NAVAL CENTER FOR COST ANALYSIS

Modeling the Risk and Uncertainty of Inflation Expectations

Using Survey and Market Data

Risk Track: ICEAA Conference 2013

New Orleans, LA

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Technomics
The Science of Informed Decision Making

"Experience in controversies such as these brings out the impossibility of learning anything from facts till they are examined and interpreted by reason; and teaches that the most reckless and treacherous of all theorists is he who professes to let facts and figures speak for themselves, who keeps in the background the part he has played, perhaps unconsciously, in selecting and grouping them, and in suggesting the argument post hoc ergo propter hoc."

Alfred Marshall

Contents

Introduction

- Perspective
  - Macro
    - A sustained increase in the general level of prices in the economy
  - Micro or Commodity
    - An increase in the price of an identical good or service from one time period to another
  - Sector
    - A sustained increase in the general level of prices in a major business subset of the economy, such as shipbuilding, IT, or defense aerospace
- Variations
  - Deflation, stagflation, inflation

Creeping, Crawling, Walking, Galloping, Hyper

Measurement Challenge

Background

- Aggregation problem
  - Over goods and services, time, & space
- Types of comparisons:
  - Temporal
    - Difference in prices and quantities over time, at a given space
      - E.g., labor rates at Bath Iron Works (BIW), 2012 versus 2013
  - Spatial
    - Difference in prices and quantities across regions or entities, at a given time
      - E.g., labor rates at BIW versus Newport News in 2013

Indices

- By definition, measures of relative change
  - Price indices
    - Consumer Price Index, Producer Price Index, Employment Cost Index
  - Volume (Quantity) indices
    - Index of Industrial Production, Index of Services

***Challenge**: How exactly should microeconomic information involving possibly millions of prices and quantities be aggregated into a smaller number of price and quantity variables?*

Basic Formulae

- **Laspeyres Price Index** = $\frac{\sum P_{current,i}\, Q_{base,i}}{\sum P_{base,i}\, Q_{base,i}}$
  - Base period quantities
  - Generally overstates inflation
- **Paasche Price Index** = $\frac{\sum P_{current,i}\, Q_{current,i}}{\sum P_{base,i}\, Q_{current,i}}$
  - Current period quantities
  - Generally understates inflation

Only difference in the formulas is that the Laspeyres uses base-period quantities while the Paasche uses current-period quantities

- **Fisher Price Index**
  - Square root of the product of Paasche & Laspeyres indices
  - Best measure of inflation
    - Consumers typically react to price changes by changing the quantities they buy

Irving Fisher: "The greatest expert of all time on index numbers." [James Tobin]

Consumer Price Index

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- Change in prices paid for a market basket of goods and services
  - Consumption sector of economy
    - Sales tax included; income tax excluded
    - Investment items excluded
      - Stocks, bonds, houses
- Three main indices published
  - CPI-U (All Urban Consumers)
    - Covers 87% of population
    - Excludes farm families, military families, and those living in institutions (prisons, mental hospitals)
  - CPI-W (Wage Earners and Clerical Workers)
    - Covers 32% of population
  - Chained CPI-U, or C-CPI-U
    - Captures consumers' behavior as they respond to relative price changes

Official CPI-U

Year	'82 to '84 = 100
1982	96.5
1983	99.6
1984	103.9
1985	107.6
1986	109.6
1987	113.6
1988	118.3
1989	124.0
1990	130.7
1991	136.2
1992	140.3
1993	144.5
1994	148.2
1995	152.4
1996	156.9
1997	160.5
1998	163.0

Defense Inflation Indices

- OSD(Comptroller)
  - Program and Financial Control Directorate
  - GDP Price Index
    - Fisher construction
    - 70% consumption expenditures
- Bureau of Labor Statistics
  - Producer Price Index (PPI) for "Military Self-Propelled Ships, New Construction"
    - Measures output prices rather than input costs
    - Fails to account for Δs in unit prices due to learning curves
    - Updates expenditure weights only every 7.5 years
      - Weights not ship quantities
      - Instead, ship price as a percent of company revenue
    - Uses a Laspeyres formula
    - Uses a changing mix of voluntary respondents
      - Repair shops to major yards
      - Can't confirm if "big six" yards even participate in survey
- Bureau of Economic Analysis
  - Deflator for Military Aircraft
    - Similar issues to BLS's index
    - BEA counsels against use for defense cost estimating
- Unique commodity indices
  - E.g., aircraft, spacecraft, ships
    - Attempt to measure changes in costs of components
    - Methodological issues
      - Distinguishing between changes in labor mix and labor rates
      - Capturing changes in productivity
      - Accounting for new systems in the market basket
      - Using a technically valid construct

***Challenge**: Develop statistically-sound indices*

Study Focus

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***Focus**: estimation of probability distributions of inflation expectations up to 30 years out to support risk and uncertainty analysis at Milestones A, B, C and FRP DRs*

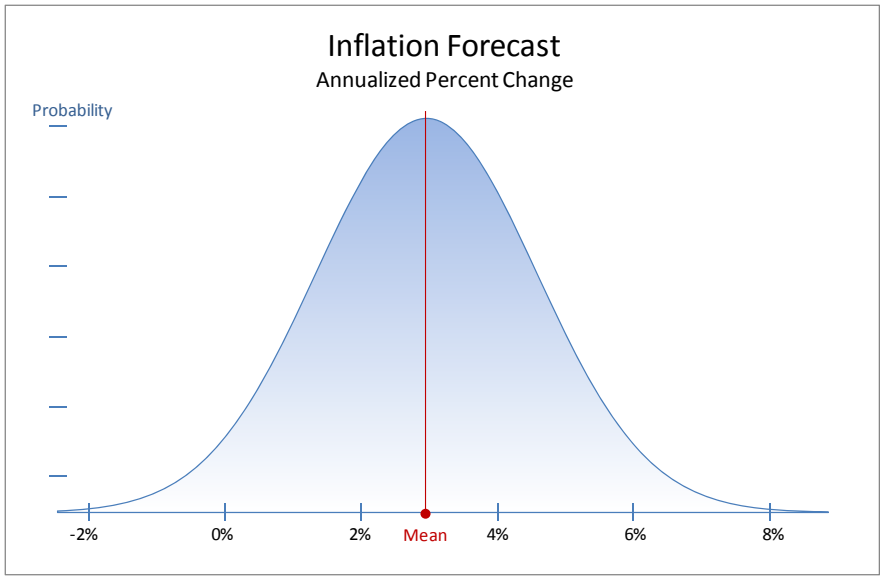
Escalation ~15% of acquisition cost at MS B; $60B for F-35 alone

Survey-Based Measures

- Survey of Professional Forecasters
  - Explicit observations of mean values 1 to 10 years out
  - Probabilistic forecasts 2 years out
    - Enables construction of near-term PDFs

Market-Based Measures

- Treasury Breakevens
  - Point predictions up to 30 years out
- Zero-Coupon Inflation Swaps
  - Likewise, point predictions 30 years ahead
- Cap and Floor Derivatives
  - **PDFs implied by call-price function!**
  - Based on daily interaction of agents who buy and sell inflation protection in a $1.5B+/year market



***Note**: focus sharpens and credibility rises when prices are set by those with "skin in the game"*

Survey of Professional Forecasters

- Survey produces set of data "very rare" in Economics and Finance
  - Point as well as [in some cases] probabilistic forecasts
    - Same sources
    - Variables clearly defined
    - Results professionally tabulated
- Oldest such survey in the U.S
  - Professional forecasters
  - Captures forecasts of 32 macroeconomic variables, including
    - Interest rates, nominal GDP, corporate profits, unemployment rates, non-farm payroll employment, net exports, fixed investment, housing starts, and inflation
- Inflation forecasts
  - Point
    - 1, 2, 5, and 10 years ahead
  - Probabilistic
    - 1 and 2 years ahead

Administered by the Federal Reserve Bank of Philadelphia

- Current forecasters include:
  - Who's-Who on Wall Street
    - Barclays, Bloomberg, BNP Paribas, Credit Suisse, Deutsche Bank, Goldman Sachs, JPMorgan Chase, Moody's Analytics, Wells Fargo
  - Academia
    - Johns Hopkins Center for Financial Economics, George Washington University
  - Forecasting Firms
    - Chmura Economics & Analytics, Decision Economics , IHS Global Insight
  - Others
    - Bank of Tokyo-Mitsubishi, National Association of Home Builders, Thomson Reuters, US Chamber of Commerce

Probabilistic Forecasts

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Each projection reflects a respondent's uncertainty about future inflation

Projections of core inflation from 2012:Q4 to 2013:Q4[1]

Forecaster	< 0.0%	0.0-0.4%	0.5-0.9%	1.0-1.4%	1.5-1.9%	2.0-2.4%	2.5-2.9%	3.0-3.4%	3.5-3.9%	>= 4.0%
A	0	0	0	6	34	44	15	1	0	0
B	0	5	30	35	30	0	0	0	0	0
C	0	0	0	0.88	50.24	48.04	0.84	0	0	0
...										
n										
Mean	0.01	0.18	1.44	6.19	46.7	40.41	4.38	0.65	0.04	0.00

Typically, n = 30 to 40

- Each probabilistic projection *not* a single point estimate of expected value of inflation
- Instead, a *set of probabilities*
  - Chances in 100 that future inflation will fall into each of ten bins

- P_i^1 = Year-one projections of the i^{th} forecaster
  - For example, $P_A^1 = \{0,0,0,6,34,44,15,1,0,0\}$ is the response of forecaster "A"
- P_i^2 = Year-two projections of the i^{th} forecaster [not shown]

[1] *Seasonally adjusted, annual rate, excluding transitory price changes*

Conflation of Forecasts

- Conflation
  - Combining *n* subjective probability distributions into one

$$Q = f(P_1, P_2, \ldots P_n)$$

- Classical convex combination or weighted average

$$Q = \sum_{i=1}^{n} w_i P_i, \text{ where } \sum_{i=1}^{n} w_i = 1$$

  - Weights might be assigned to individual forecasters [each P_i]
    - Based on their track record
    - But doesn't guarantee future accuracy
    - And many studies highlight gain in accuracy from a consensus view
  - Commonplace to use equal weights

$$w_i = 1/n, \text{ for } i = 1 \text{ to } n$$

    - Equivalent to the average of *n* responses

- Normal curves fit to the conflated distributions[1]
  - By survey date
    - 2007:Q1 and later
      - Start of Fed elicitation of these probabilistic forecasts
    - Forecast period
      - One-year ahead
      - 2nd year
  - Parameters estimated
    - Means, variances, CVs

