Central Bank Policy Impacts on the Distribution of Future Interest Rates

Douglas T. Breeden and Robert H. Litzenberger***

Reference notes for talks at central banks and universities in Southeast Asia:
Hong Kong, Singapore, Cambodia, Thailand, Taiwan, Brunei, Malaysia.
September 2016

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***We thank Robert Merton and Robert Litterman for helpful comments and Song Xiao, Lu Liu, Xingchen Ling, Rebekah Ackerman, Yue Teng and their predecessors for research assistance.

I. Overview of the Presentation

1. Before and after analysis shows that the U.S. Federal Reserve, the European Central Bank and Bank of England's policies often have significant impacts on the distributions for future interest rates. Central bank research papers show central bank awareness.

2. Interest Rate Caps and Floors have been used for the last 30 years to hedge interest rate risks of financial institutions. They are portfolios of interest rate put and call options. We show how to use their prices to estimate the market's implied "insurance prices" for what LIBOR will be 3 to 5 years in the future. We also use options on the S&P 500 stock index to see market's pricing of economic risk. High risk aversion is evident in insurance prices vs. historical frequencies.

3. Empirically, interest rate insurance prices 2003-2016 have shifted from bell-shaped curves to positively skewed ones. Some key market prices show "bipolar" views on future rates that reflect either (1) normalization or (2) fears of recession or deflation.

4. Graphs show markets reactions to Brexit and calming after, and then worries about rate rises and normalization.

II. How to Find Interest Rate Insurance Prices From Option Prices:

*See Ross (1976), Quarterly Journal of Economics article "Options and Efficiency" and Breeden and Litzenberger (1978) Journal of Business article, "Prices of State-Contingent Claims Implicit in Option Prices." B-L's MIT working paper in 2013 (updated March 2016) on "Central Bank Policy Impacts on the Distribution of Future Interest Rates" gives the method for calculations in this talk. .

Breeden-Litzenberger Method (1978, 2013) used by Central Banks to find price distributions from option prices.

Probability distributions of future asset prices implied by option prices

By Bhupinder Bahra of the Bank's Monetary Instruments and Markets Division.

Introduction

Many monetary authorities routinely use the forward-looking information that is embedded in financial asset prices to help in formulating and implementing monetary policy. For example, they typically look at changes in the forward rate curve implied by government bond prices to assess changes in market perceptions of future short-term interest rates.[1] But, although implied forward rates are informative about the market's mean expectation for future interest rates, they tell us nothing about the range of expected outcomes around such estimates. For this, we can turn to options markets.

exercising it only if the price of the underlying asset lay above the strike price at that time.

Consider a set of European options on the same underlying asset, with the same time-to-maturity, but with different exercise prices. The prices of such options are related to the probabilities attached by the market to the possible values of the underlying security on the maturity date of the options. Intuitively, this can be seen by noting that the difference in the price of two options with adjacent exercise prices will reflect the value attached to the ability to exercise the options when the price of the underlying asset lies between the two exercise prices. This price difference in turn depends on the probability of the underlying asset price

1996 Bank of England Quarterly

The Breeden and Litzenberger approach

Breeden and Litzenberger (1978) derived a relationship linking the curvature of the call pricing function to the terminal RND function of the price of the underlying asset. In particular, they showed that the second partial derivative of the call pricing function with respect to the exercise price is directly proportional to the terminal RND function. Details about the derivation of the Breeden and Litzenberger result are given in Bahra (1996). The rest of this article focuses on how this result can be applied in order to estimate market RND functions for short-term interest rates in the future and how such RND functions can be used for policy analysis.

FEDERAL RESERVE BANK OF MINNEAPOLIS

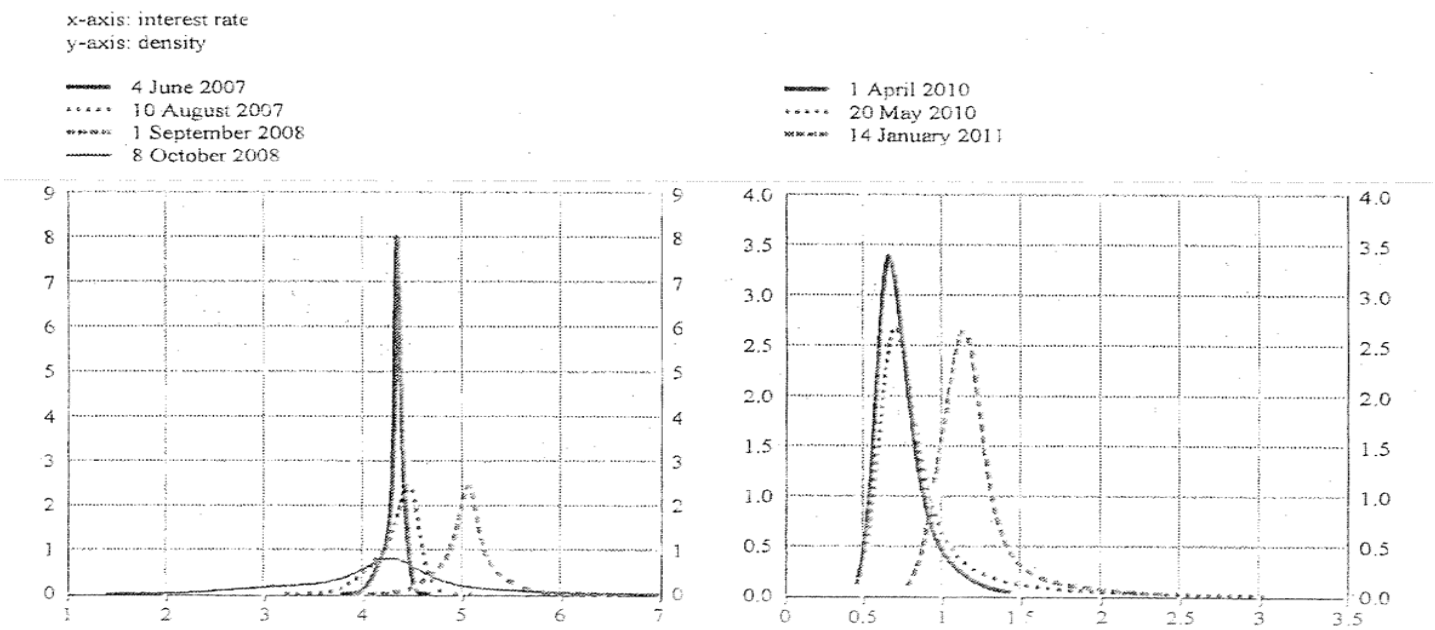
BANKING AND POLICY STUDIES

Methodology for Estimating Risk Neutral Probability Density Functions

We estimate risk neutral probability density functions (RNPDs) for a variety of different asset classes using a variation of the technique developed by Shimko (1993). This procedure involves fitting a curve to the implied volatilities of a series of options and expressing the volatility as a function of the strike price. The implied volatilities are then translated into continuous call option prices, and the risk neutral distribution of the underlying asset is obtained through the Breeden-Litzenberger (1978) method.

European Central Bank's Monthly Bulletin, February 2011, uses the Breeden-Litzenberger 1978 method to estimate
<u>interest rate distributions for what Euribor will be in 3 Months</u>:

THE INFORMATION CONTENT OF OPTION PRICES DURING THE FINANCIAL CRISIS



Sources: NYSE Liffe and ECB calculations.

Breeden-Litzenberger Method
Constructs Pure Bet Insurance Prices from Call Option Prices

Breeden-Litzenberger 1978, *Journal of Business*

Underlying Asset Price

Spreads Butterfly Spread

				Call Option Portfolios		
	Payoffs on Call Options			Port. A	Port. B	Port.C=A-B
P	C(X=2)	C(X=3)	C(X=4)	C(2)-C(3)	C(3)-C(4)	C(2)-2C(3)+C(4)
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	1	0	0	1	0	1
4	2	1	0	1	1	0
5	3	2	1	1	1	0
6	4	3	2	1	1	0
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
N	N-2	N-3	N-4	1	1	0

"Butterfly Spreads" of Options Give Pure Insurance Prices.

Breeden and Litzenberger (1978) derived Arrow's state prices for different levels of the stock market (relative to today's level) and different maturities, using the Black-Scholes option pricing formula, as given on the following slide.

Breeden and Litzenberger found prices of $1 payoffs for various stock market Increases and declines for periods up to 20 years out. (1978, J. Business)

B-L derived that the price of $1.00 received if underlying price ends between Y_1 and Y_2 and the Black-Scholes formula holds is: $\Delta(Y_1, Y_2, T) = B(T)\{N[d_2(X = Y_1)] - N[d_2(X = Y_2)]\}.$

TABLE 3 **Delta-Security Prices***

$\frac{Y_1}{M_0} - \frac{Y_2}{M_0}$	Time to Maturity									
	3 Mos.	6 Mos.	9 Mos.	1 Yr.	2 Yrs.	3 Yrs.	4 Yrs.	5 Yrs.	10 Yrs.	20 Yrs.
0–.1										.2¢
.1–.2									.3¢	.9
.2–.3							.1¢	.3¢	1.2	1.6
.3–.4					.1¢	.3¢	.7	1.2	2.5	1.9
.4–.5					.6	1.5	2.4	3.0	3.5	2.0
.5–.6			.2¢	.5¢	2.5	4.0	4.7	4.9	4.0	1.9
.6–.7		.6¢	1.7	3.0	6.1	6.8	6.7	6.4	4.2	1.8
.7–.8	1.2¢	5.0	7.6	9.0	9.9	9.0	8.0	7.1	4.2	1.7
.8–.9	13.1	16.6	16.5	15.7	12.4	10.1	8.5	7.3	4.0	1.6
.9–1.0	34.8	26.4	21.9	18.9	12.9	10.0	8.2	6.9	3.6	1.4
1.0–1.1	32.5	24.3	20.0	17.3	11.7	9.1	7.4	6.2	3.3	1.3
1.1–1.2	13.5	14.7	13.8	12.8	9.6	7.7	6.4	5.5	3.0	1.2
1.2–1.3	2.9	6.5	7.8	8.1	7.3	6.2	5.4	4.7	2.6	1.0
1.3–1.4	.4	2.2	3.7	4.6	5.3	4.9	4.4	3.9	2.3	.9
1.4–1.5		.6	1.5	2.3	3.7	3.7	3.5	3.2	2.0	.9
1.5–1.6				1.1	2.5	2.8	2.8	2.6	1.8	.8
1.6–1.7				.5	1.6	2.1	2.2	2.1	1.5	.7
1.7–1.8				.2	1.0	1.5	1.7	1.7	1.3	.6
1.8–1.9				.1	.6	1.1	1.3	1.4	1.2	.6
1.9–2.0					.4	.8	1.0	1.1	1.0	.5
2.0–2.1					.2	.5	.8	.9	.9	.5
2.1–2.2					.1	.4	.6	.7	.8	.4
2.2–2.3					.1	.3	.4	.6	.7	.4
2.3–2.4					.1	.2	.3	.5	.6	.4
2.4–2.5						.1	.3	.4	.5	.3
2.5–2.6						.1	.2	.3	.5	.3
2.6–2.7						.1	.1	.2	.4	.3
2.7–2.8							.1	.2	.4	.3
2.8–2.9							.1	.1	.3	.2
2.9–3.0							.1	.1	.3	.2
3.0–3.1							.1	.1	.2	.2
3.1–3.2								.1	.2	.2
3.2–3.3								.1	.2	.2
3.3–3.4									.2	.2
3.4–3.5									.1	.2
3.5–3.6									.1	.1
3.6–3.7									.1	.1
3.7–3.8									.1	.1
3.8–3.9									.1	.1
3.9–4.0									.1	.1
4.0–4.1									.1	.1

* Assumptions for all maturities are: $r = .06$, $\delta = .04$, $\sigma = .20$.

Journal of Business

State-contingent Claims in Option Prices

Notes for Nerds: Quite generally, B-L showed that 2nd derivatives of option pricing functions provide the pricing density that prices many derivative securities.

In general, any derivative asset with payoffs $f(\widetilde{P})$ can be priced by arbitrage from the prices of \$1 "elementary claims" on $\widetilde{P}$. An elementary claim on $\widetilde{P}$ has a payoff of \$1 contingent upon $\widetilde{P} = P_1, \widetilde{P} = P_2, \cdots \widetilde{P} = P_N$. With these, we can price all payoffs of the form $f(\widetilde{P})$.

