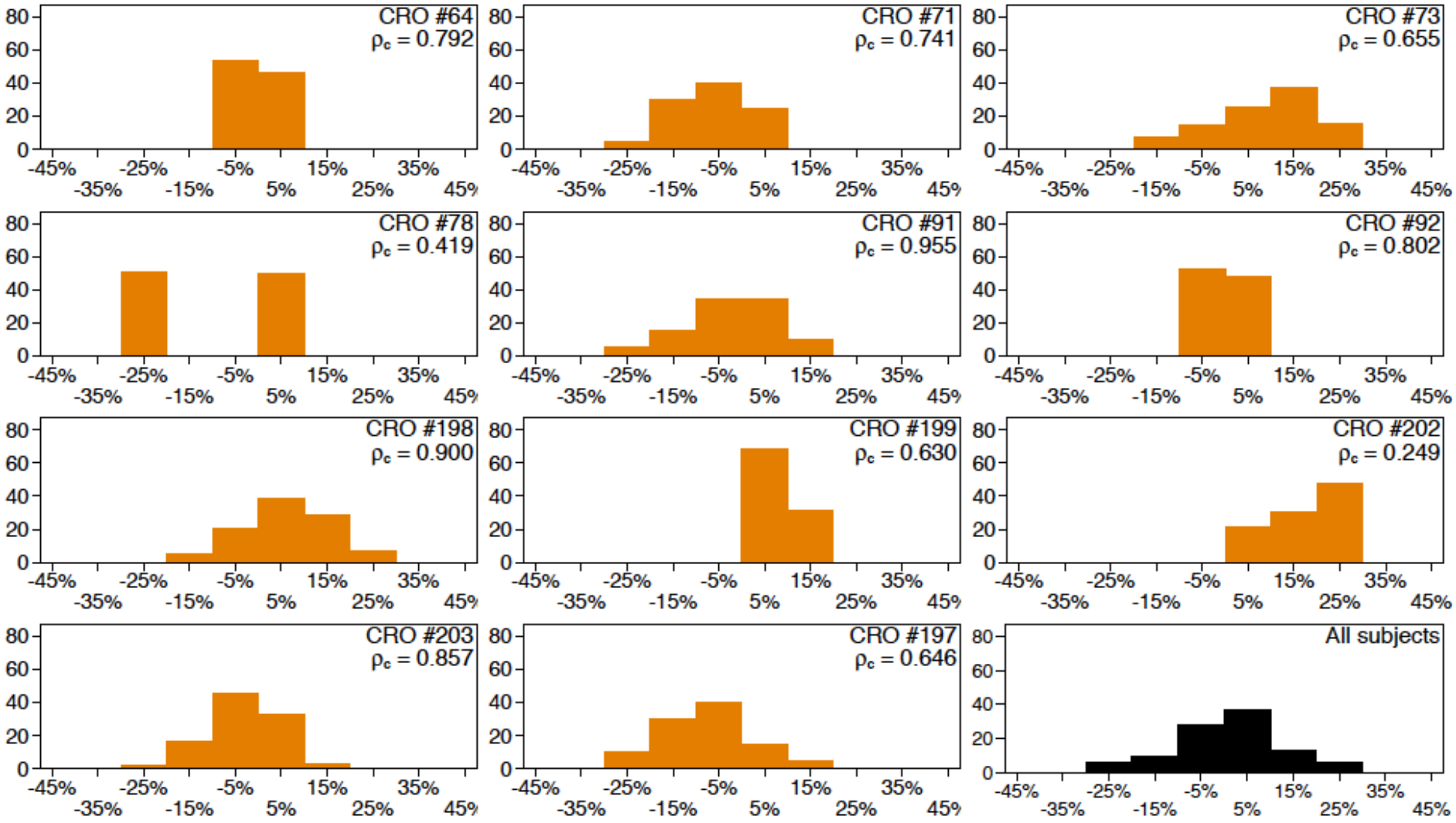


Figure 1: Elicited Subjective Beliefs of All Subjects on the Return on the *Standard & Poors 500 Index* in One Year