[1] $Q \sim N(\mu, \sigma^2)$ allows for deflation

One-Year Forecasts

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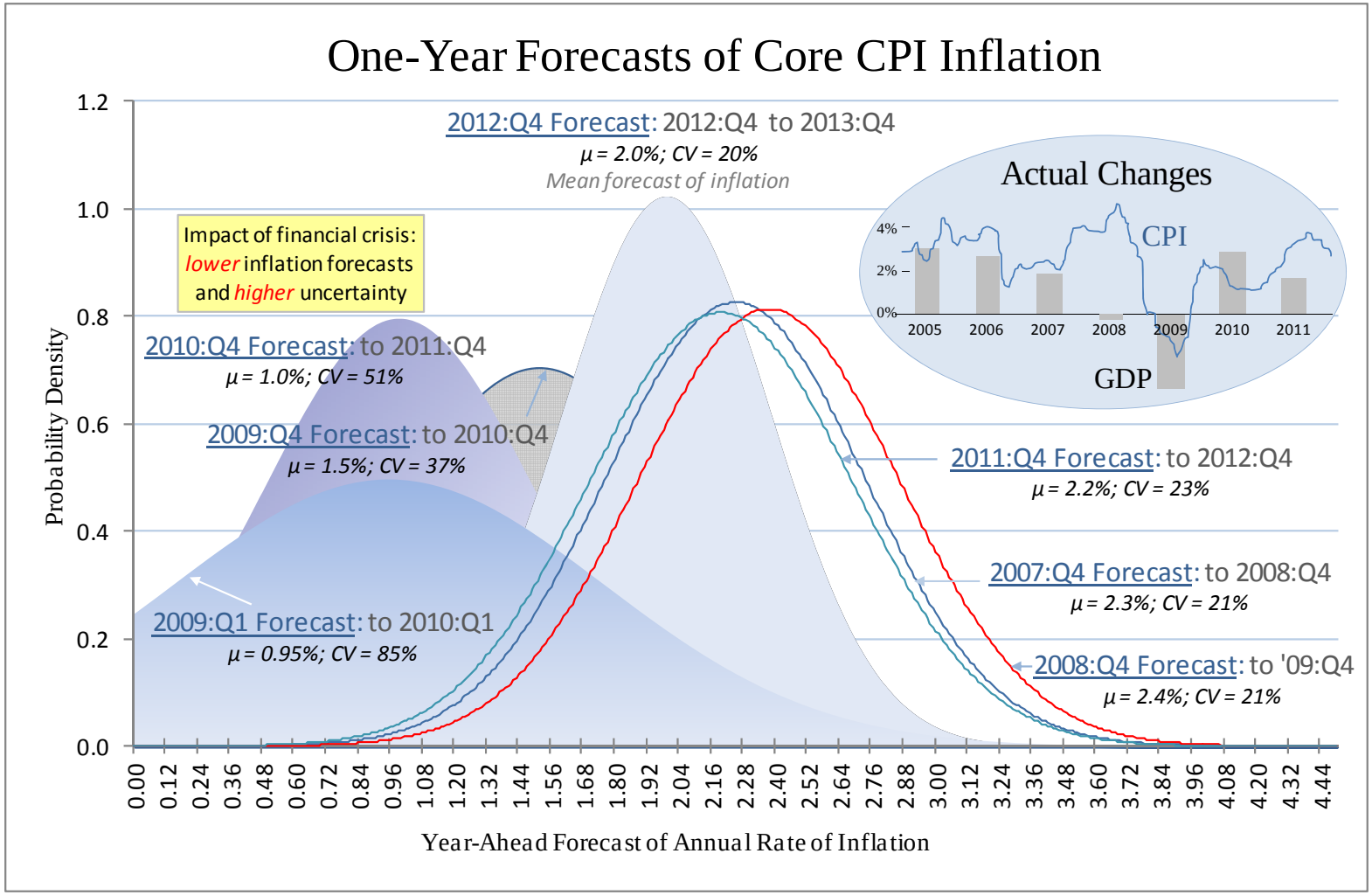

"Increased volatility tends to be associated with decreased predictability"

[Zarnowitz, University of Chicago, 1992]

Year-Two Forecasts

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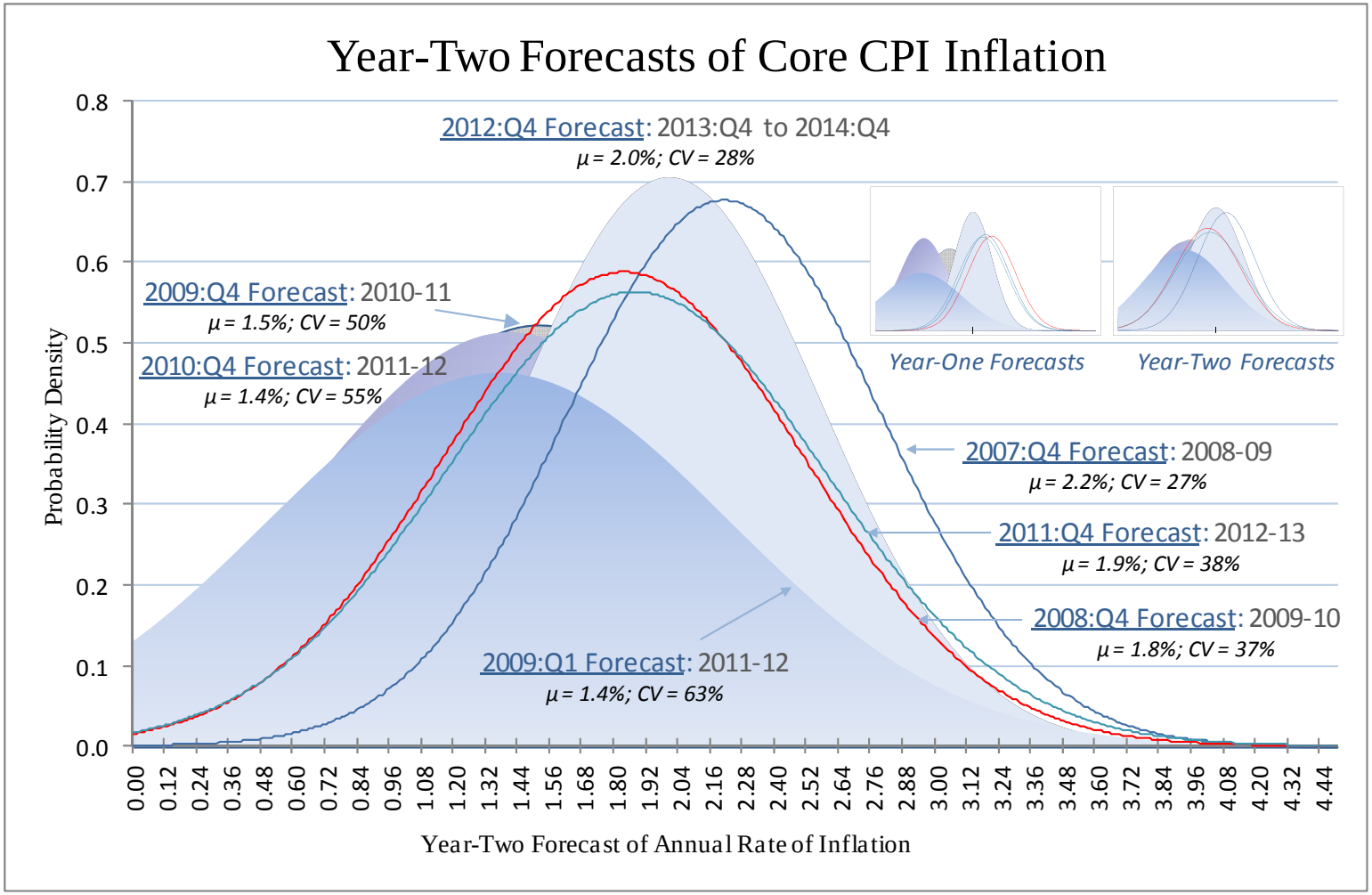

Greater convergence but less certainty than year-one forecasts

Numerical Comparison

- Year-two CVs uniformly higher than year-one CVs
- For cost estimation, reliance on latest Fed forecast not necessarily optimal
  - Averages computed
    - Against all 24 density functions
    - And without high-variance years of financial crisis
- Reasonable values
  - Quartiles for bounds
  - Means of 27% and 33%