The following construction shows that elementary claims can be created from call or put options:

With Continuous Underlying Asset Price, but Discrete Exercise prices:

Butterfly spread: $\dfrac{[c(x-\Delta)-c(x)]-[c(x)-c(x+\Delta)]}{\Delta} = \dfrac{[c(x-\Delta)-2c(x)+c(x+\Delta)]}{\Delta}$

Generally, $e(\widetilde{P}=x) = \dfrac{[c(x-\Delta)-c(x)]-[c(x)-c(x+\Delta)]}{\Delta}$

$\lim\limits_{\Delta\to 0}\dfrac{e(\widetilde{P}=x)}{\Delta} = c_{xx}(x=\widetilde{P}) =$ 2nd partial of call price w.r.t. exercise price, evaluated at $x=\widetilde{P}$.

Values of derivative assets:

$$PV(f(\widetilde{P})) = \int_{\widetilde{P}} c_{xx}(x=\widetilde{P})\cdot f(\widetilde{P})d\widetilde{P},$$

where $c(x,P)$ = price of European call option with exercise price x,

and c_{xx} is its second partial derivative with respect to x.

A similar formula holds with regard to European put formula, e.g.:

$$PV(f(\widetilde{P})) = \int_{\widetilde{P}} g_{xx}(x=P)\cdot f(P)dP.$$

These are pure arbitrage relations. Preferences and probabilities are reflected in c_{xx} and g_{xx}, but are not otherwise needed. Don't need homogeneous probability beliefs

Disadvantages of Many Prior Approaches

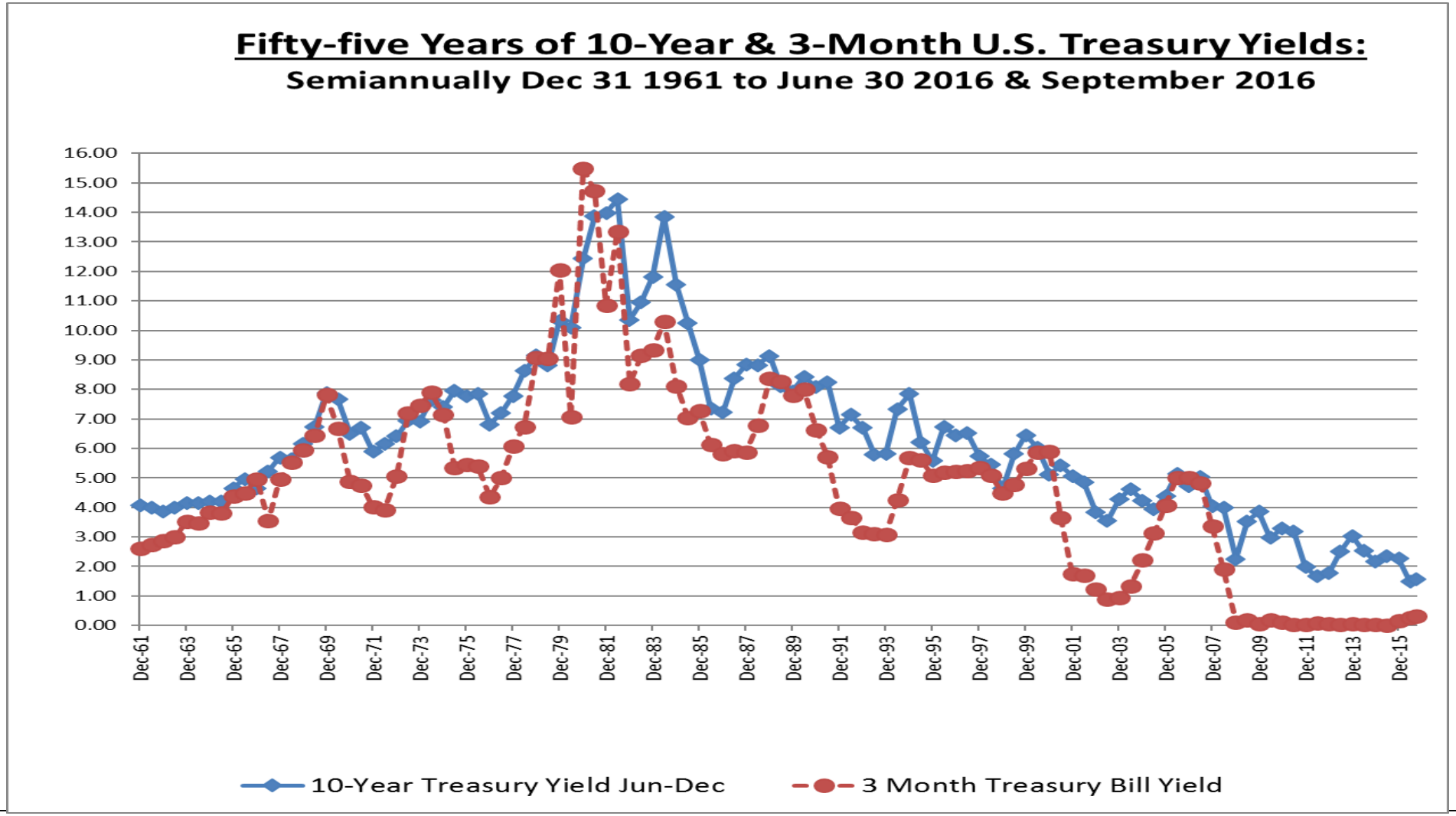
- 1. ***Short-term option prices used***.

Most options mature in 3 months to 18 months, as many markets only have active markets for those maturities. Often there are not options actively traded for a large number of standardized strike prices. We use interest rate caps and floors that have longer term maturities from 2 to 10 years.

- 2. ***Parametric vs. nonparametric approach.***

Applications often parameterize option prices with 3 or 4 parameters (mean, variance, skewness, kurtosis) and estimate implied volatility surfaces and entire risk-neutral densities. It is well-known among practitioners that these methods can be off significantly in estimating tail risks.

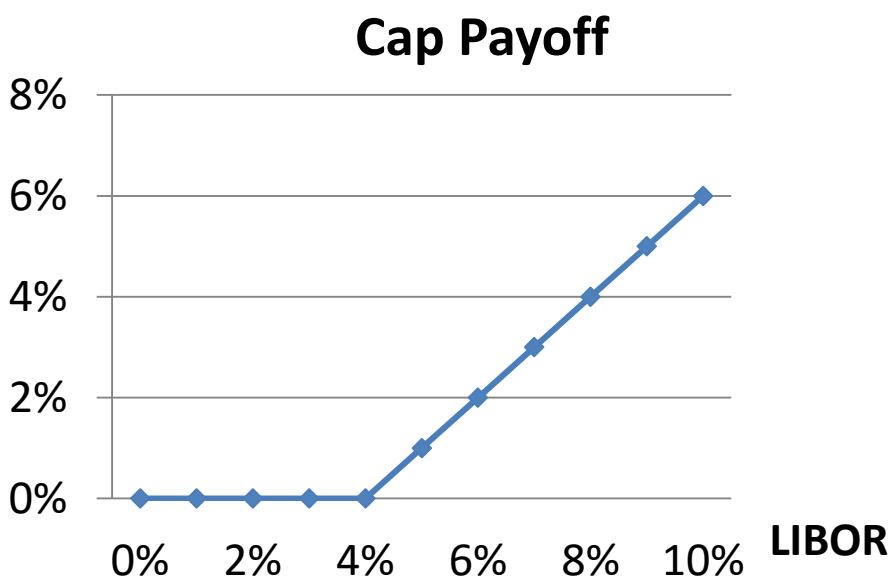
Interest Rate Caps and Floors are long-term interest rate protection agreements for hedging. Traded since interest rate surge in 1981-82.

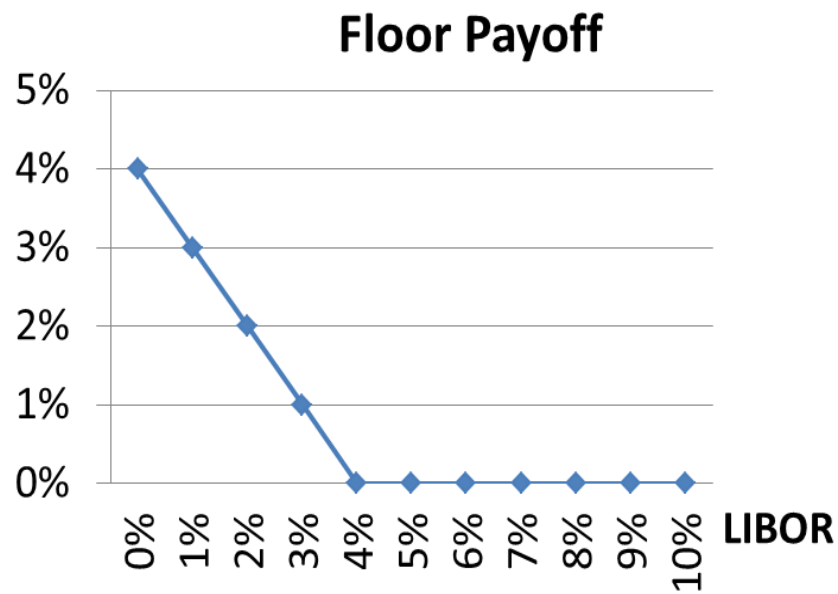


Payoffs on Interest Rate Caps and Floors

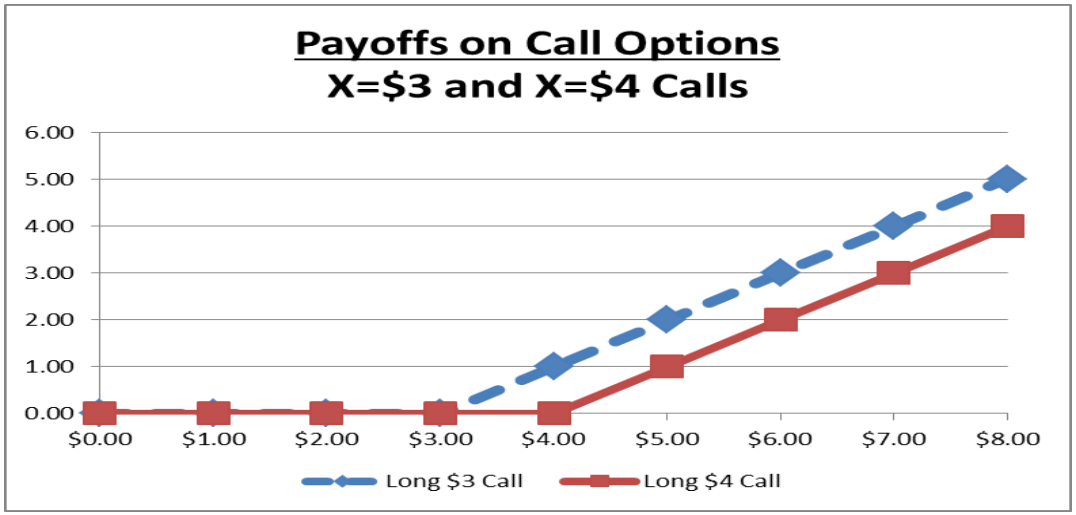
Purchaser of a 5-year **interest rate cap** on 3-month LIBOR, with a "strike rate" (exercise price) of 4% receives quarterly for 5 years the difference between then-current LIBOR and 4%. (0 if <4%).