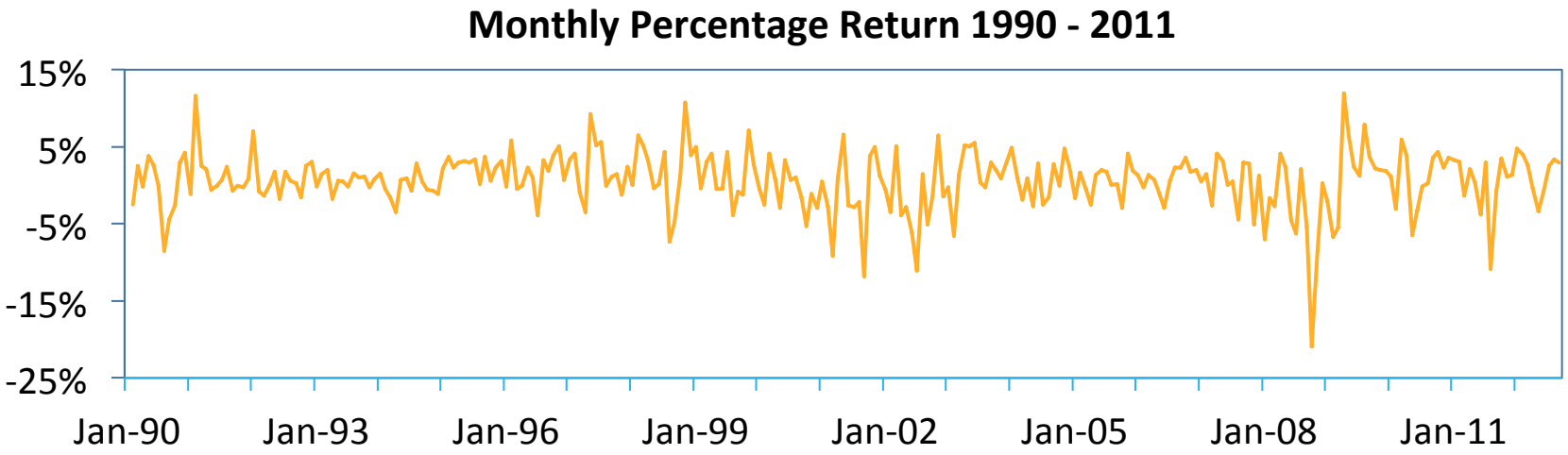
Based on N=11 CRO elicitations between June 17 and 21, 2013
Average of concordance indices $\rho_c = 0.695$



Baseline Historical Data-Based Forecasts

- Goal: Compare our **subjectively elicited** distributions with **objective** probability distributions derived from historical data
- Estimation Methodology: Factor-Augmented Vector Autoregressions
  - Bernanke, Boivin and Eliasz (*QJE* 2005)
- Prediction Methodology: Nonparametric bootstrap prediction interval technique
  - Thombs and Schucany (*JASA* 1990)
  - Kim (IJF, 1999)