Survey			Year-One Forecasts			Year-Two Forecasts		
Year	Quarter	#	Mean	St Dev	CV	Mean	St Dev	CV
2007	1	1	2.25	0.55	0.24	2.20	0.57	0.26
2007	2	2	2.35	0.50	0.21	2.25	0.54	0.24
2007	3	3	2.25	0.49	0.22	2.17	0.53	0.24
2007	4	4	2.25	0.48	0.21	2.21	0.59	0.27
2008	1	5	2.18	0.62	0.28	2.15	0.72	0.33
2008	2	6	2.45	0.58	0.24	2.33	0.61	0.26
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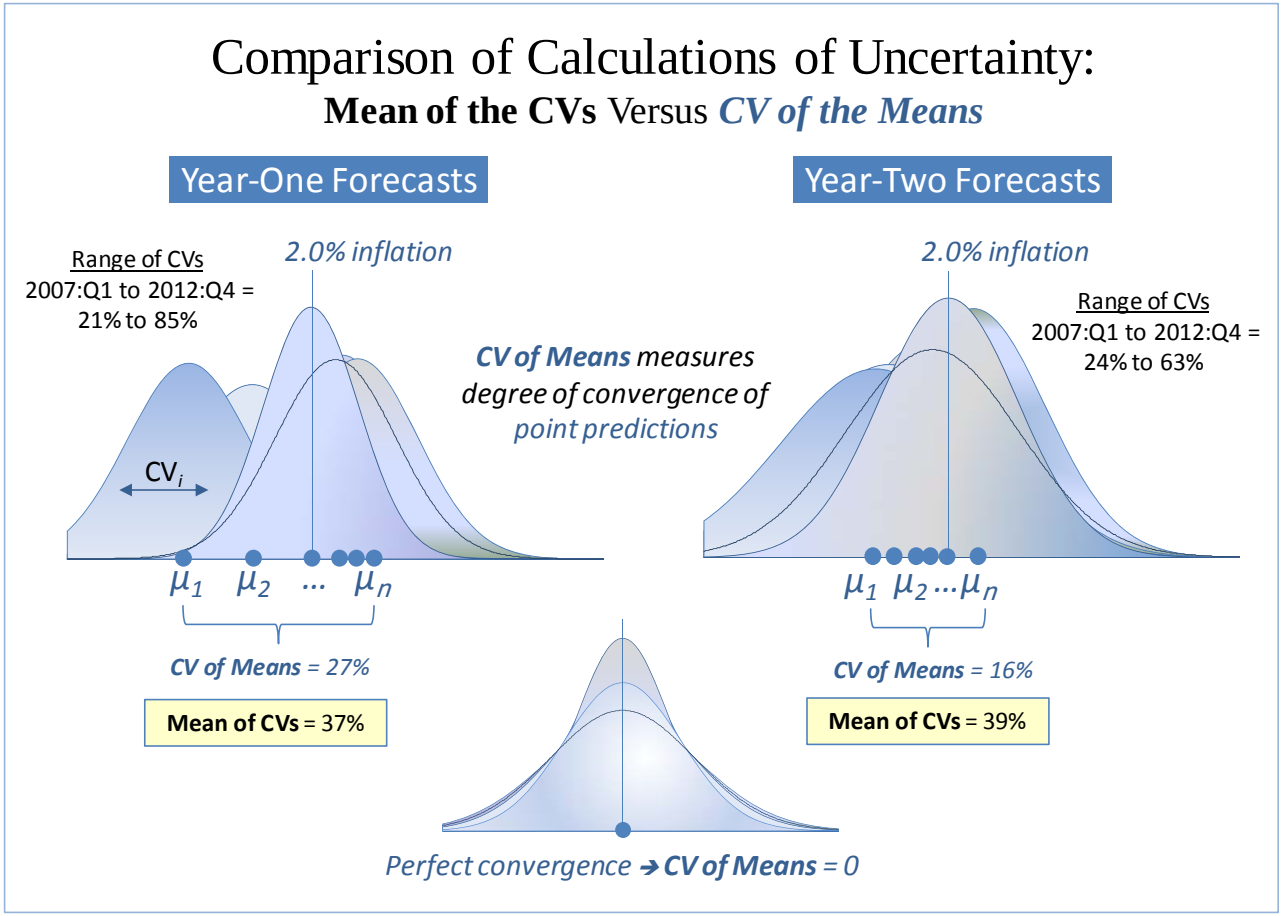
2012	3	23	2.02	0.53	0.26	2.02	0.69	0.34
2012	4	24	1.99	0.39	0.20	2.00	0.57	0.28

Summary Statistics

1st Quartile	1.43	0.50	0.23	1.62	0.60	0.28
Average (n = 24)	1.82	0.59	0.37	1.88	0.70	0.39
Average [without 2009/ 10]	2.10	0.56	0.27	2.06	0.66	0.33
3rd Quartile	2.25	0.67	0.47	2.15	0.78	0.47

Dubious Assessment of Uncertainty

- Underlying probability distributions are often unobservable
  - Focus shifts from the *mean of the CVs* to the *CV of the means*
- But, assumes that an *interpersonal* measure of dispersion is a good proxy for the dispersion of *intrapersonal* predictive probabilities
  - Holds only serendipitously
- Underestimation of uncertainty the usual result

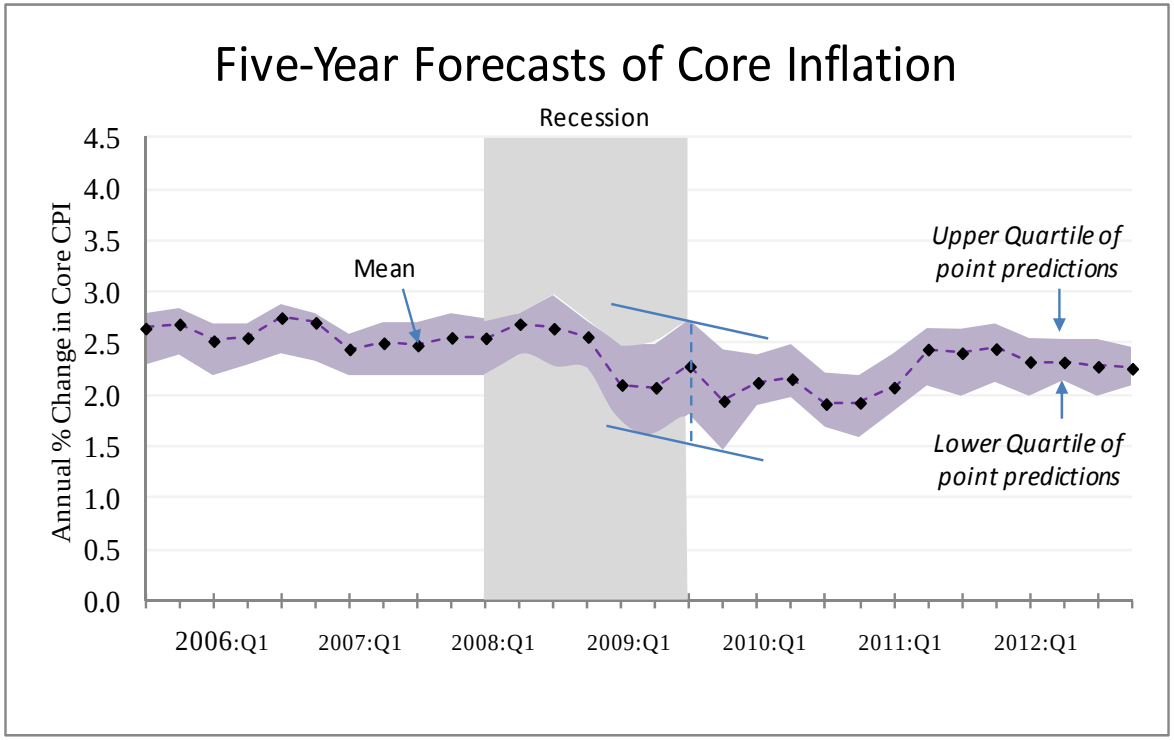


"Inferences from point forecasts do not produce … an informed assessment of uncertainty"

[Zarnowitz]

Long-Term Forecasts

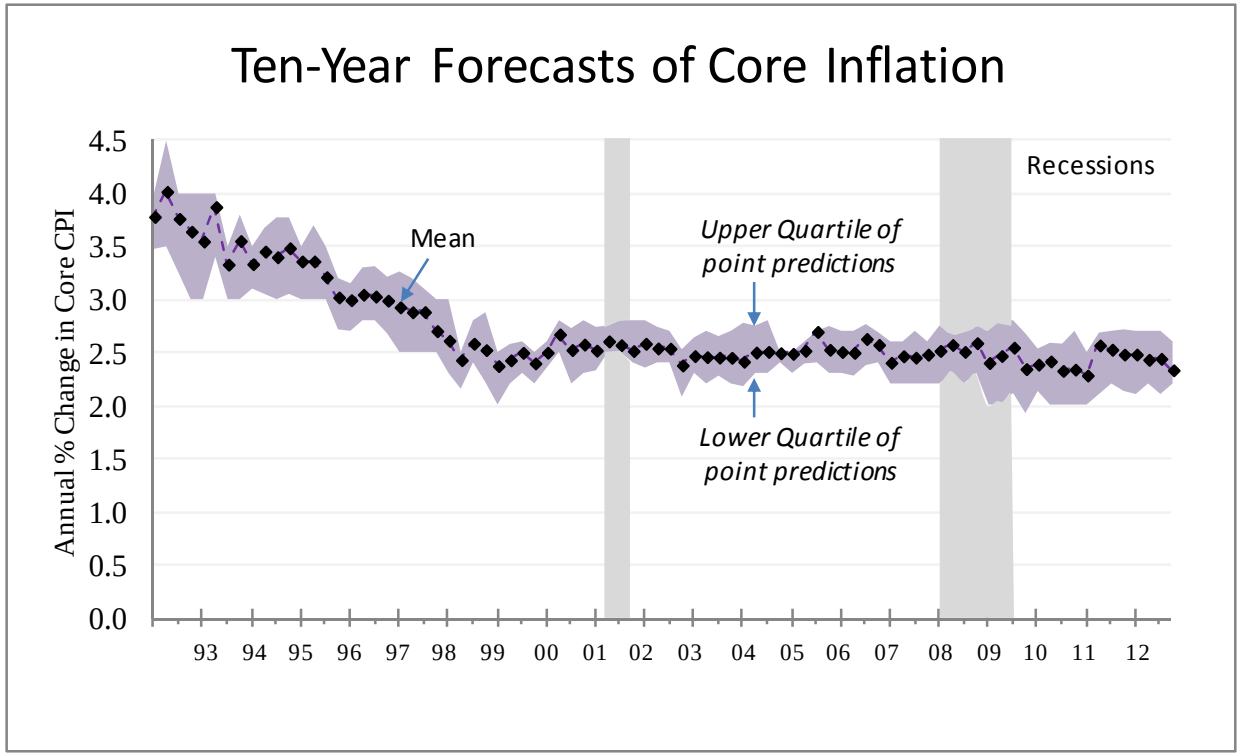
- For longer-term forecasts, Philadelphia Fed asks only for *point predictions*
  - Average annual inflation over entire forecast interval
    - Five and ten years
- Observations:
  - Secular decline
  - Narrow band
    - 2.0% to 3.0%
    - 2.0% to 2.5% more recently
  - Increase in dispersion during financial crisis



First moments are valuable information; but impossible to make scientifically-sound inferences of forecast uncertainty from point predictions

Long-Term Forecasts

- Pronounced secular decline
  - Forecasters adapt to changing economic circumstances
  - But, notice instances of mean pushing against upper quartile
    - E.g., 2011:Q2
    - Due to a maverick forecaster!
    - Predicting 6% per annum inflation!