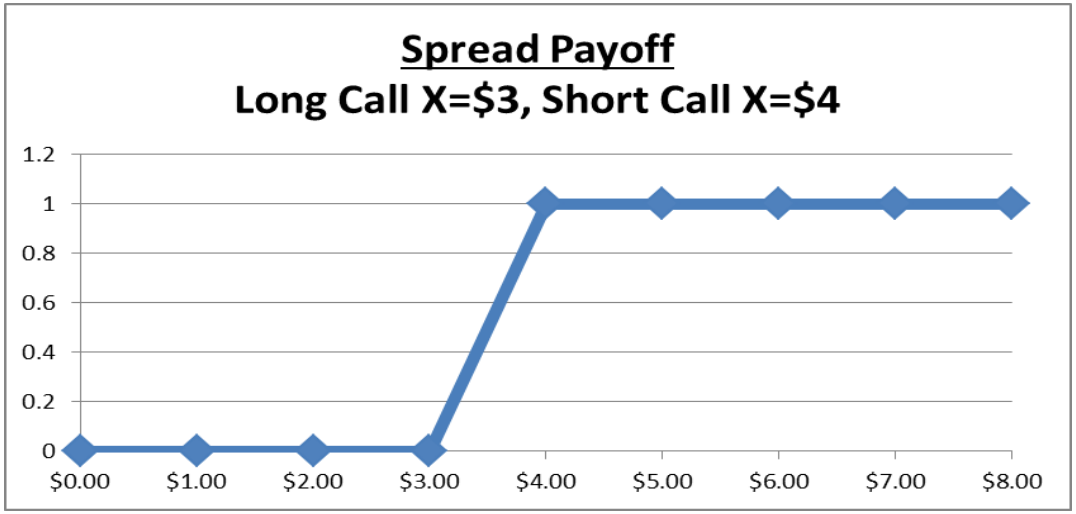
Caps hedge against higher interest rates. As rates increase, the cap's cash flows increase and pay increased funding costs. Caps win when rates increase, like portfolios of put options on bond prices.



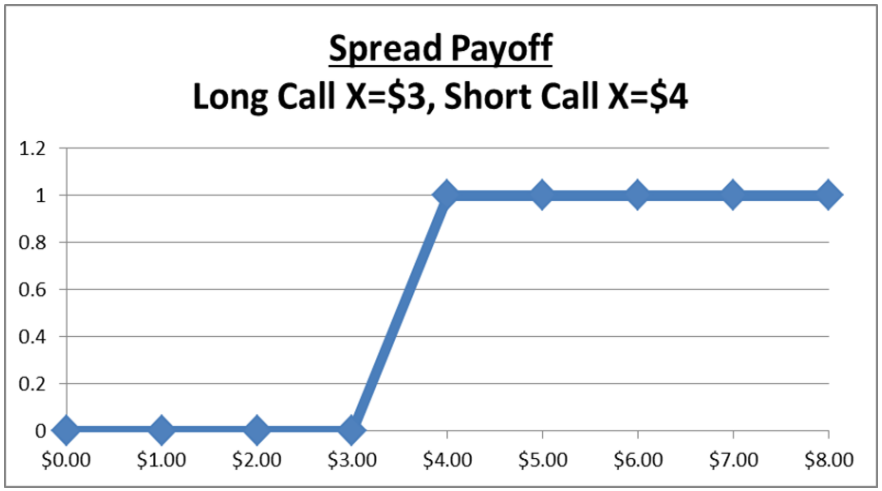


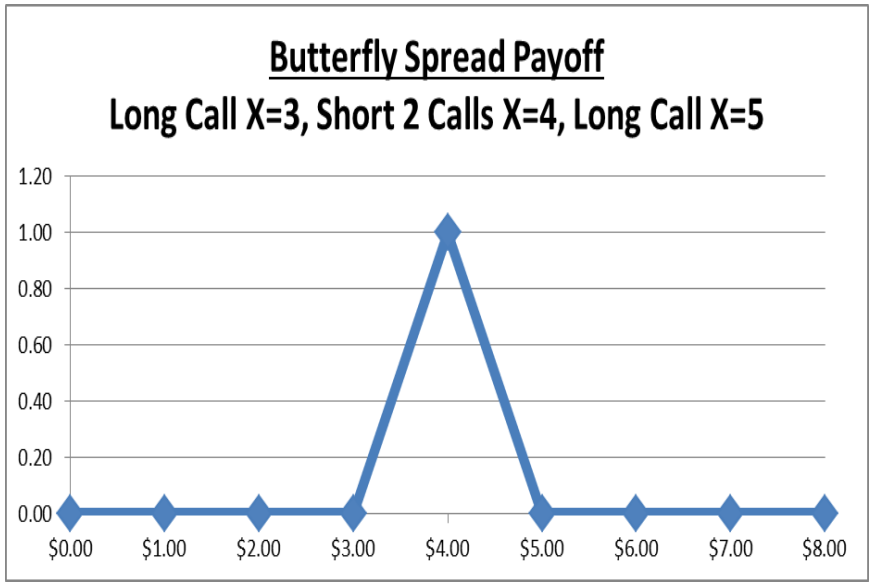
Option payoffs with continuous movements in the underlying asset prices…

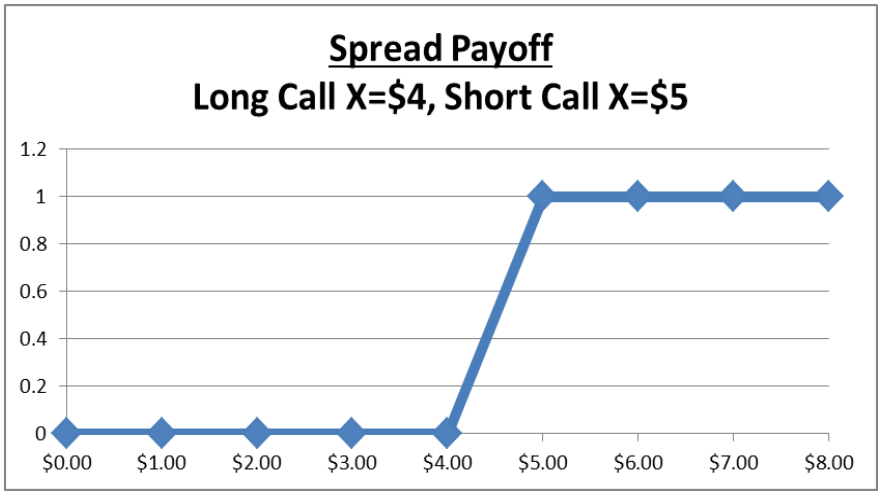




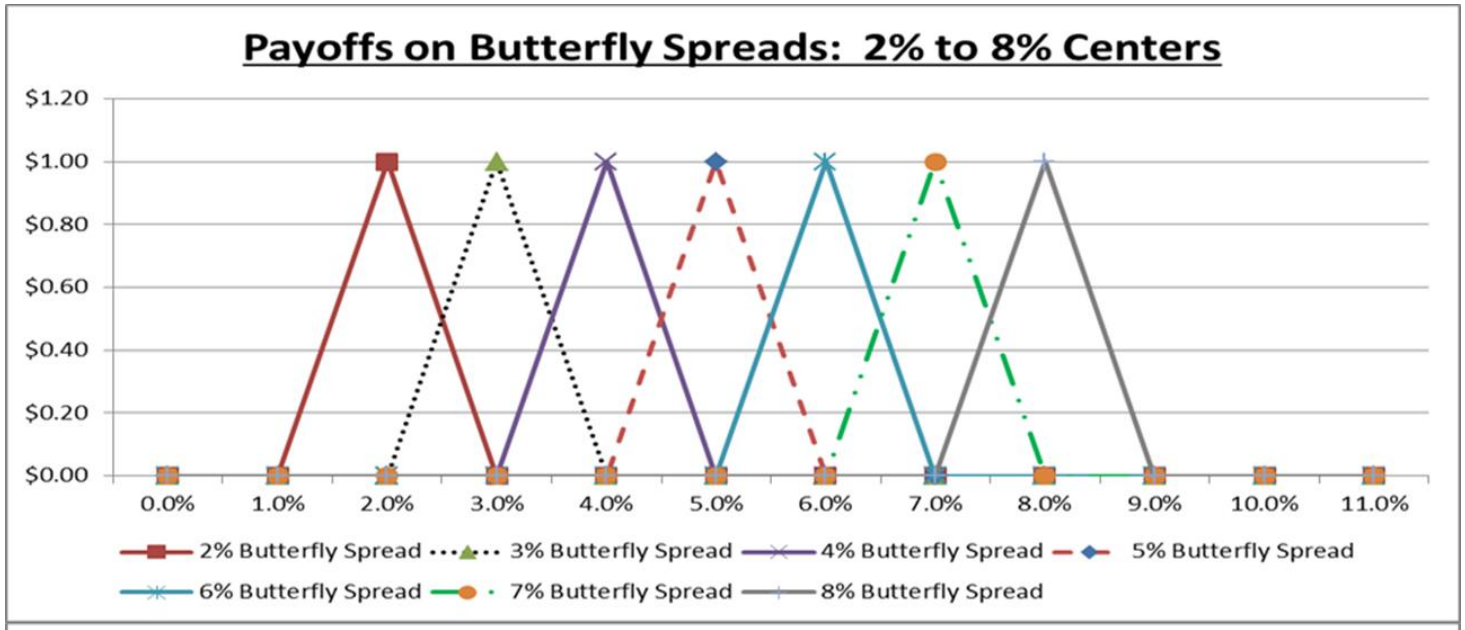
Butterfly spread of options is a spread of spreads: Payoffs are a pure bet on a specific range, zero elsewhere