Standard & Poor's 500 Equity Return



Source: Bloomberg

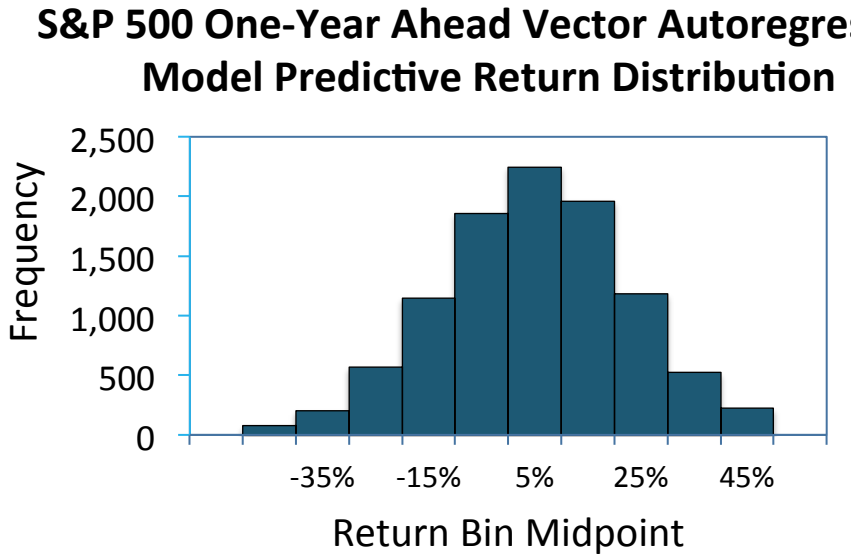


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Figure 4: Elicited vs. Modeled Distributions of the 10-Year U.S. Government Treasury Bond Yield at the End of February 2015