The Treasury Market

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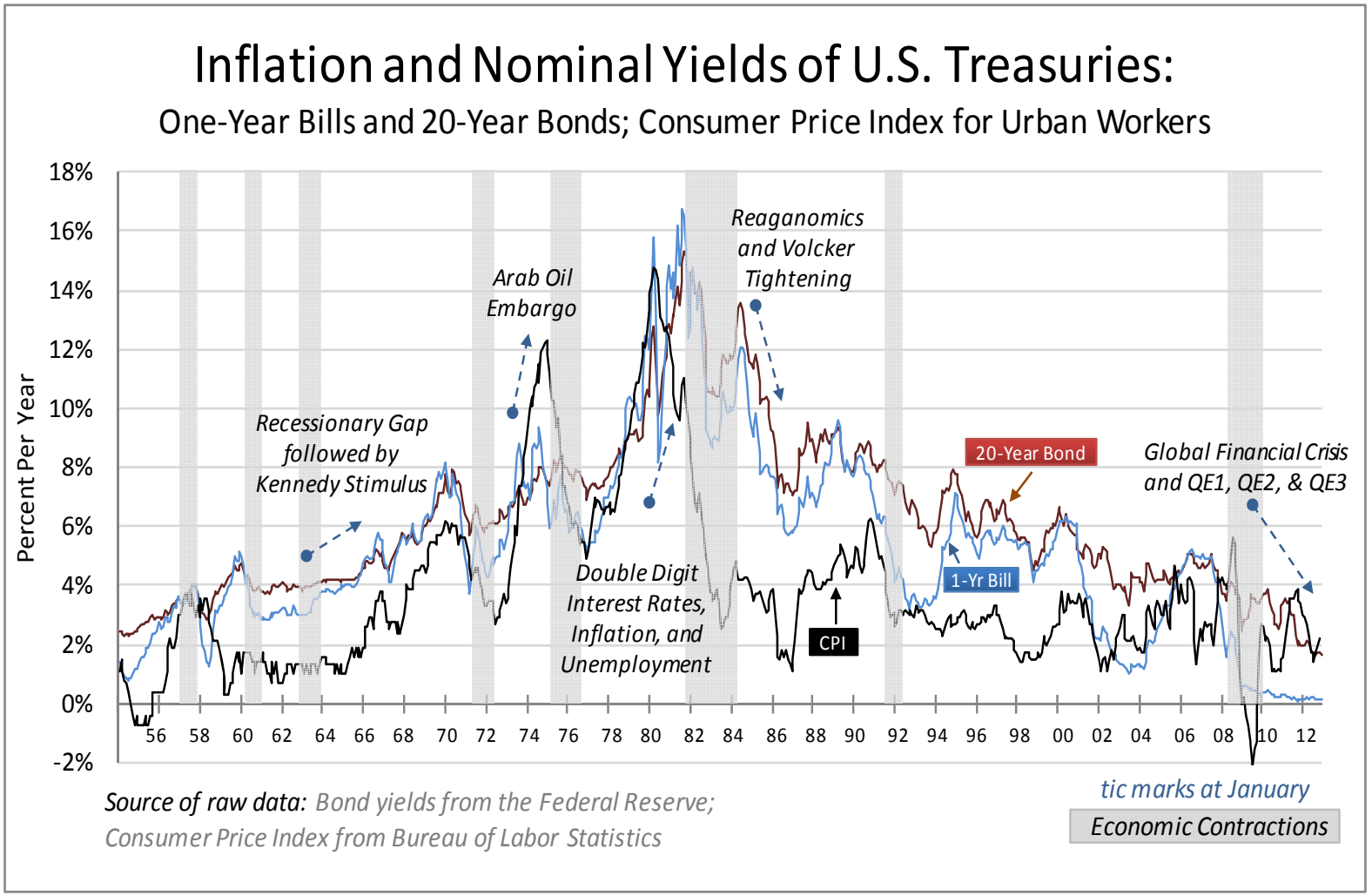

Treasury sells bills, notes, bonds; yields closely linked to inflation

["Fisher equation": $i = r + \pi$, where i = nominal interest rate, r = rate of inflation, π = real return]

The TIPS Market

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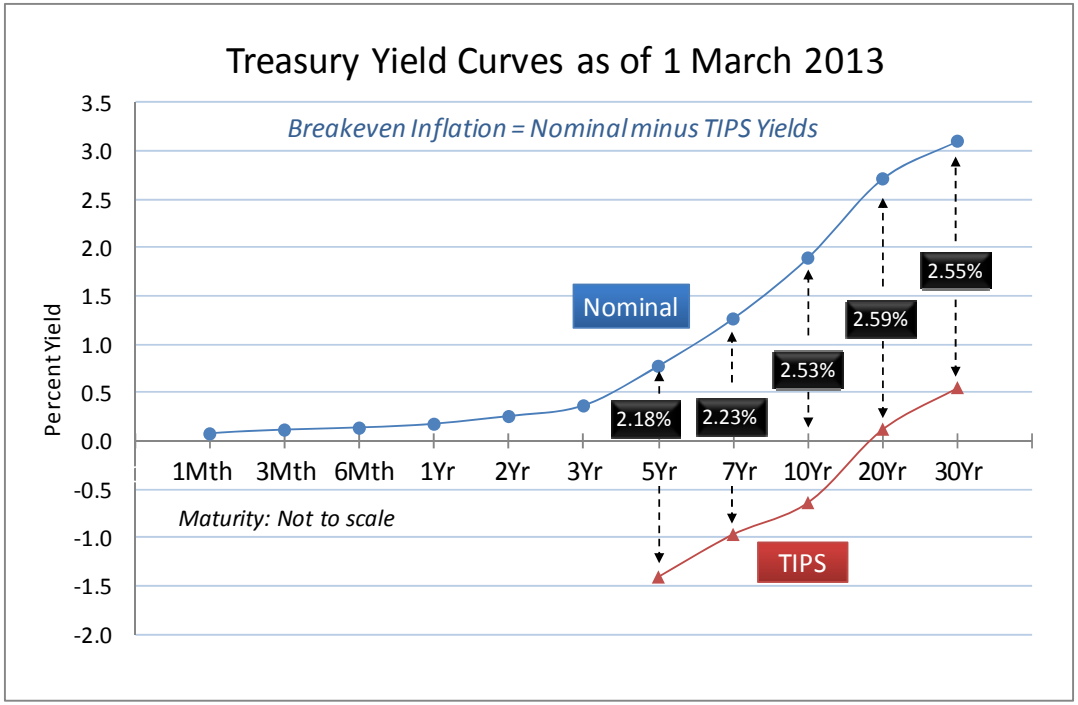
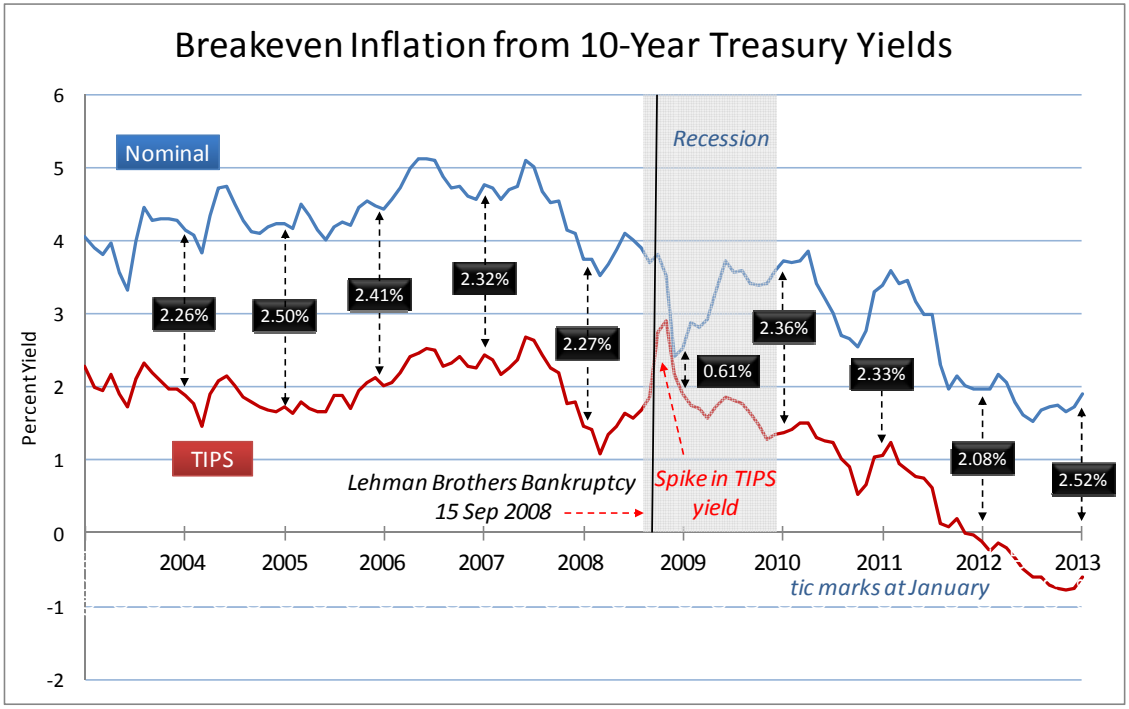
- Treasury Inflation-Protected Securities
  - Added to mix of financial instruments in 1997
  - Sold today in maturities of 5, 7, 10, 20, and 30 years
- Unlike nominals, principal of a TIPS is automatically adjusted to the CPI
  - Provides hedge against inflation so long as security held to maturity
- Coupon rate constant
  - Generates a different amount of interest as principal changes



Breakeven inflation = Nominal yield – TIPS yield
[for an identical maturity]

The TIPS Market

- Use of breakeven inflation rates as a true measure of inflation expectations confounded by presence of risk premia
  - Nominal Treasuries
    - Risk premium that inflation will overshoot expected path
  - TIPS
    - Less liquid than a nominal
    - Lehman Brothers
- Liquidity much higher now than earlier
  - TIPS today ~ 8% to 9% of total Treasury market
  - Risk component estimated at roughly a few basis points up to 50
    - Midpoint of upper bound reasonable



Breakeven rate is market's point expectation of future inflation, duly adjusted for risk premia

-- It's not a probability distribution

-- Computing CV based on breakeven inflation over time yields faulty results

Inflation Derivatives

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- Derivatives
  - Financial instruments that derive value from the value of an underlying asset
    - E.g., gold, wheat, bond, index
- Market for inflation protection has grown with the TIPS market
  - Almost non-existent in US 20 years ago
- Zero-coupon vanilla inflation swaps
  - Bilateral contract between a buyer and seller of inflation protection
  - Exchange of cash flows
- Breakeven swap rate quoted daily in the market place
  - Set such that market considers value of fixed leg equal to value of floating leg