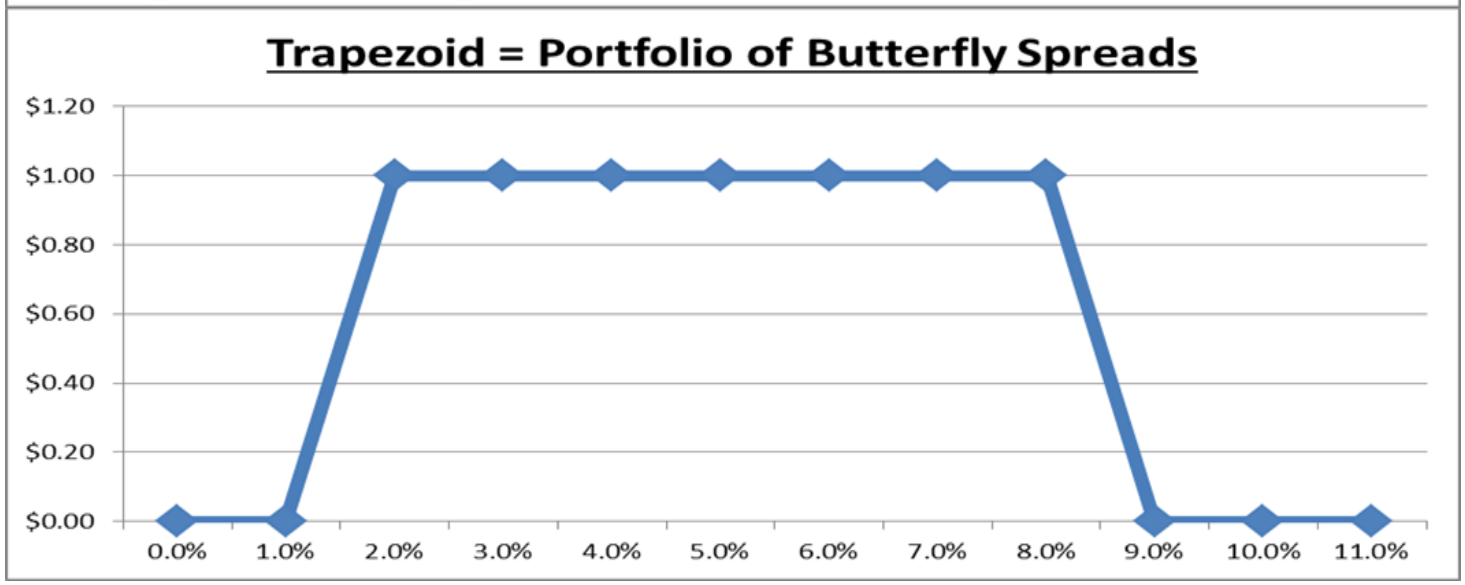


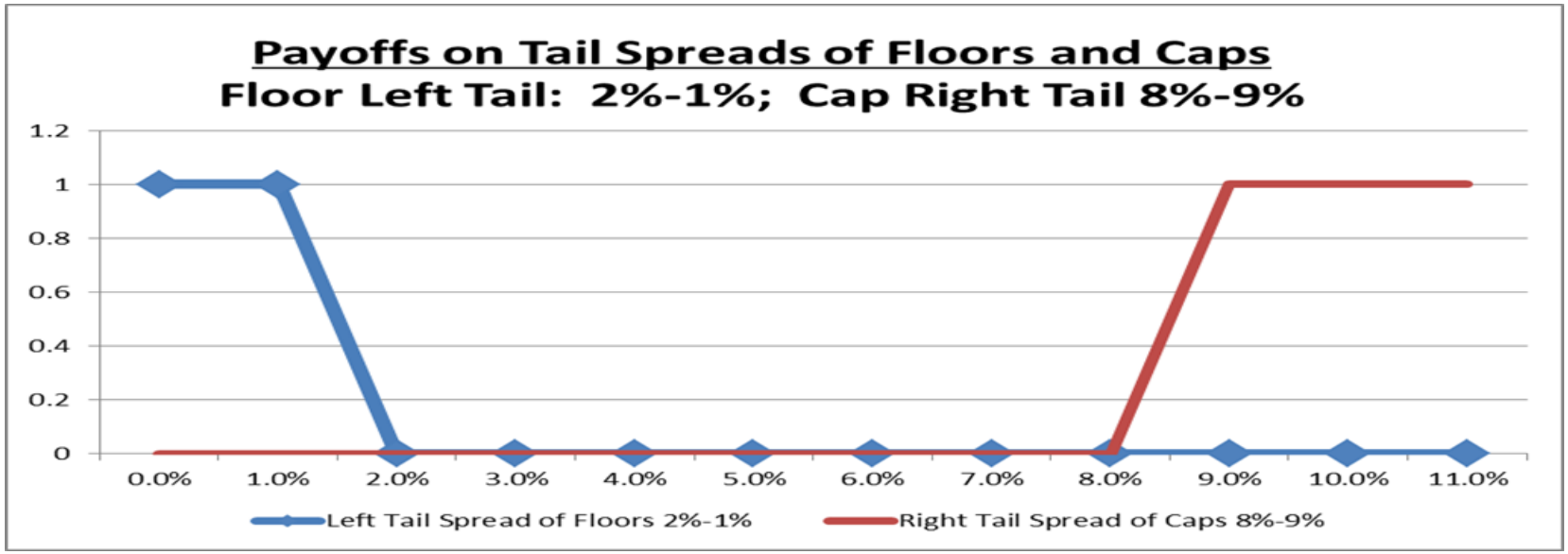


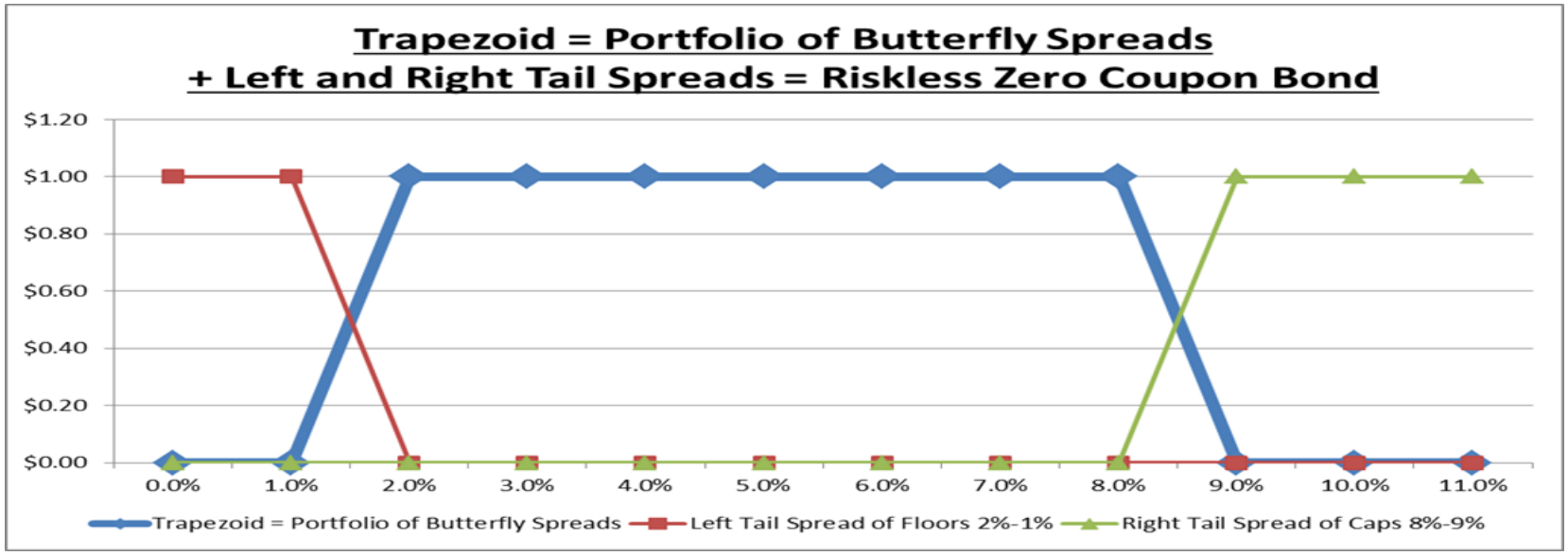


Butterfly spread with strikes of $3, $4, $5 pays off only if Underlying asset falls in that range.


Payoffs on Butterfly Spreads: 2% to 8% Centers
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
0.0%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
8.0%
9.0%
10.0%
11.0%
2% Butterfly Spread
3% Butterfly Spread
4% Butterfly Spread
5% Butterfly Spread
6% Butterfly Spread
7% Butterfly Spread
8% Butterfly Spread


Trapezoid = Portfolio of Butterfly Spreads
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
0.0%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
8.0%
9.0%
10.0%
11.0%


Payoffs on Tail Spreads of Floors and Caps
Floor Left Tail: 2%-1%; Cap Right Tail 8%-9%
1.2
1
0.8
0.6
0.4
0.2
0
0.0%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
8.0%
9.0%
10.0%
11.0%
Left Tail Spread of Floors 2%-1%
Right Tail Spread of Caps 8%-9%


Trapezoid = Portfolio of Butterfly Spreads
+ Left and Right Tail Spreads = Riskless Zero Coupon Bond
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
0.0%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
8.0%
9.0%
10.0%
11.0%
Trapezoid = Portfolio of Butterfly Spreads
Left Tail Spread of Floors 2%-1%
Right Tail Spread of Caps 8%-9%

Butterfly Spread and Tail Spread Costs and Risk Neutral Probabilites (Insurance Prices)

	Spread Cost	"Risk-Neutral Probability"
"0%" = Left tail spread: Long 1%, Short 0% floorlet	$0.290	0.297
1% Butterfly spread (Long 0%, Short 2 1%, Long 2%)	$0.320	0.328
2% Butterfly spread (Long 1%, Short 2 2%, Long 3%)	$0.180	0.184
3% Butterfly spread	$0.080	0.082
4% Butterfly spread	$0.037	0.038
5% Butterfly spread	$0.028	0.028
6% Butterfly spread	$0.014	0.014
7% Butterfly spread	$0.007	0.007
8% Butterfly spread	$0.007	0.007
9%+ = Right tail spread: Long 8%, Short 9% caplet	$0.015	0.015
Totals	$0.977	1.000

Notes for Nerds: Theorem: If Risk Neutral Density is Linear in the Rate Range, then Digital Option (Arrow) Value Equals Butterfly Cost

Proposition: The relationship between butterfly spread values and digital option values:

If the risk-neutral density (RND) is a linear function of the interest rate within the range of the butterfly strikes, then the value of a digital option that pays off $1.00 over the middle half of the range is equal to the value of the butterfly.

Proof: Let x be the interest rate, such that $x = c$ at the lower strike of the butterfly, $x = c+1$ at the mid-point strike of the butterfly, and $x = c+2$ at the high strike of the butterfly.

Assume that between c and c+2 the risk-neutral density = RND $= a + b(x-c)$

The forward value of a digital option that pays off $1.00 between $x = c+0.5$ and $x = c+1.5$ is:

$$\int_{c+0.5}^{c+1.5} [a + b(x-c)] \cdot 1 dx = a + b$$

The forward value of a butterfly is $\int_{c}^{c+1} \{[a+b(x-c)](x-c)\} dx + \int_{c+1}^{c+2} \{[a+b(x-c)](c+2-x)]\} dx$

$$= \frac{1}{3}bx^3 + \frac{1}{2}(a-2bc)x^2 + (bc^2 - ac)x \Big|_{c}^{c+1} - \frac{1}{3}bx^3 + (bc + b - \frac{1}{2}a)x^2 + (2a - 2bc - bc^2 + ac)x \Big|_{c+1}^{c+2} = a$$

Of course, since forward values are equal at the same date, present values are also equal.

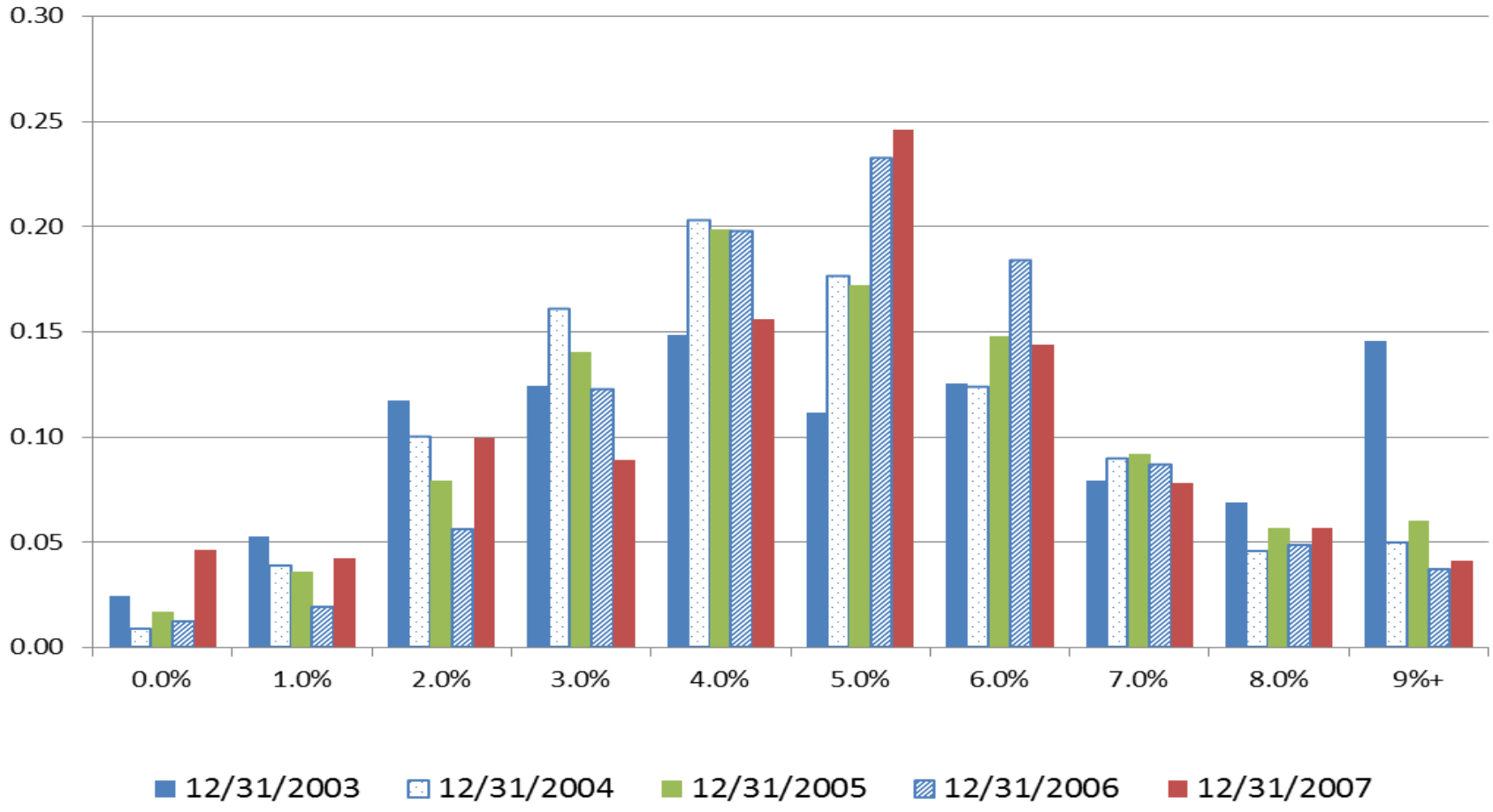
Q.E.D.