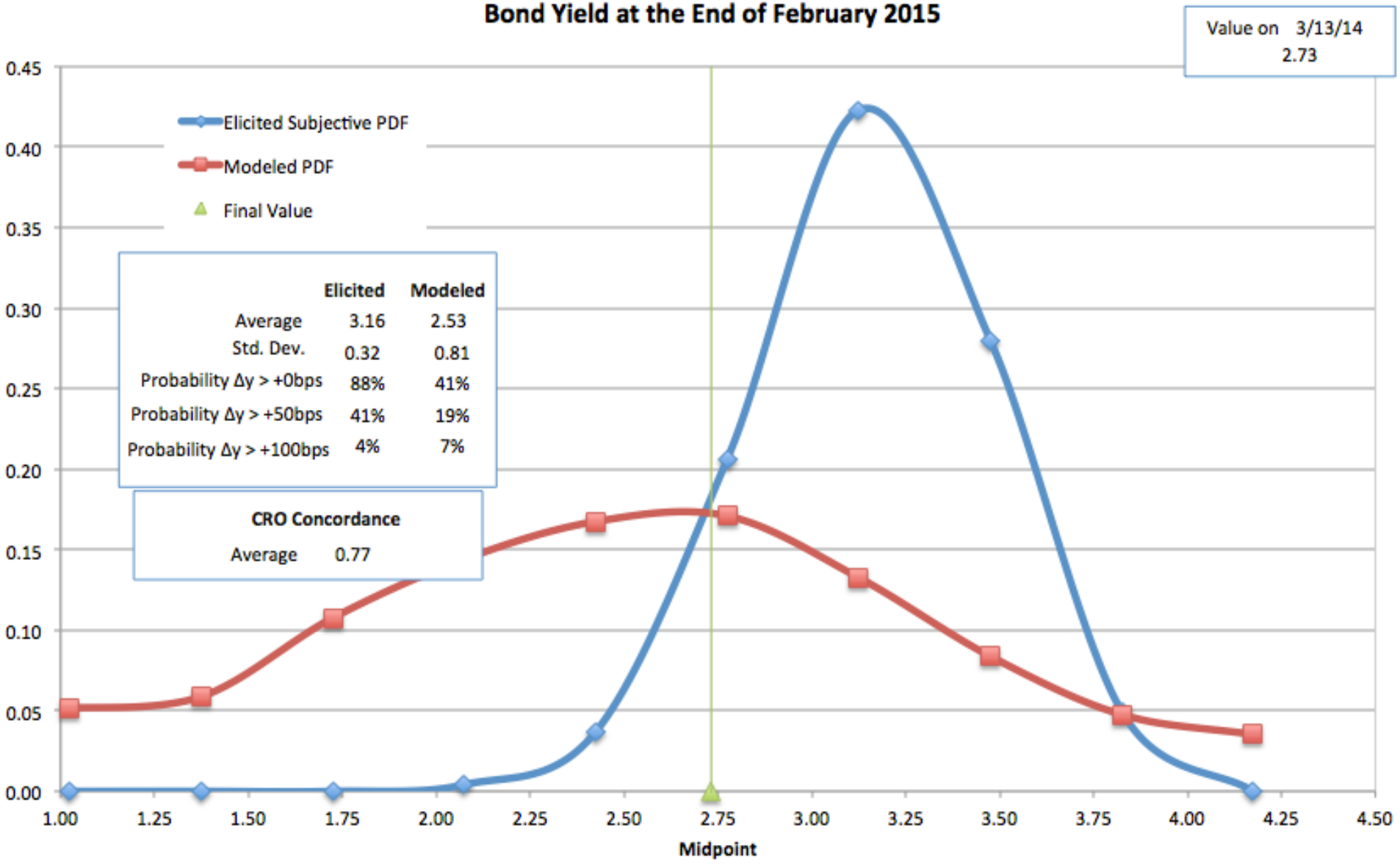