Simple Inflation Swap

Floating Leg

Buyer receives realized or actual inflation

Buyer Pays Expected Inflation

Captures the delta between actual and expected inflation

Seller Pays Realized Inflation

Buyer pays current expected inflation

Fixed Leg

Market's inflation expectation

$$Payment\ of\ expected\ inflation = \$notional * [\ (1 + b)^{tenor} - 1\ ]$$

$$Payment\ of\ realized\ inflation = \$notional * [CPI_{t+tenor}/CPI_t - 1\ ]$$

Swap rate includes a net premium demanded by seller for bearing asymmetric risk

Yield Curves on Swaps

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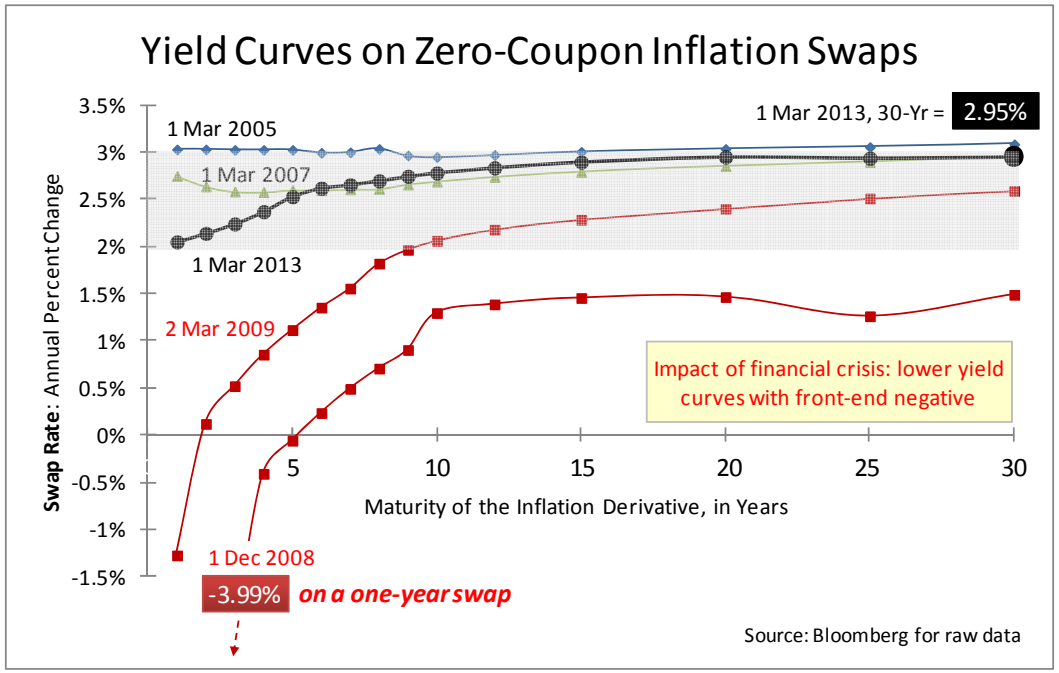
- Recent rates in a 2% to 3% band
  - Steady-state economic climate
- Shorter-term tenors more volatile than longer
  - 30-year maturities converge to roughly 3% per annum
    - Unadjusted for risk
    - Cleveland Fed estimates risk premium at roughly 100 basis points for 30-year instrument
- Deflation regarded as a distinct possibility during financial crisis
  - Swap rate of -3.99% meant sellers willing to receive 96 cents on the dollar to provide inflation protection a year out!



Convergence long-term does not imply less uncertainty regarding inflation three decades out

-- Instead, reflects lack of variation in the market's expectation of a mean, long-term value

Caps and Floors

- New market in inflation derivatives
  - "Caps and floors"
    - Started in Europe in 2003 and US in 2009
    - Options-like securities
  - Payoff linked to realized changes in an index
    - United States
      - » Consumer Price Index for Urban Wage Earners (CPI-U)
    - Europe
      - » Harmonised Index of Consumer Prices (HICP)
- PDF for inflation
  - Extractable from market prices!

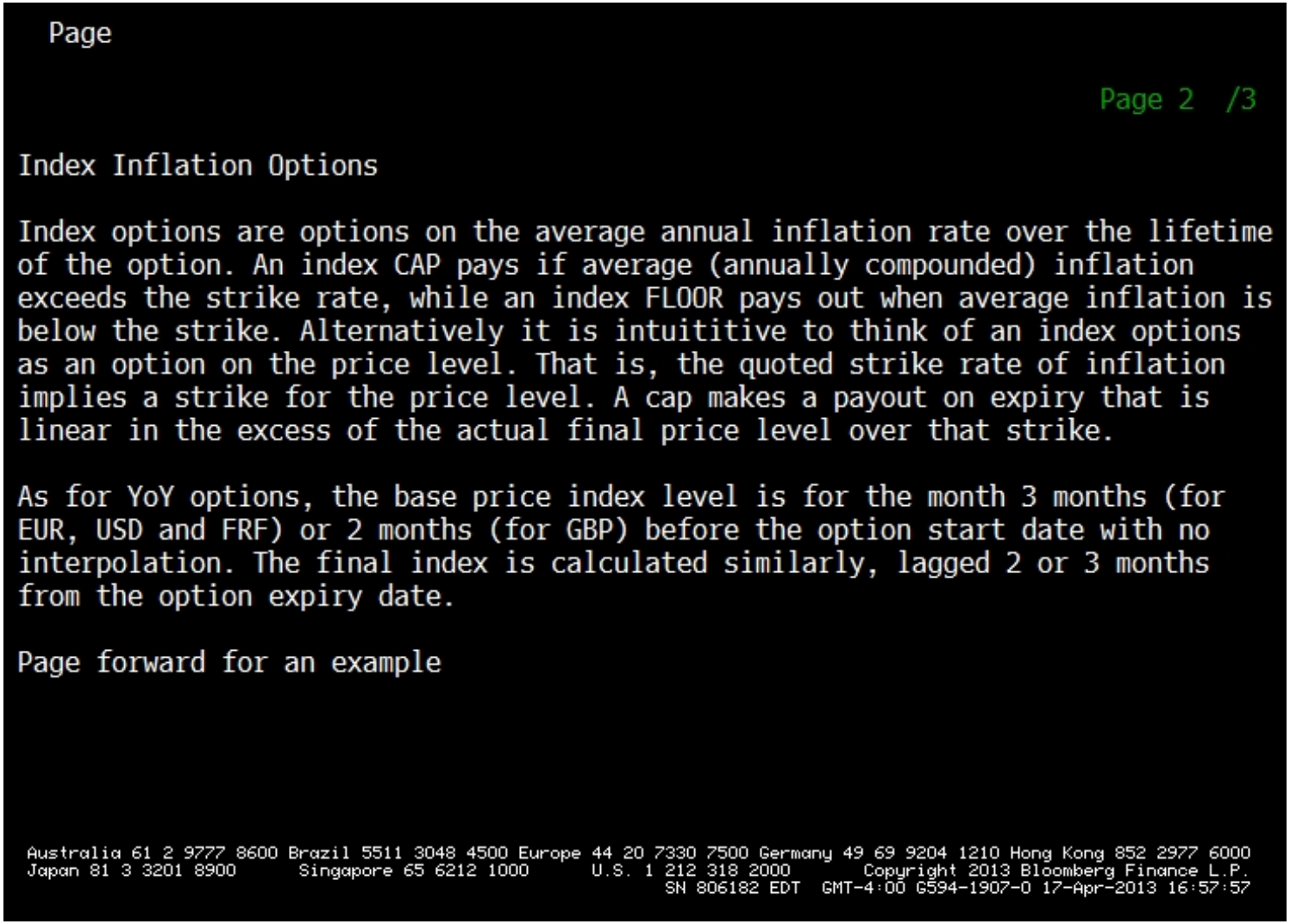
Seller of the cap promises to pay:

$$\$N \cdot \max\left[\left\{(CPI^T/CPI_0)^{(1/T)} - 1\right\} - k, 0\right], \text{ where}$$

$N = notional dollar amount
T = Maturity in years
k = strike of the cap, or yearly inflation rate

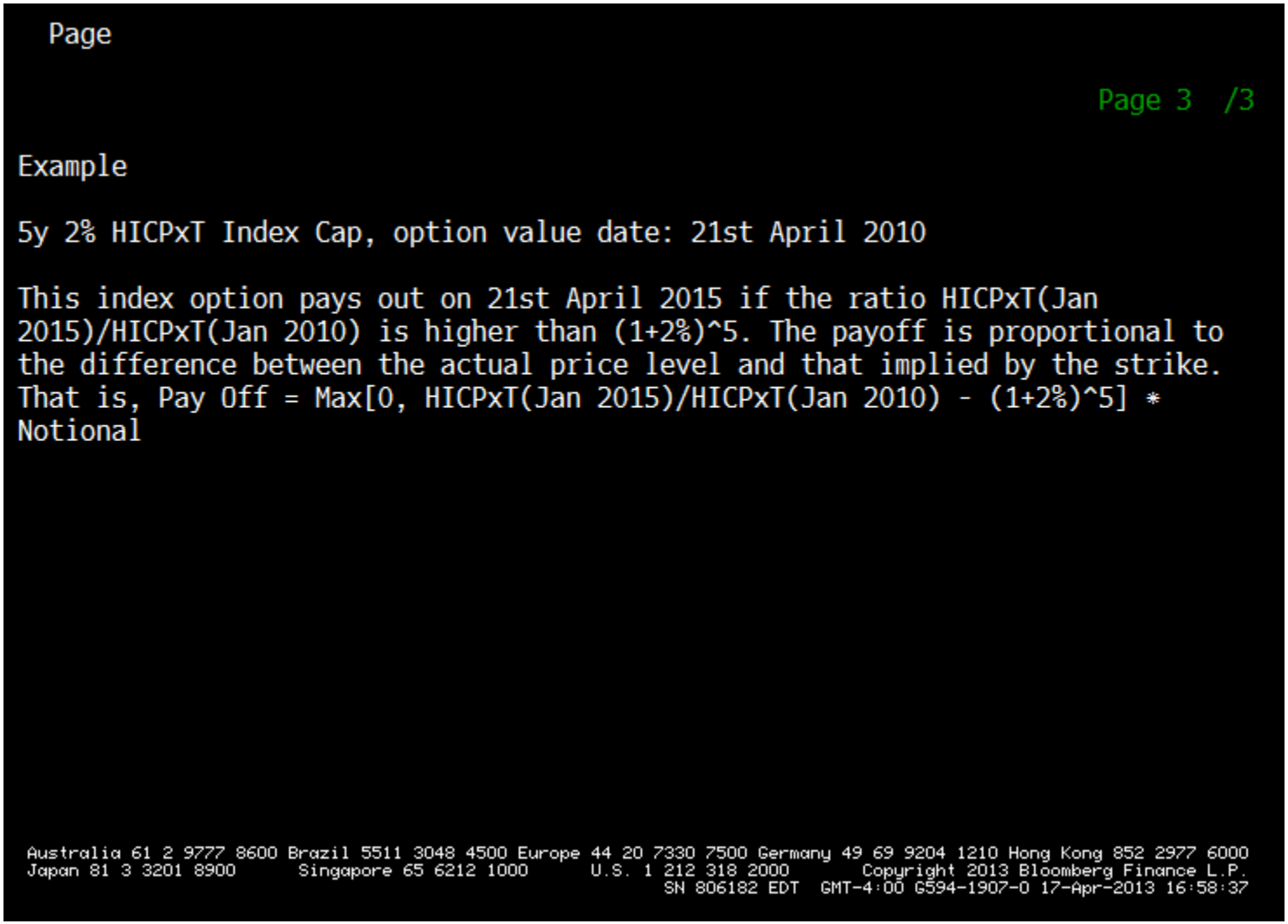
In return for the protection, the buyer makes an upfront payment of $P_0(k,T)$