[1] Do note that there is a macro inconsistency in applying this approach with RNDs linear in rates where the {a,b} coefficients change from rate range to rate range, as would be realistic. With overlapping triangles, this would give an RND for the 4% to 5% range that is different for the 3/4/5 butterfly than for the 4/5/6 butterfly. Thus, this Proposition's result is just an approximation that is for useful intuition about butterflies and digital options.

III. Estimates of Interest Rate Insurance Prices Implicit in Prices of Interest Rate Caps and Floors 2003-2007.

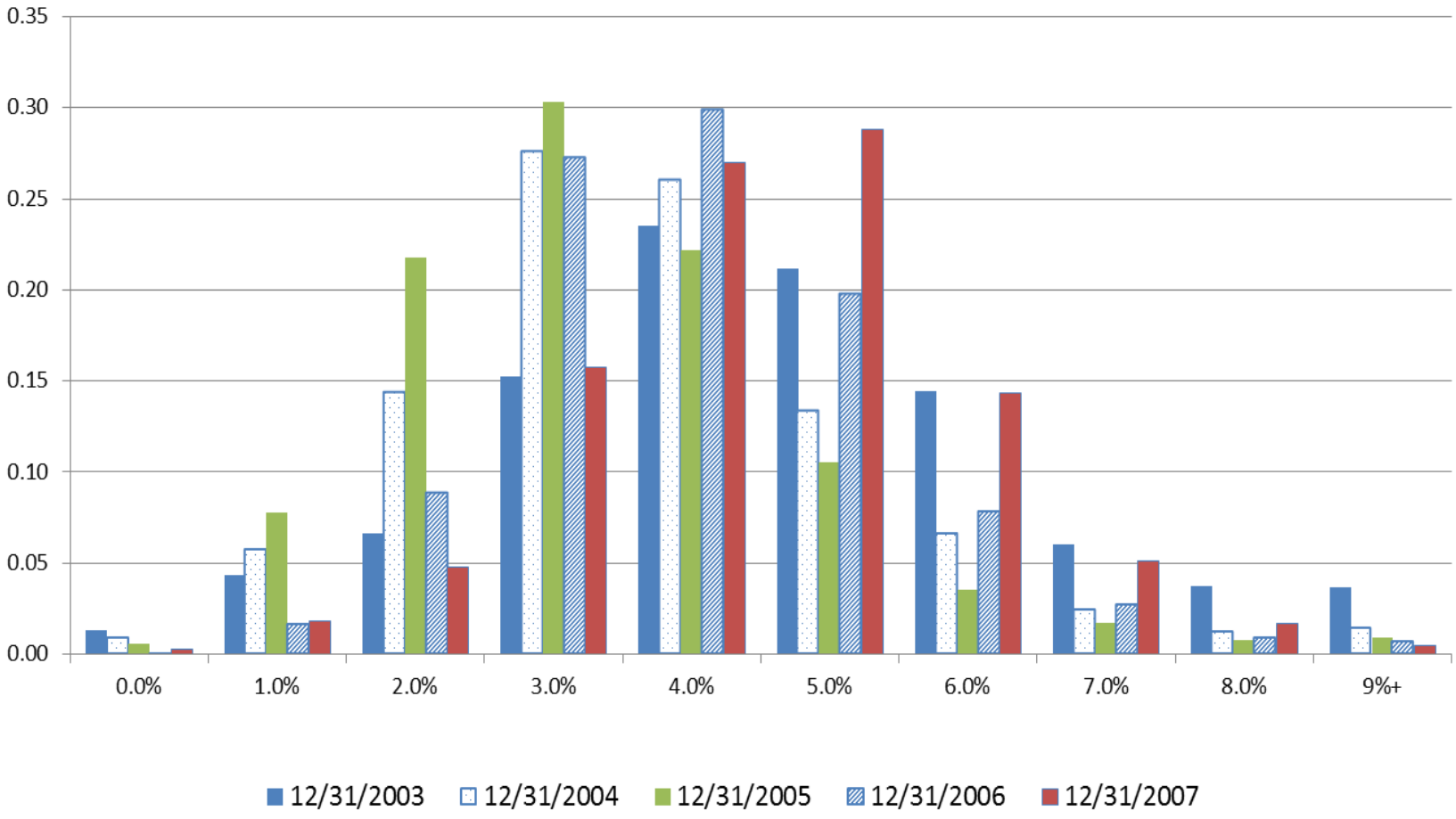
USA Insurance Prices for 3-Month LIBOR in 5 Years, as of December 31, 2003, 2004, 2005, 2006, 2007:

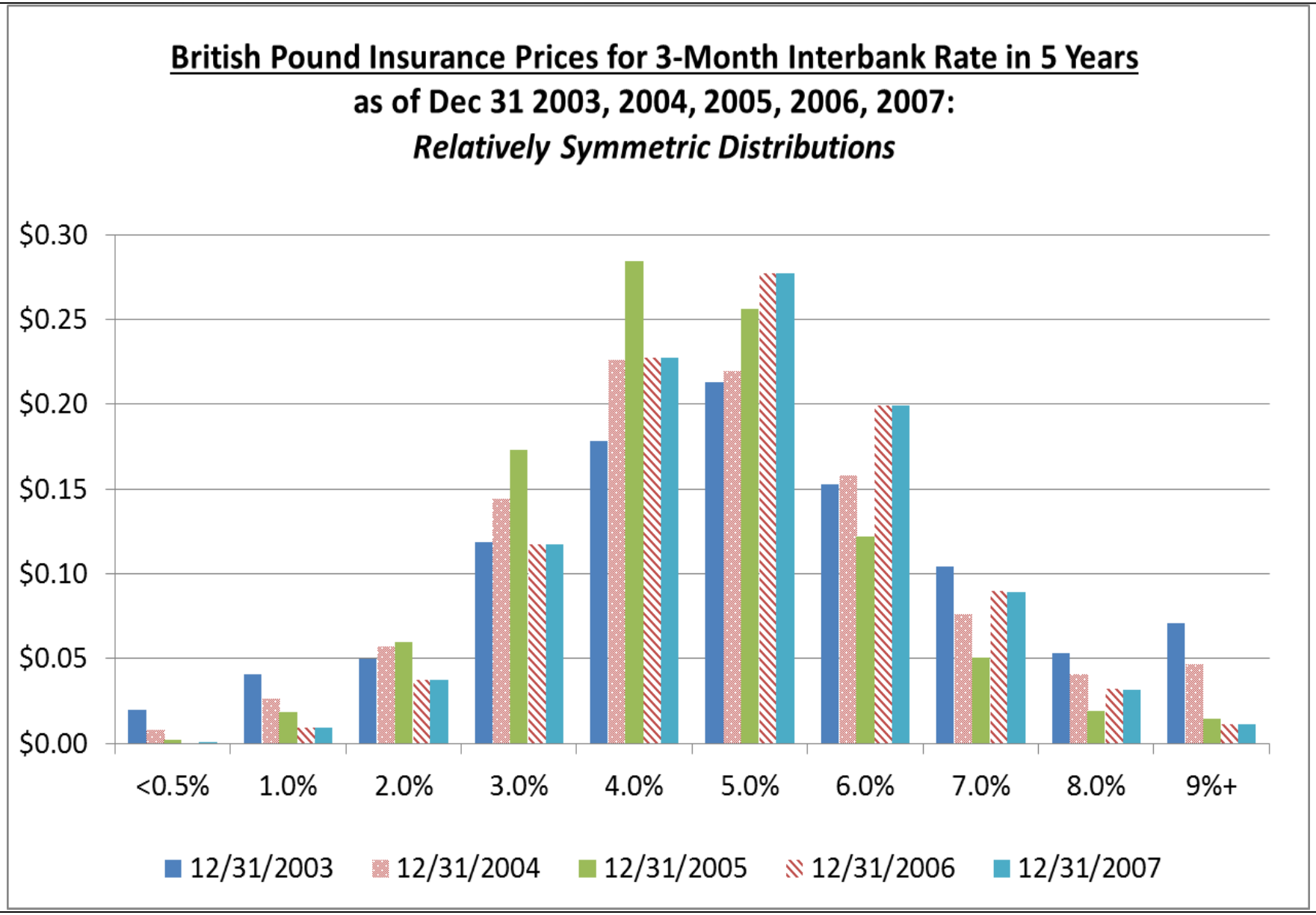
Relatively Symmetric Distributions



Euro Area Insurance Prices for 6-Month Euribor in 5 Years, as of December 31, 2003, 2004, 2005, 2006, 2007

Relatively Symmetric Distributions




British Pound Insurance Prices for 3-Month Interbank Rate in 5 Years
as of Dec 31 2003, 2004, 2005, 2006, 2007:
Relatively Symmetric Distributions
$0.30
$0.25
$0.20
$0.15
$0.10
$0.05
$0.00
<0.5%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
8.0%
9%+
12/31/2003
12/31/2004
12/31/2005
12/31/2006
12/31/2007

IV. True Probabilities vs. Insurance Prices or "Risk Neutral Probabilities"

Insurance prices or "risk neutral probabilities" differ from true, objective probabilities, because investors price assets higher for those that pay off most when times are bad (negative beta). Thus, their insurance prices (risk neutral probabilities) exceed their true probabilities.

States that correspond to good economies will have lower insurance prices, and their insurance prices will underestimate the true probabilities.

Notes for Nerds: In a general state preference model:

Inserting eq. 6 for the zero coupon bond gives:

$$\frac{\phi^*_{tr_j}}{\pi_{tr_j}} = \frac{E\left[\tilde{u}'_{ts} \middle| r_j\right]}{E[\tilde{u}'_t]} \tag{12}$$

Thus, we see that the risk-neutral probability to true probability ratio at the optimum for r_j is equal to the expected marginal utility of consumption, conditional upon the interest rate being at the specified level, divided by the unconditional expected marginal utility of consumption at time t. So if we are looking at butterfly spreads or digital options centered upon LIBOR = 2%, we need to compute the conditionally expected marginal utility of consumption, given that 2% rate.

If assume power utility (CRRA) and lognormally distributed consumption, we get a simple <u>formula for state price to probability ratios:</u>

$$\log\left(\frac{\phi^*_{ts}}{\pi_{ts}}\right) = \gamma\left[\mu_t - g_{ts} - \frac{1}{2}\gamma\sigma_c^2\right]t \tag{19}$$