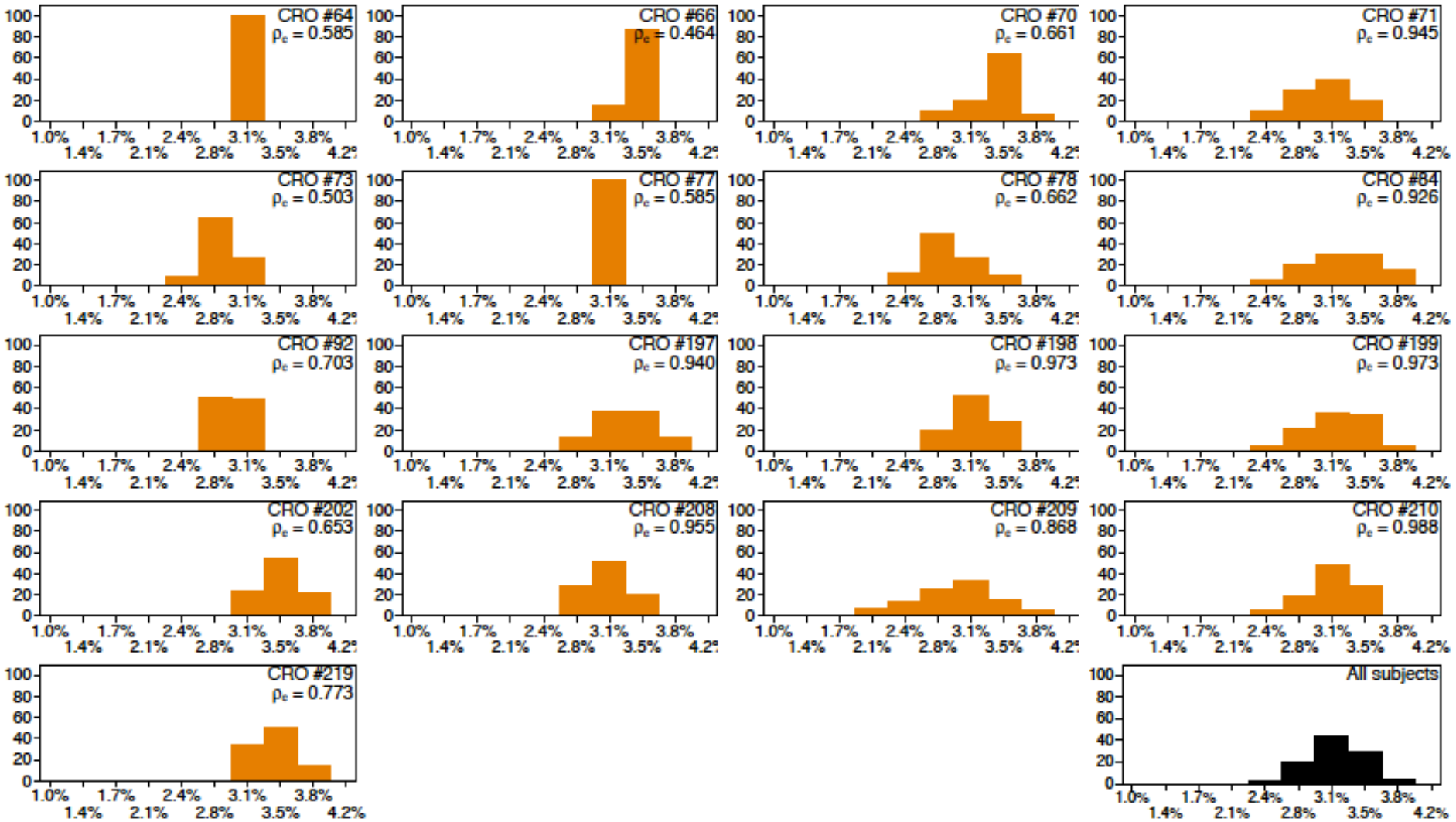