Screen Shots



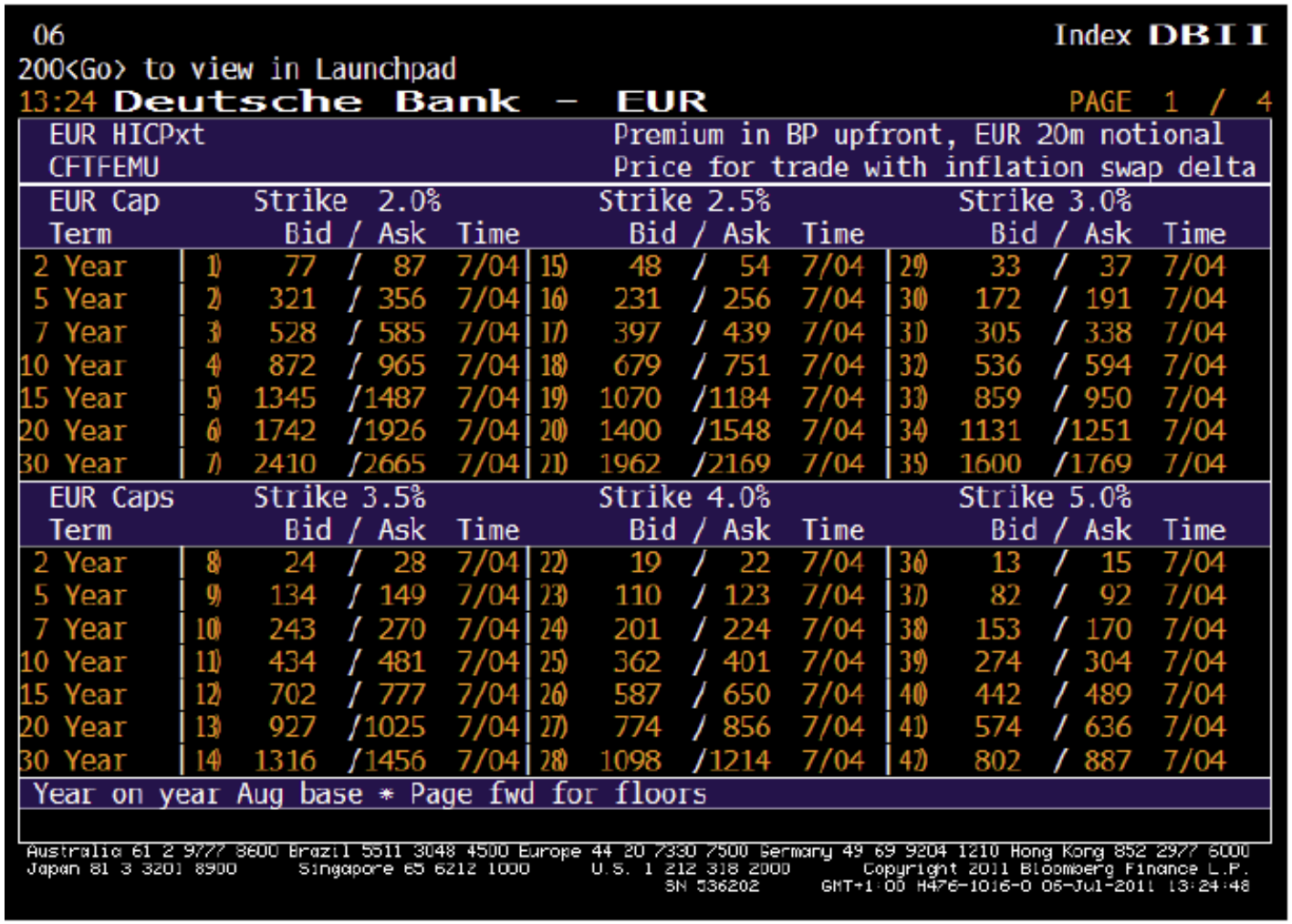
Courtesy: Bloomberg and the Federal Reserve Bank of Cleveland

Screen Shots



Courtesy: Bloomberg and the Federal Reserve Bank of Cleveland

Real-Time Market Data



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13:24 Deutsche Bank - EUR PAGE 1 / 4

EUR HICPxt — Premium in BP upfront, EUR 20m notional
CFTFEMU — Price for trade with inflation swap delta

EUR Cap Term		Strike 2.0% Bid / Ask	Time		Strike 2.5% Bid / Ask	Time		Strike 3.0% Bid / Ask	Time
2 Year	1)	77 / 87	7/04	15)	48 / 54	7/04	29)	33 / 37	7/04
5 Year	2)	321 / 356	7/04	16)	231 / 256	7/04	30)	172 / 191	7/04
7 Year	3)	528 / 585	7/04	17)	397 / 439	7/04	31)	305 / 338	7/04
10 Year	4)	872 / 965	7/04	18)	679 / 751	7/04	32)	536 / 594	7/04
15 Year	5)	1345 /1487	7/04	19)	1070 /1184	7/04	33)	859 / 950	7/04
20 Year	6)	1742 /1926	7/04	20)	1400 /1548	7/04	34)	1131 /1251	7/04
30 Year	7)	2410 /2665	7/04	21)	1962 /2169	7/04	35)	1600 /1769	7/04

EUR Caps Term		Strike 3.5% Bid / Ask	Time		Strike 4.0% Bid / Ask	Time		Strike 5.0% Bid / Ask	Time
2 Year	8)	24 / 28	7/04	22)	19 / 22	7/04	36)	13 / 15	7/04
5 Year	9)	134 / 149	7/04	23)	110 / 123	7/04	37)	82 / 92	7/04
7 Year	10)	243 / 270	7/04	24)	201 / 224	7/04	38)	153 / 170	7/04
10 Year	11)	434 / 481	7/04	25)	362 / 401	7/04	39)	274 / 304	7/04
15 Year	12)	702 / 777	7/04	26)	587 / 650	7/04	40)	442 / 489	7/04
20 Year	13)	927 /1025	7/04	27)	774 / 856	7/04	41)	574 / 636	7/04
30 Year	14)	1316 /1456	7/04	28)	1098 /1214	7/04	42)	802 / 887	7/04

Year on year Aug base * Page fwd for floors

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000
Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000 Copyright 2011 Bloomberg Finance L.P.
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Courtesy: Bloomberg and Deutsche Bank

Theoretical Underpinnings

PDF for inflation derived from expression of market price (P_0) of the option

Discount operator *Payoff at maturity*

$$P_0(K,T) = e^{-rT}\mathbb{E}[\max(S_T - K, 0)]$$

where k = strike price
T = maturity
r = interest rate
S_T = spot or market price at delivery date

Equivalently,

$$P_0(K,T) = e^{-rT}\int_{K}^{\infty}(S_T - K)f(S_T)\,dS_T$$

unlimited upside

PDF of value of option at maturity

exposure capped

$$\frac{\partial P}{\partial K} = e^{-rT}\left(1 - F(S_T)\right)$$

First derivative a function of the cum distribution of inflation rate

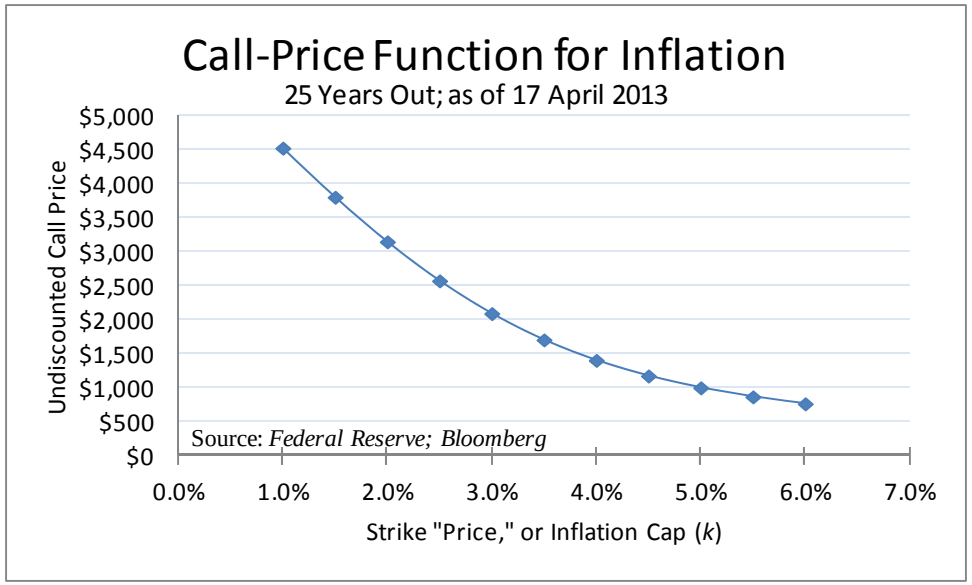
$$\frac{\partial^2 P}{\partial K^2} = e^{-rT}f(S_T)$$

Second derivative gives the PDF!