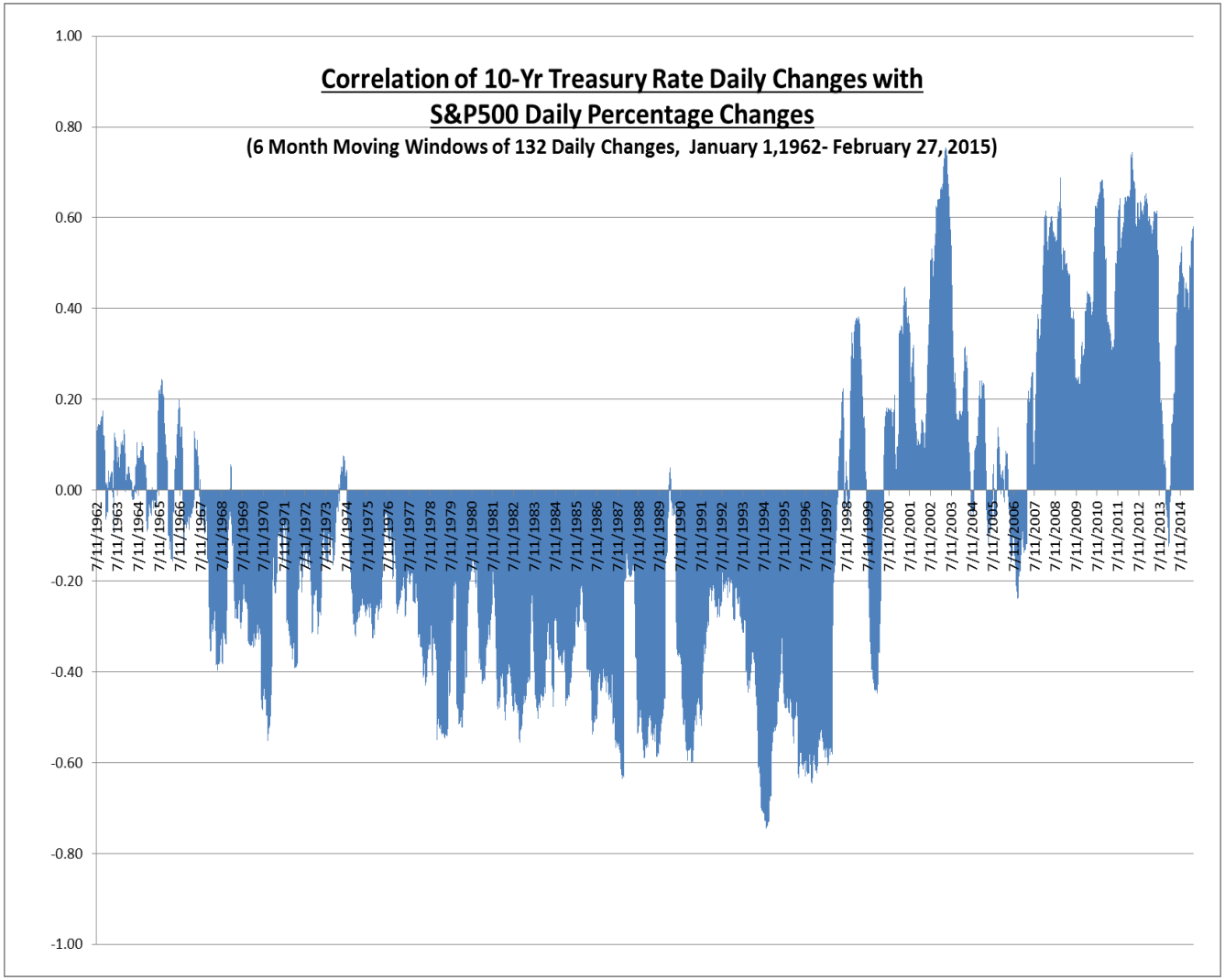
As expected, higher growth states for consumption have lower $\left(\frac{\phi^*_{ts}}{\pi_{ts}}\right)$ ratios. One could input different estimates of relative risk aversion and different states' growth rates and consumption volatility into the eq. 19 and compute the estimated log of the risk neutral probability to the true probability.

Illustration of State Prices vs. Probabilities and Cap and Floor Prices

				RND*			
3-MoLIBOR Rate (the "State")	Projected Real GDP Growth	True Probability of State	State Price	Normalized State Price	RiskNeut Probab/ TrueProb	3% Cap Payoffs	4% Floor Payoffs
1.0%	-2.3%	0.10	0.126	0.13	1.30	0	3
2.0%	-0.9%	0.12	0.140	0.15	1.25	0	2
3.0%	0.6%	0.15	0.165	0.17	1.13	0	1
4.0%	2.0%	0.20	0.194	0.20	1.00	1	0
5.0%	3.4%	0.15	0.126	0.13	0.87	2	0
6.0%	4.8%	0.12	0.097	0.10	0.83	3	0
7.0%	6.2%	0.10	0.078	0.08	0.80	4	0
8.0%	7.6%	0.06	0.039	0.04	0.67	5	0
Total =	2.3%	1.00	0.97	1.00	Value =	$1.24	$0.82

*RND = Risk Neutral Density

When rates are high, is marginal utility high or low? Depends on the time period.

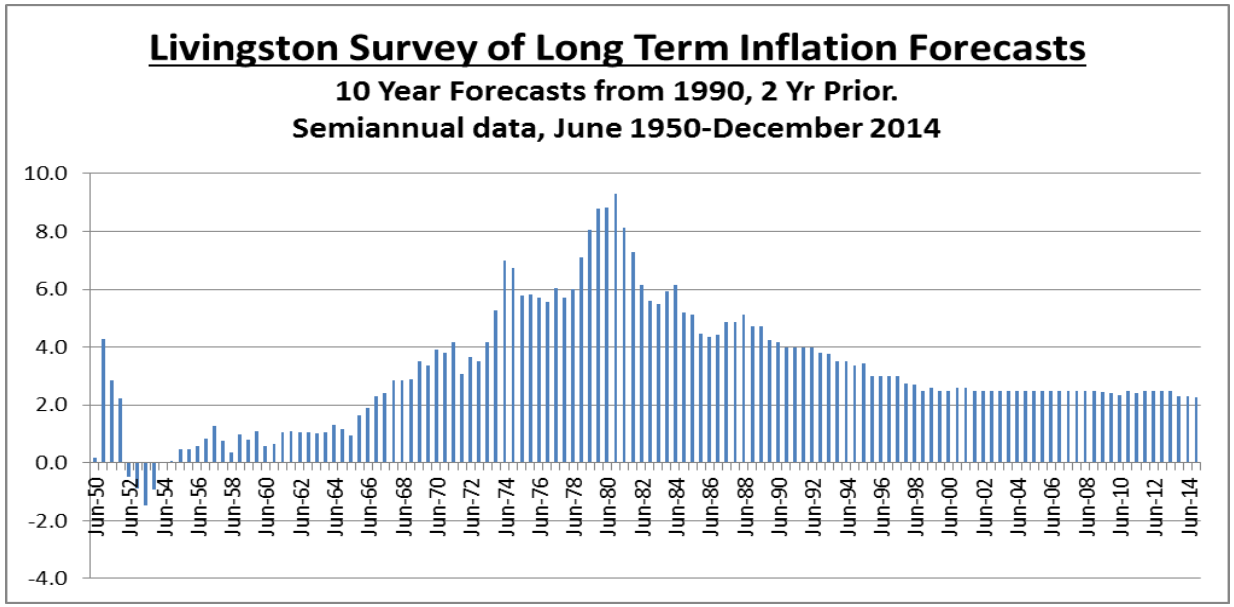


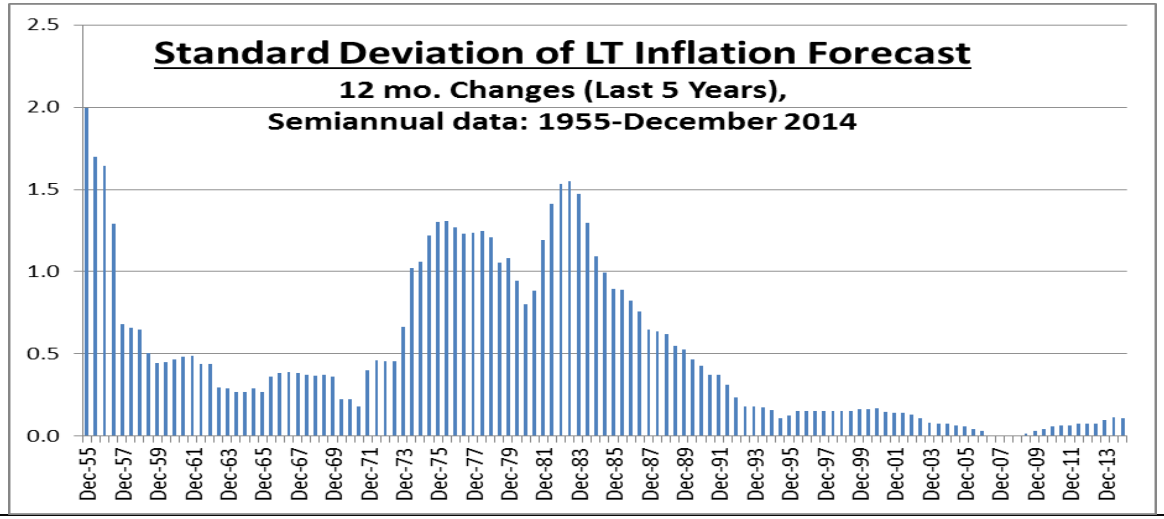
This graph shows the dramatic switch from negative to positive in 1999/2000 in the correlation between changes in the 10-year interest rate and moves in the S&P 500.

This switch in correlation reflects a shift from supply-oriented inflation concerns in the 1970s and 1980s to inflation concerns dominated more by demand issues.

The beta of long-term bond returns versus stock returns and the economy thus shifted from positive to negative. The fair risk premium on long-term bonds should have shifted from positive to negative, as long-term bonds became excellent hedges for risks of a bad economy.

What caused correlations of interest rates and stocks to change sign in 2000-2015?

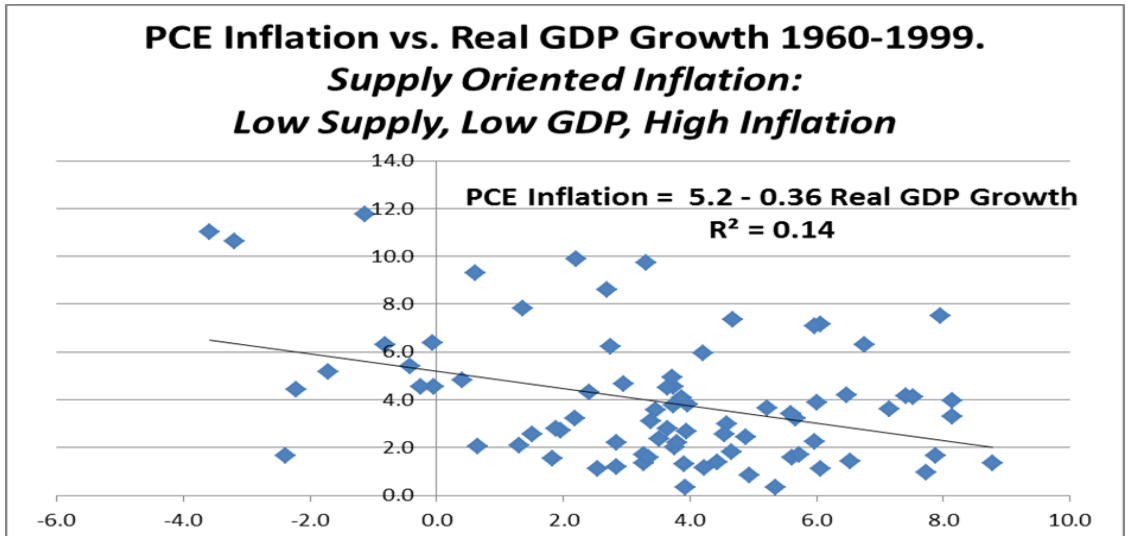




The Livingston/Philly Fed semiannual survey of inflation expectations shows the dramatically higher inflation rate in the 1970s and early 1980s, with notable surges in 1974/75 due to oil price and grain price shocks, as well as in 1981/82 when the second major round of OPEC oil price shocks occurred.

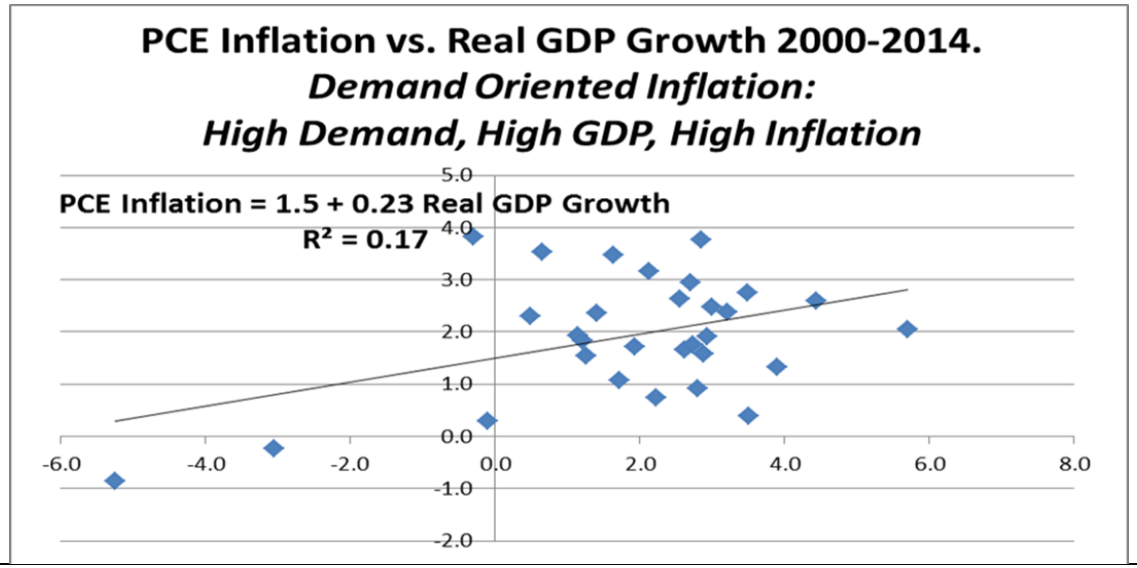
After the Volcker Fed in 1979-1981 let interest rates increase dramatically while focusing on controlling money supply growth, inflation was sharply reduced. Inflation expectations peaked in 1981 at 9% and dropped to less than 5% by the end of the 1980s. With continued monetary discipline, the 10-year inflation forecast dropped through the 1990s until it hit 2.5% in 1999/2000. The inflation rate forecast has remained anchored between 2.0% and 2.5% from 2000 to 2014, with very low volatility of the inflation forecast.