Figure 4: Elicited Subjective Beliefs of All Subjects on the Yield on the *10-Year U.S. Treasury Bond* in One Year

Based on N=17 CRO elicitations between March 17 and 23, 2014
Average of concordance indices $\rho_c = 0.774$



Summary Statistics March 2014 Elicitation

Interest Rate Indices N = 17 respondents

Index	Value on 2/14/14	Forecast Rate EV	Forecast Rate σ	Probability Rate Rises > 0bps	Probability Rate Rises > 50bps	Probability Rate Rises > 100bps	Ave. CRO Concordance
10-Year U.S. Treasury Government Bond Yield							
Subjective	2.73	3.16	2.73	88%	41%	4%	0.77
Model	2.73	2.53	2.73	41%	19%	7%	
10-Year German Government Bond Yield							
Subjective	1.59	1.91	1.59	80%	28%	8%	0.54
Model	1.59	1.92	1.59	72%	38%	12%	
10-Year Japanese Government Bond Yield							
Subjective	0.64	0.69	0.64	55%	1%	0%	0.67
Model	0.64	0.53	0.64	33%	5%	0%	

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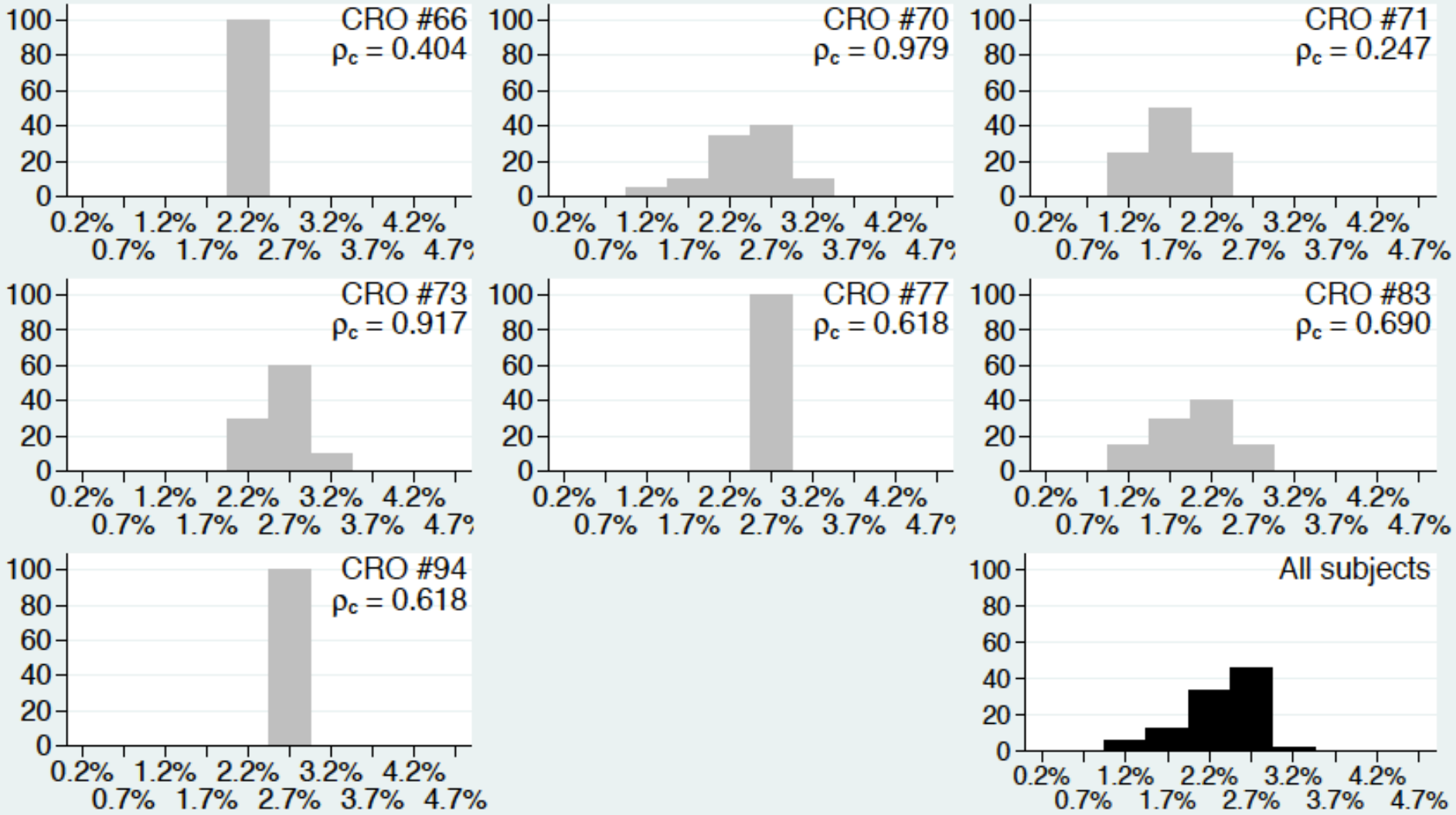
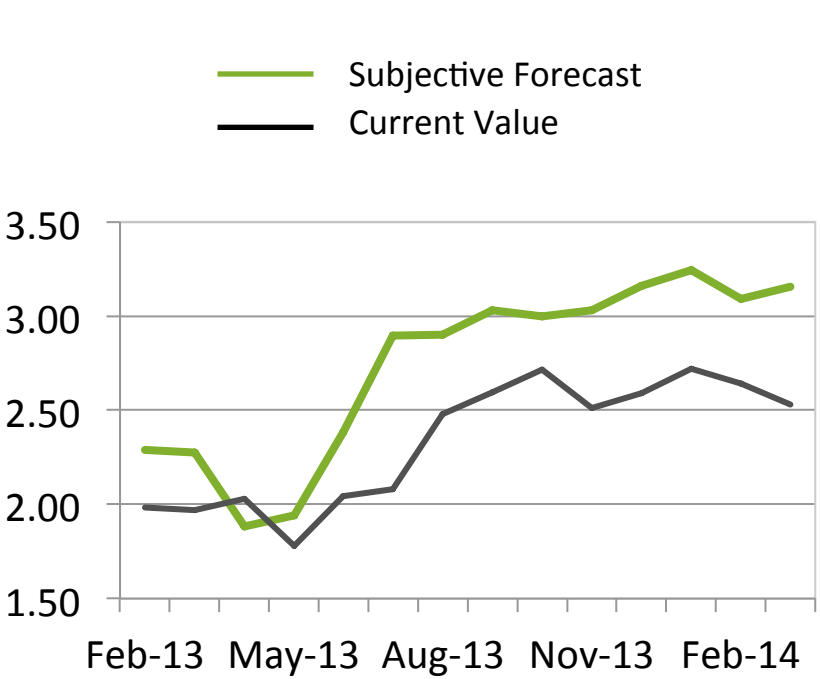
Figure 4: Elicited Subjective Beliefs of All Subjects on the Yield on the *10-Year U.S. Treasury Bond* in One Year