Call-Price Function

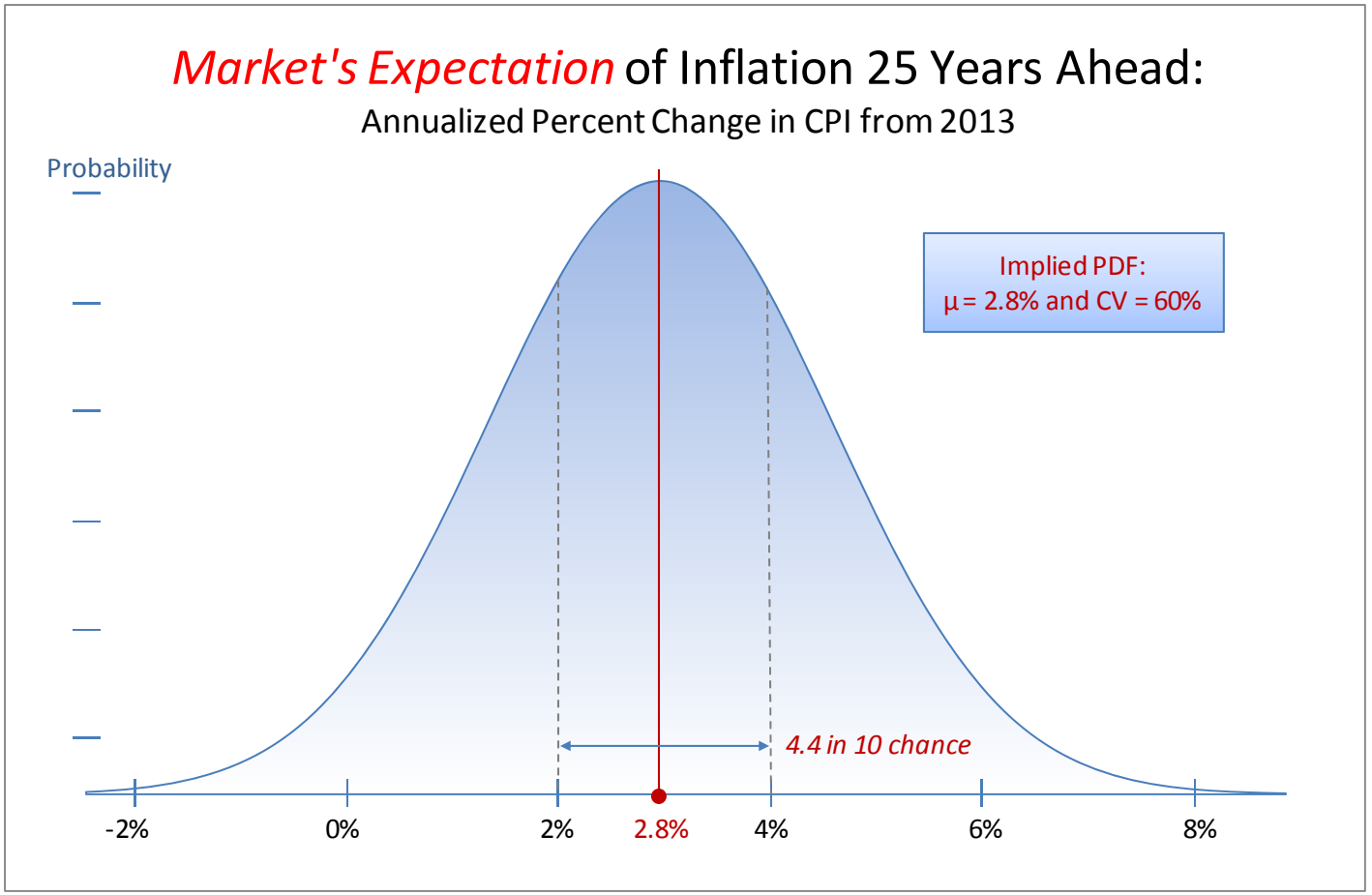
Extraction Techniques:

- Non-Parametric (ROM estimate)
  - Constructs histogram from market data
  - Fits a continuous distribution
- Parametric
  - Assumes a functional form of the PDF
    - Combination of two lognormal distributions
      - For call and put options
    - Estimates the PDF to maximize fit with implied call-price function
      - As in maximum likelihood estimation
- "Smile" Interpolation
  - Filters observed option prices to ensure monotonicity and convexity
  - Transforms (strike, price) data into (delta, implied volatility) data
    - Black-Scholes formula
  - Fits a smooth function through the transformed data (volatility smile)
  - Transforms data back into (strike, price) space
  - Computes 2nd derivative using a numerical algorithm



"A call option with a lower strike price will always be worth more than a higher strike option. This is because the option with the lower strike price will have a higher pay-off if exercised and has a higher probability of delivering a positive pay-off." [Bank of England]

PDF for Inflation



Extracted using a numerical technique (ROM estimate)

Fed, using a volatility smile (best practice, computationally sophisticated), estimates CV of ~ 70%

Forecast Accuracy

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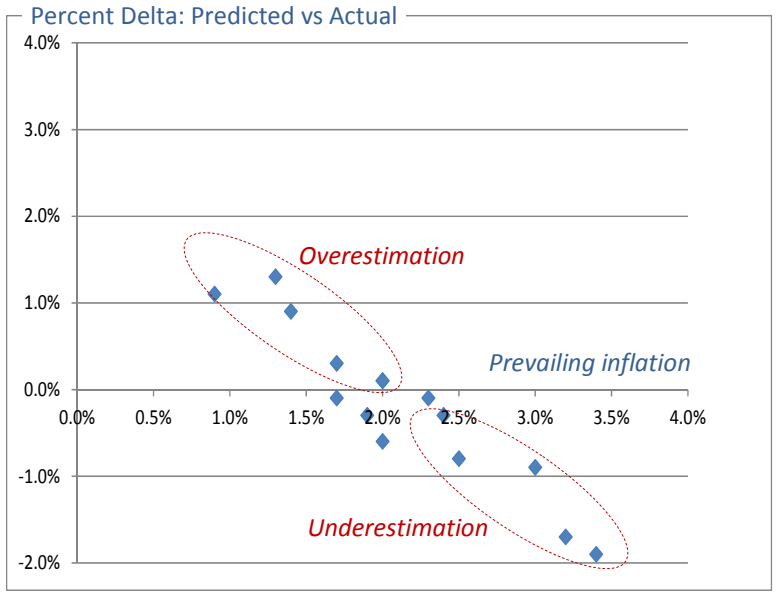
- Excursion
  - Examination of accuracy of Troika's forecasts
    - GDP Price Index
    - Data from Comptroller's "Green Book"
      - Values for FY98 to FY12
  - Forecast errors computed for up to 10-years ahead
    - Percent delta between predicted and actual values
  - Results:
    - Errors clearly not independently and identically distributed (iid)
    - Instead, prediction error = f(prevailing inflation rate at the time of forecast)
    - Rates *overestimated* during times of *low* inflation and *underestimated* during times of *high* inflation

One-year Ahead Forecast Accuracy



Implication: during times of instability, Troika overestimates speed of adjustment of economy to a mean, "normal" level of inflation

Summary of Estimates

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Source or Technique	Time Frame of Inflation Projections in Years							
	1	2	5	7	10	20	25	30
Mean Values of Annualized Inflation *(unless noted otherwise)*								
Survey of Professional Forecasters[1]								
Average for 2007:Q1 to 2012:Q4	1.82%	1.88%						
Average for 2007:Q1 to 2012:Q4 *without* 2009/10	2.10%	2.06%						
2012:Q4	1.99%	2.00%	2.26%		2.34%			
2013:Q1	x	x	2.25%		2.33%			
Breakeven Inflation on Treasury Securities								
Trade data of 1 March 2013								
Raw delta between nominal and TIPS securities			2.18%	2.23%	2.53%	2.59%		2.55%
Adjusted for risk and liquidity premia					2.28%	2.34%		2.30%
Yield on Zero-Coupon Inflation Swaps								
Trade data of 1 March 2013								
Raw rate	2.05%	2.14%	2.53%	2.66%	2.78%	2.95%	2.94%	2.95%
Adjusted for risk (by Federal Reserve Bank of Cleveland)	1.05%	1.17%	1.29%	1.36%	1.47%	1.75%	1.86%	1.95%
Cap and Floor Derivatives								
Trade data of 17 April 2013	x				x	x	2.80%	x
OSD Comptroller Guidance								
Issued 27 Feb 2013 (GDP Price Index; from OMB)	1.90%	1.90%	1.90%	1.90%	1.90%	1.90%	1.90%	1.90%
Coefficients of Variation for Inflation Expectations								
Survey of Professional Forecasters[2]								
Average for 2007:Q1 to 2012:Q4	37%	39%						
Average for 2007:Q1 to 2012:Q4 *without* 2009/10	27%	33%						
2012:Q4	20%	28%						
2013:Q1	x	x						
Cap and Floor Inflation Derivatives								
Trade data of 17 April 2013	x				x	x	60%	x

Conflation of probabilistic forecasts

Premlinary estimate = 60% CV 25years out

Implementation

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- Monte Carlo Simulation
  - Inflation projections
    - Calculation of forward rates required
      - Raw data: observations for years 1, 2, 5, 10, and 25
      - *5-to-10 year* and *10-to-20 year* forward rates tallied
    - Logarithmic curve used for continuous fit