What caused correlations of interest rates and stocks to change sign in 2000-2015?



In the 40-year period from 1960 to 1999, higher real GDP growth occurred in conjunction with lower inflation, and recessions generally happened with high inflation, led by the big 1974/75 and 1981/82 recessions.

Constricted oil and grain supplies caused high inflation at times of these significant recessions. High inflation led to high interest rates, so the USA had high rates in recessions. Bond returns had positive stock correlations with supply risks: returns were negative when the economy was down, positive when the economy was strong.



In the 15-year period from 2000 to 2014, higher real GDP growth occurred in conjunction with higher inflation, and recessions generally happened with low inflation, led by the Great Recession of 2008/09.

Weak demand in the Great Recession led to very low interest rates. Supply uncertainties were dominated by demand uncertainties in this period.

Bond returns had negative stock correlations when demand risks dominated, as their returns were very positive (due to the very low rates) when the economy was down sharply in 2008/9.

Illustration of True Probabilities Related to Risk Neutral Probabilities

True probability = K*Risk Neutral x exp(Gamma*(gts - mu))

Assumes: CRRA-Lognormal real growth model

Real Growth on Nominal Rate: 1998 to 2011 Data

Intercept	-3.71	(t= -2.2)
Slope	1.42	(t= 3.8)
MuCgrow	3	

Nominal Rate	Real Growth	Relative Risk Aversion (Gamma) 2	4	8
		Ratio of True Probability to Risk Neutral*		
1	-2.29	0.90	0.81	0.65
2	-0.87	0.93	0.86	0.73
3	0.55	0.95	0.91	0.82
4	1.97	0.98	0.96	0.92
5	3.39	1.01	1.02	1.03
6	4.81	1.04	1.08	1.16
7	6.23	1.07	1.14	1.29
8	7.65	1.10	1.20	1.45
9	9.07	1.13	1.27	1.63
10	10.49	1.16	1.35	1.82

*=Up to a scalar multiple

Real Growth on Nominal Rate: 1977 to 1997 Data

Intercept	4.11	(t= 3.2)
Slope	-0.12	(t= -0.8)
MuCgrow	3	

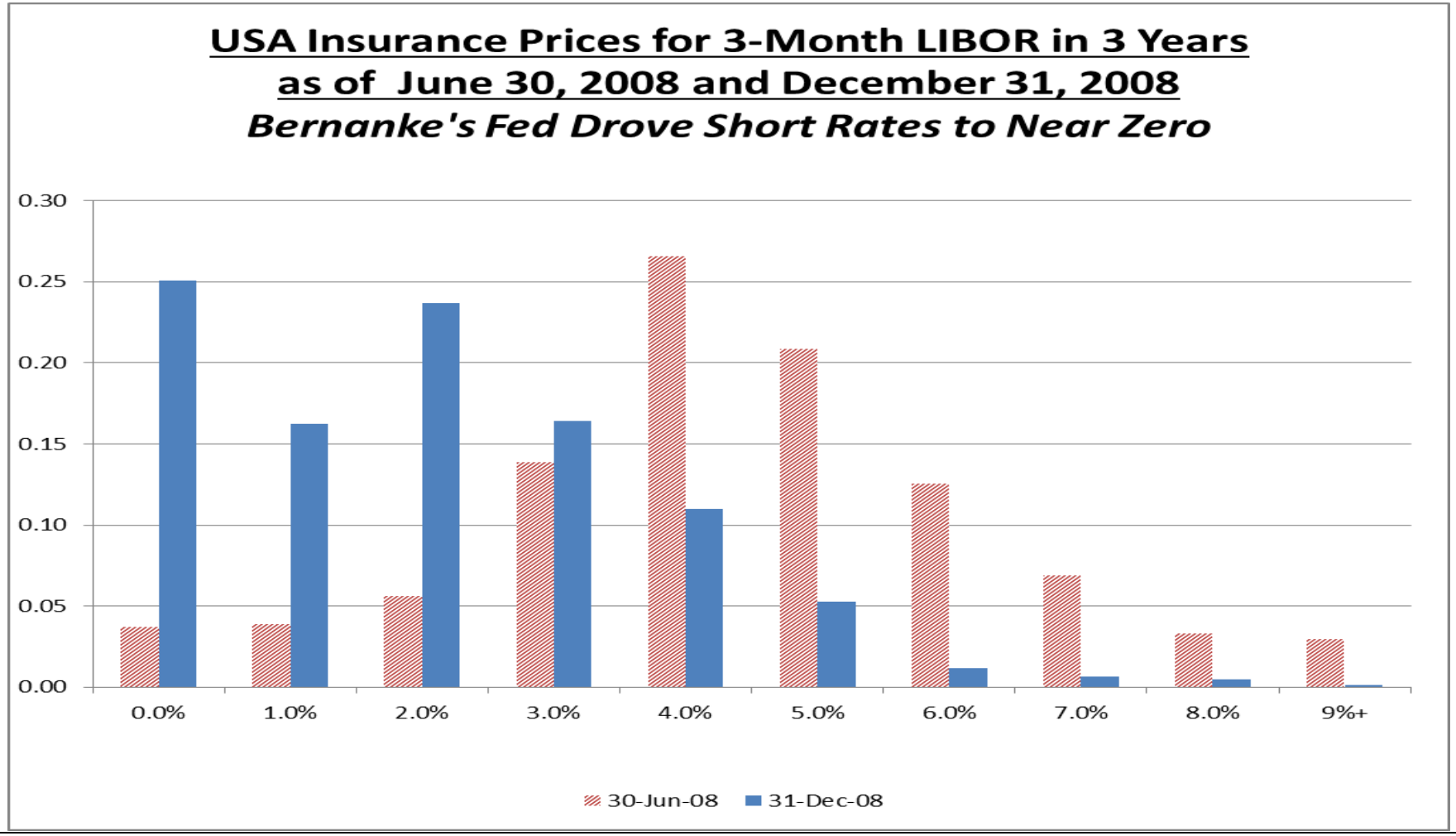
Nominal Rate	Real Growth	Relative Risk Aversion (Gamma) 2	4	8
		Ratio of True Probability to Risk Neutral*		
1	3.99	1.02	1.04	1.08
2	3.87	1.02	1.04	1.07
3	3.75	1.02	1.03	1.06
4	3.63	1.01	1.03	1.05
5	3.51	1.01	1.02	1.04
6	3.39	1.01	1.02	1.03
7	3.27	1.01	1.01	1.02
8	3.15	1.00	1.01	1.01
9	3.03	1.00	1.00	1.00
10	2.91	1.00	1.00	0.99
11	2.79	1.00	0.99	0.98
12	2.67	0.99	0.99	0.97
13	2.55	0.99	0.98	0.96
14	2.43	0.99	0.98	0.96
15	2.31	0.99	0.97	0.95
16	2.19	0.98	0.97	0.94

V. Impact of U.S. Federal Reserve Policy Announcements on Interest Rate Insurance Prices for 3-Month LIBOR: 2008-2016

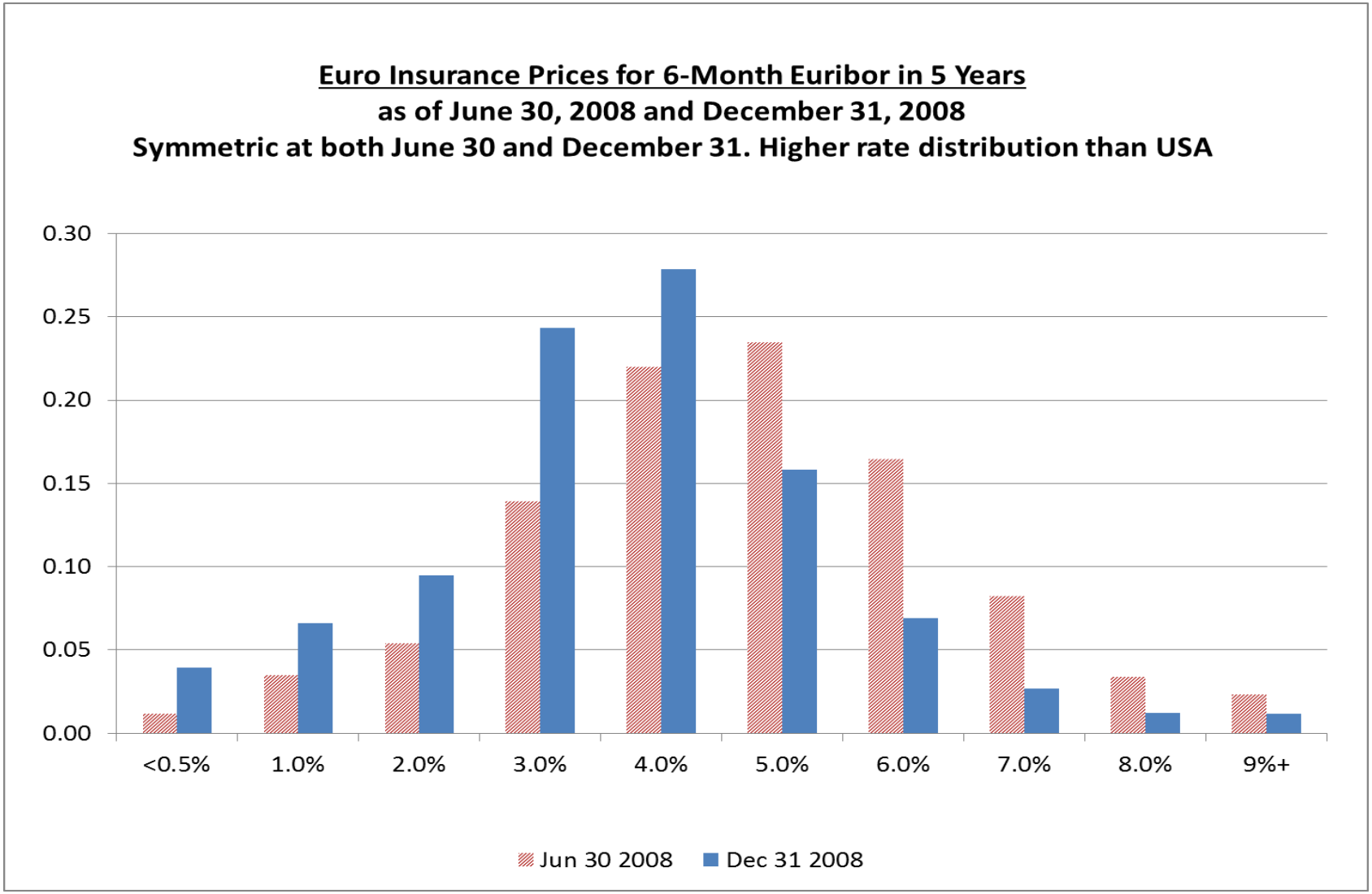
Major Federal Reserve Announcements 2008-2016

- **December 2008**. Cut rates to record lows in financial panic.
- **March 2009**: Will keep rates close to zero for "extended period." Stock market bottoms March 9th. Unemployment rate increases to peak of 10.0% in October 2009.
- **August 2011**: Budget impasse. Fed "will keep rates extremely low "at least until 2013."
- **September 2012**: Low "at least until 2015"
- **December 2012**: Will tie low rates to range in Unemployment (>6.5%), Inflation(<2%).
- **May/June 2013**: **May 22**: Given economic strength, Fed is seriously considering "tapering" asset purchases (QE3). **June 19:** Housing market is strong and supportive; tapering QE3 likely in 2nd half 2013.
- **Sept 18, 2013**: Fed announces "No tapering yet" and surprises markets.
- **Dec 18, 2013.** Bernanke Fed announces beginning of tapering, $10 billion/month.
- **March 19, 2014**. Yellen Fed indicates short rates may rise in 6 months after end of tapering, perhaps by mid-2015, earlier than markets expected.
- **April 30, 2014**. Job growth strong. Unemployment rate drops sharply: 6.7% to 6.3%.
- **October, 2014**. Unemployment at 5.9%. Yellen Fed ending asset purchases (QE).
- **March, 2015.** Unemployment at 5.5%, rapid job growth. Fed drops "patience" talk. "Dots" show that Fed members expect a slower ramping up of rates after liftoff.
- **December, 2015.** Fed "lifts off" and raises its policy rate 0.25%, first since the Great Recession.