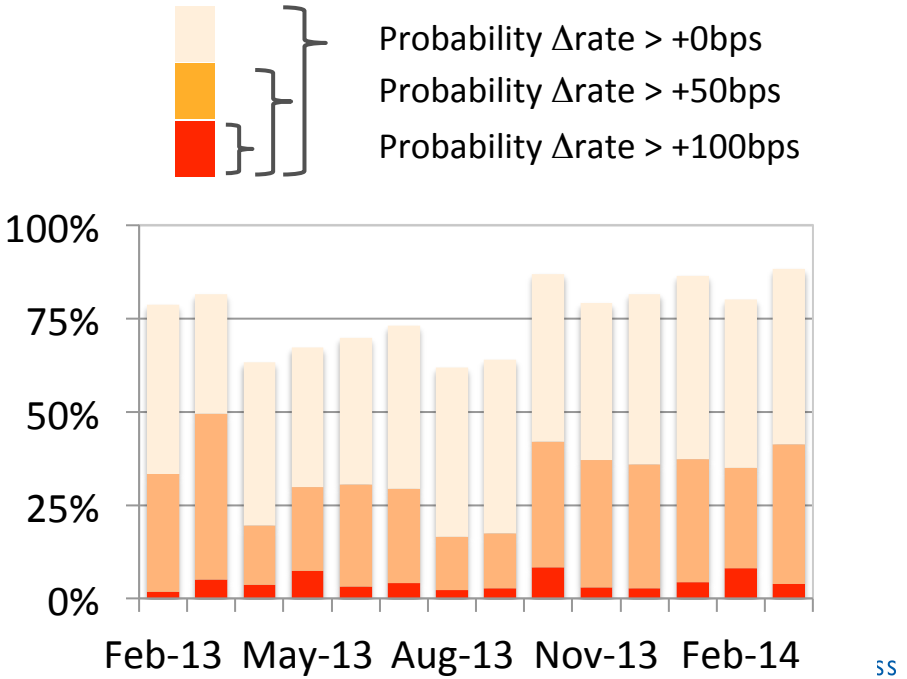
Based on N=7 CRO elicitations between March 18 and 21, 2013
Average of concordance indices $\rho_c = 0.639$



Longitudinal Results: 10 Year U.S. Treasury Rate

	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14
Number of Respondents	7	5	11	11	14	14	13	10	16	16	12	18	17
Risk Council Members	9	10	12	16	17	17	19	21	21	21	21	21	21
Current Value	1.88	1.72	1.67	2.13	2.63	2.77	2.91	2.59	2.69	2.82	2.84	2.74	2.73
1 yr Subjective Forecast	2.28	1.88	1.94	2.38	2.90	2.90	3.03	3.00	3.03	3.16	3.24	3.09	3.16
1 yr Statistical Forecast	1.97	2.03	1.78	2.04	2.08	2.48	2.59	2.71	2.51	2.59	2.72	2.64	2.53
> + 0bps	81%	63%	67%	70%	73%	62%	64%	87%	79%	82%	86%	80%	88%
> + 50bps	49%	19%	30%	31%	29%	16%	17%	42%	37%	36%	37%	35%	41%
> + 100bps	5%	4%	7%	3%	4%	2%	3%	8%	3%	3%	4%	8%	4%
Concordance	0.64	0.67	0.60	0.60	0.68	0.77	0.71	0.58	0.70	0.74	0.82	0.71	0.77





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Closing Comments

- Web-based technologies allow collaborative exercises to be accomplished in ways not previously feasible
- The application of experimental and rigorous behavioral economics is just in its infancy in many industrial applications
- Imagine other areas of risk management where this technology could be applied