Or, use OSD or unique rates

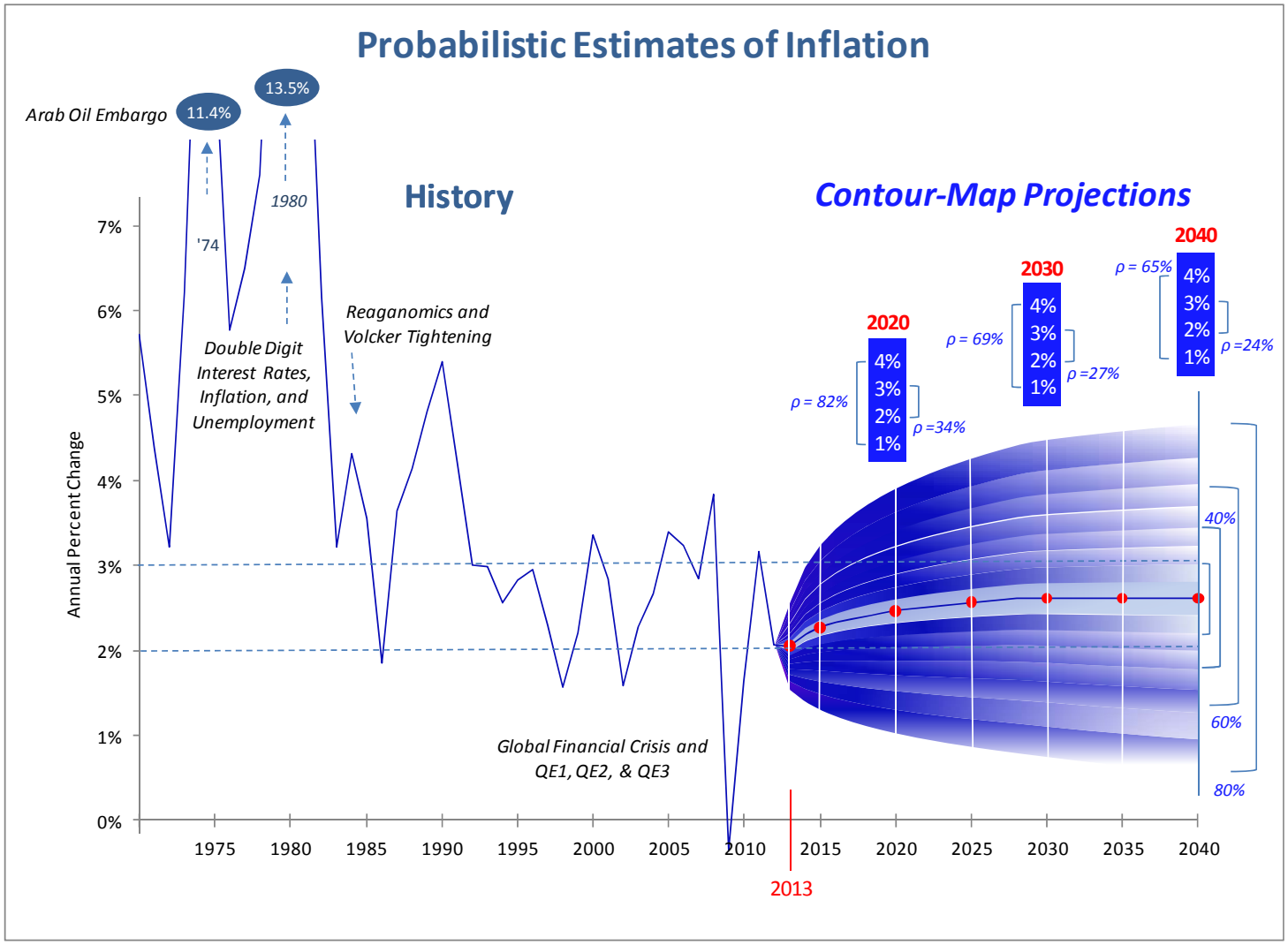
  - CV projections by year
    - Raw data
      - Survey of Professional Forecasters for years 1 and 2
      - Derivatives market for 25-year mark
    - Fit logarithmic curve
      - Accords with economic theory and empirical reality
        - » R2 = 0.9997
- eSBM
  - Focus on CVs
  - Use NCCA's S-Curve Tool to add CV
    - Based on study results and calculations of escalation dollars in MDAPs
    - Product of CV for inflation and percentage of escalation dollars equals *additional CV* for TY$ S-Curve

- Forward Inflation Rates
  - Professional forecasters' 5-year projection of *annual average inflation* covers the first five years of the 10-year horizon
    - 2.25% [5-year horizon]
    - 2.33% [10-year horizon]
  - Implied forecast over the second five years (x) computed from:

$$(1.0225)^5 \cdot (1 + x)^5 = (1.0233)^{10}$$

➔ x = 2.41%/year

Fan Chart



Specification for Monte Carlo Simulation: Raw inflation rate$_{year\ i} \sim N(\mu_i, \sigma_i^2)$

Escalation Percentages

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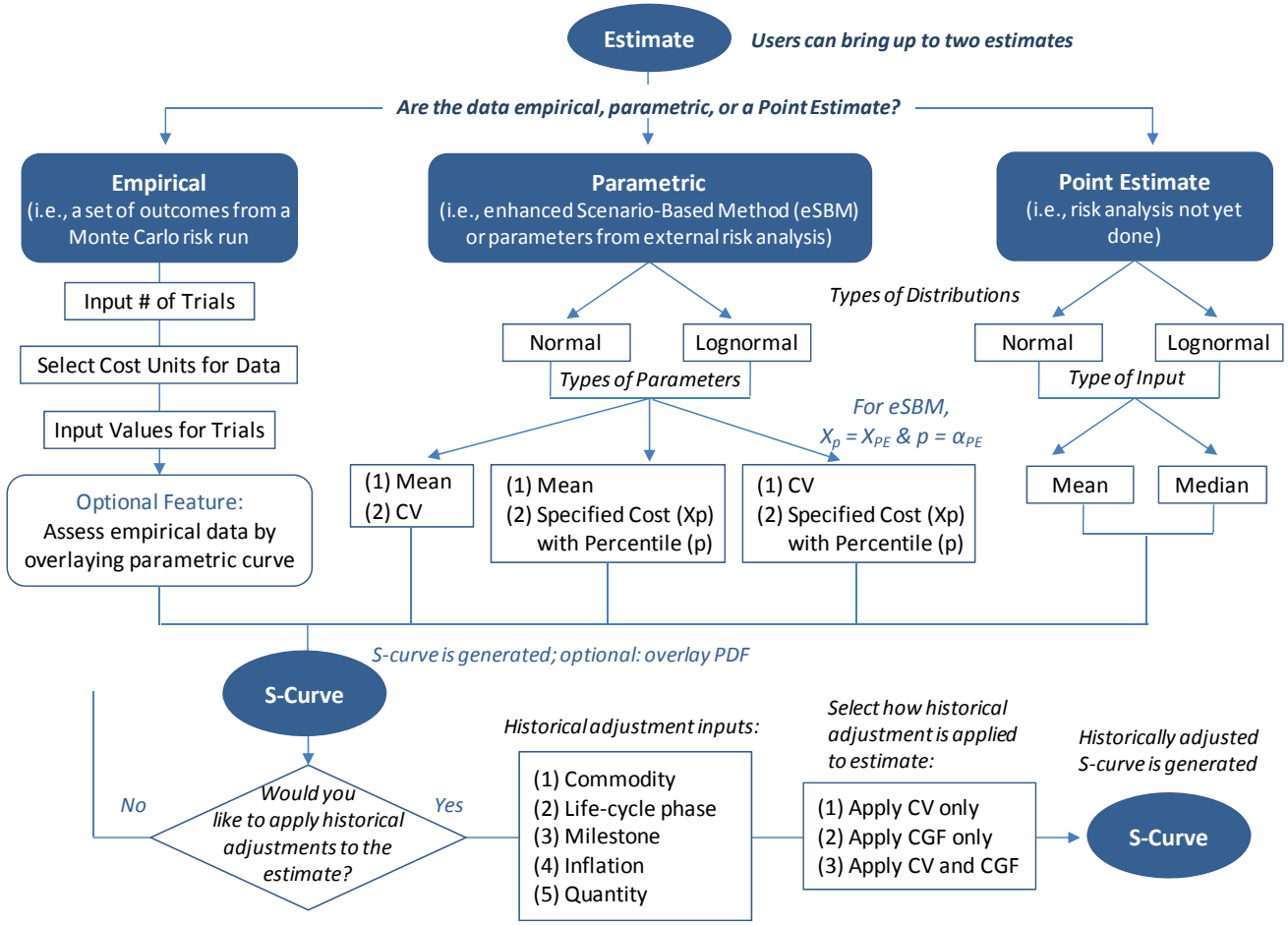
Escalation as a Percent of Total Then-Year Dollar Current Estimate

n = sample size

Milestone and Base Year	All DoD		DoD Level		Air Force		Army		Navy	
	Value	n	Value	n	Value	n	Value	n	Value	n
Milestone B										
1980 to 1984	42%	22	21%	1	35%	10	84%	4	30%	7
1985 to 1989	20%	24	21%	3	21%	5	22%	10	15%	6
1990 to 1994	17%	16	13%	3	34%	2	9%	7	26%	4
1995 to 1999	19%	18		0	19%	7	11%	6	28%	5
2000 to 2004	17%	35	10%	3	17%	8	17%	14	21%	10
2005 to 2009	13%	28	14%	1	4%	5	15%	8	15%	14
2010 to 2012	14%	11	17%	3	13%	3	11%	3	15%	2
Average: 2000-12	15%		14%		11%		14%		17%	
Milestone C										
1980 to 1984	26%	16		0	41%	4	24%	2	20%	10
1985 to 1989	20%	13	36%	1	26%	2	16%	2	18%	8
1990 to 1994	17%	17	17%	3	18%	4	14%	3	19%	7
1995 to 1999	13%	19	8%	1	11%	4	8%	7	19%	7
2000 to 2004	14%	25	8%	1	13%	6	13%	7	16%	11
2005 to 2009	10%	19		0	8%	6	10%	6	10%	7
2010 to 2012	10%	10	6%	1	11%	2	9%	5	11%	2
Average: 2000-12	11%		7%		11%		11%		12%	

NCCA S-Curve Tool



In eSBM, add percentage points of CV to TY$ estimate to cover inflation uncertainty

Milestones A: 64% CV x 0.15 = 10% *Milestone B: 57% CV x .15 = 9%*

Milestone C: 54% CV x 0.11 = 6% *FRP DR: 48% x .11 = 5%*

Conclusions

- Measurement of defense inflation
  - Challenging
  - BLS and BEA indices inappropriate
  - Use of OSD indices risky
  - Definitive indices yet to be developed
- Escalation a significant percentage of TY$ estimates
  - Currently, roughly 15% at Milestone B and 11% at C
  - Values have decreased over time, along with the CPI
- Mean of CVs ≠ CV of the means
  - Variance in point predictions fails to capture underlying probability
- Probabilistic estimates of inflation can and do change
  - CVs increase with volatility in the economy
- Point predictions of the inflation rate change with macroeconomic currents
  - Negative front-end yield curve during financial crisis
- "Breakeven" rates valuable measure of inflation
  - But, only after adjusting for risk and liquidity premia
- Cap and floor derivatives an invaluable measure of inflation uncertainty
  - Market based
  - Reflect views of those with "skin in the game"
  - Accord with economic theory
  - Available up to 30 years out
- Results can be implemented in either eSBM or Monte Carlo Simulation