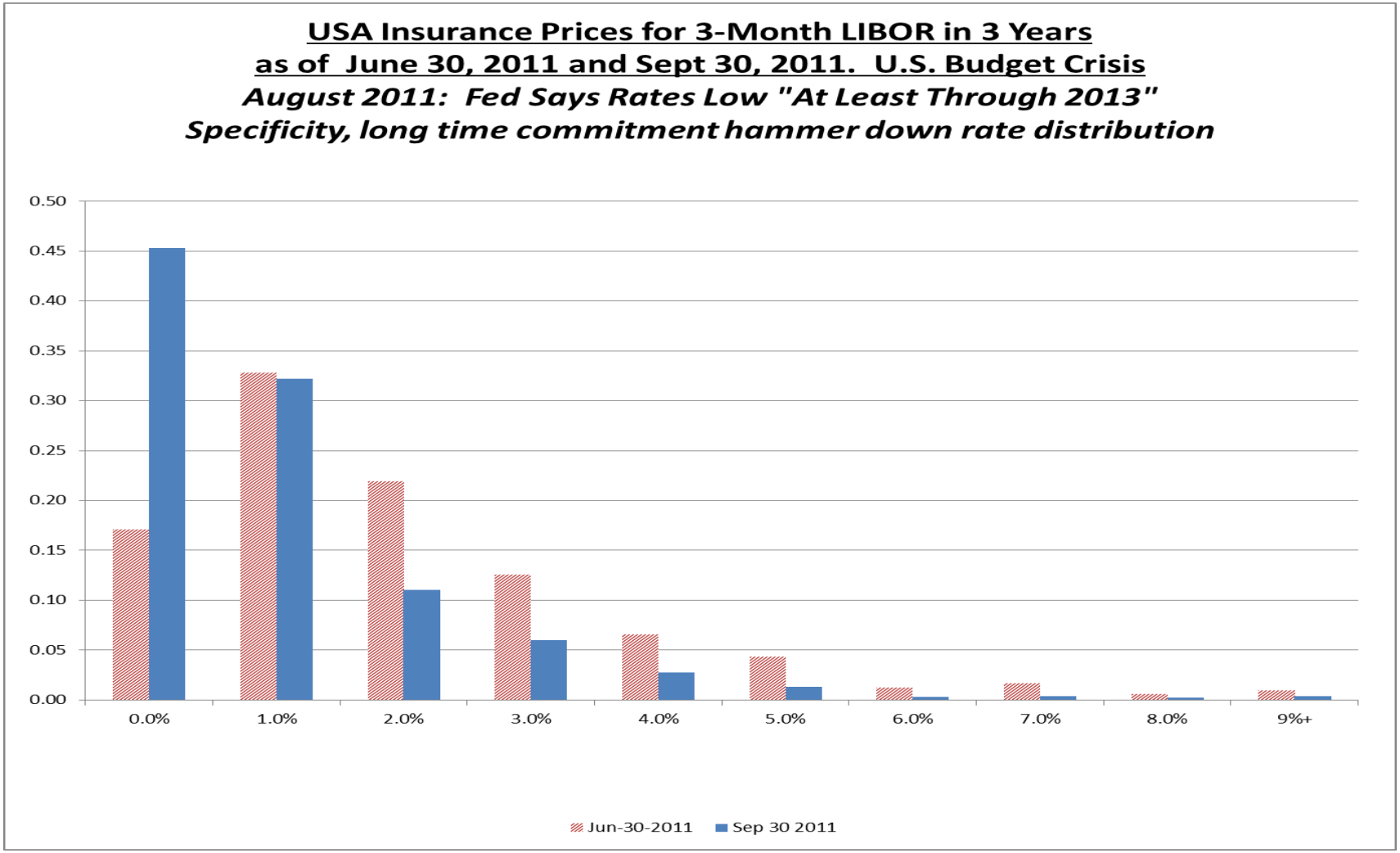
2008: U.S. Rate Distribution Transformed from Symmetric to Positive Skewness (Concentrated near zero, but long right tail)



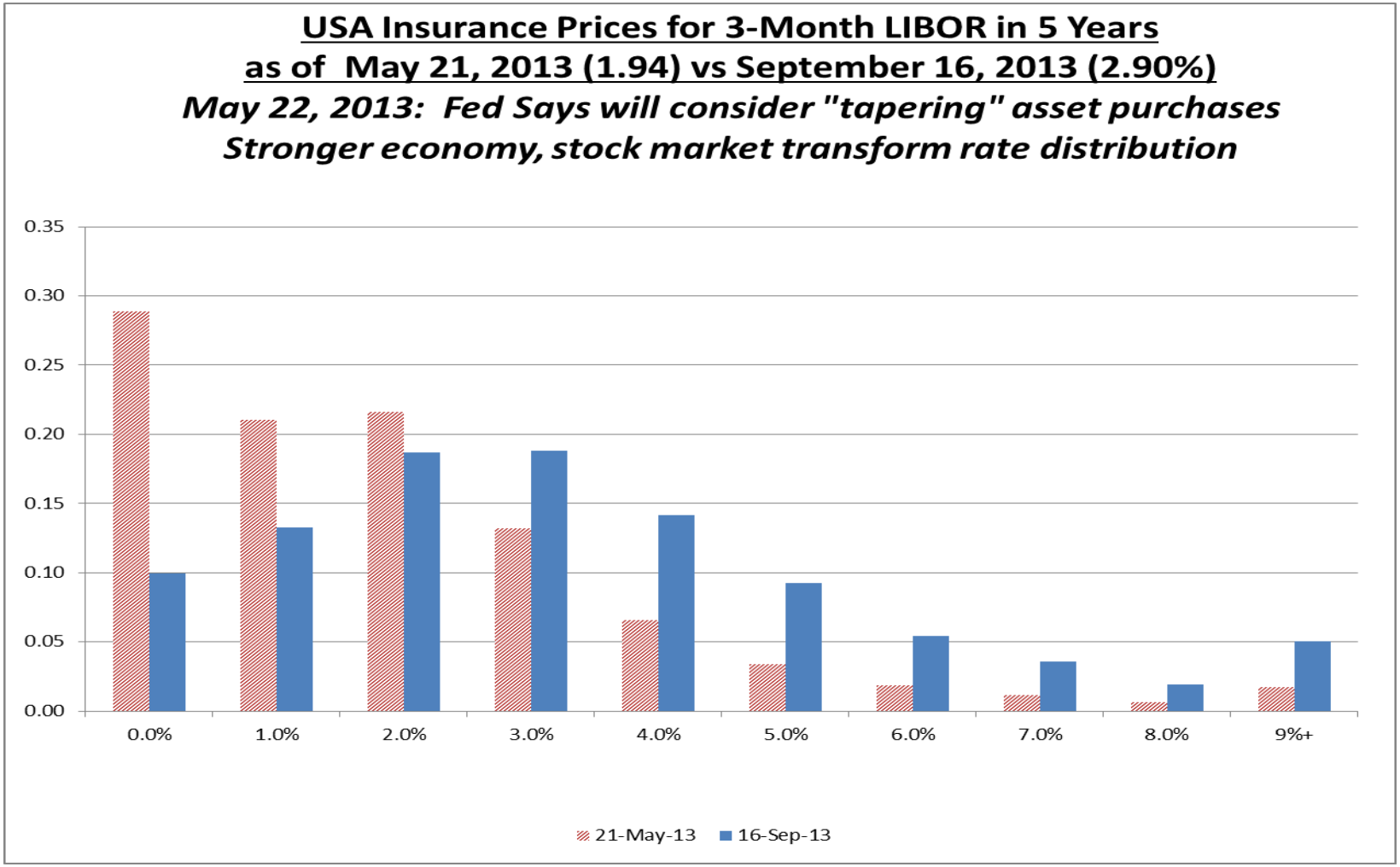
Dec 2008: Euro Area Rate Distribution Unaffected by USA problems

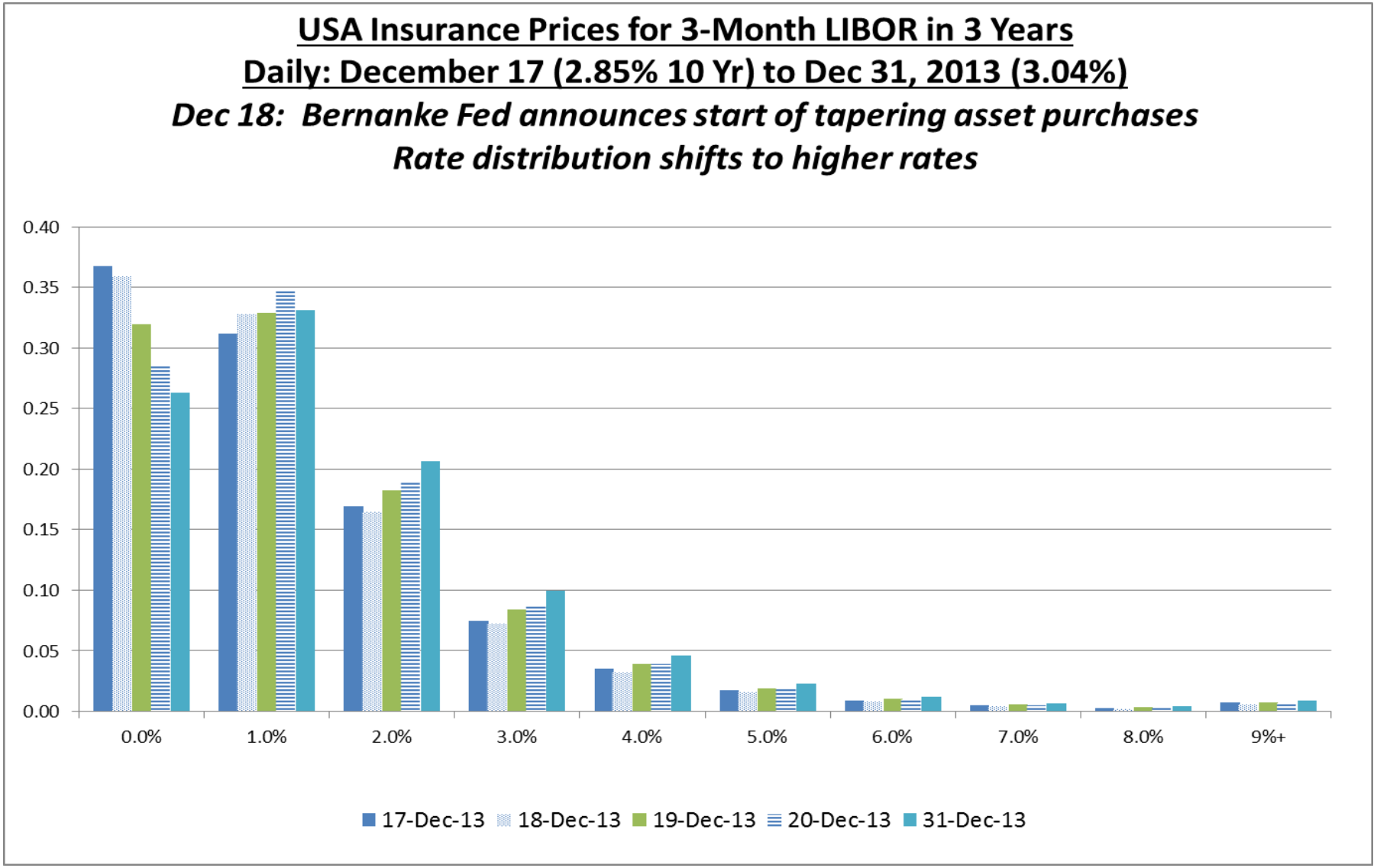


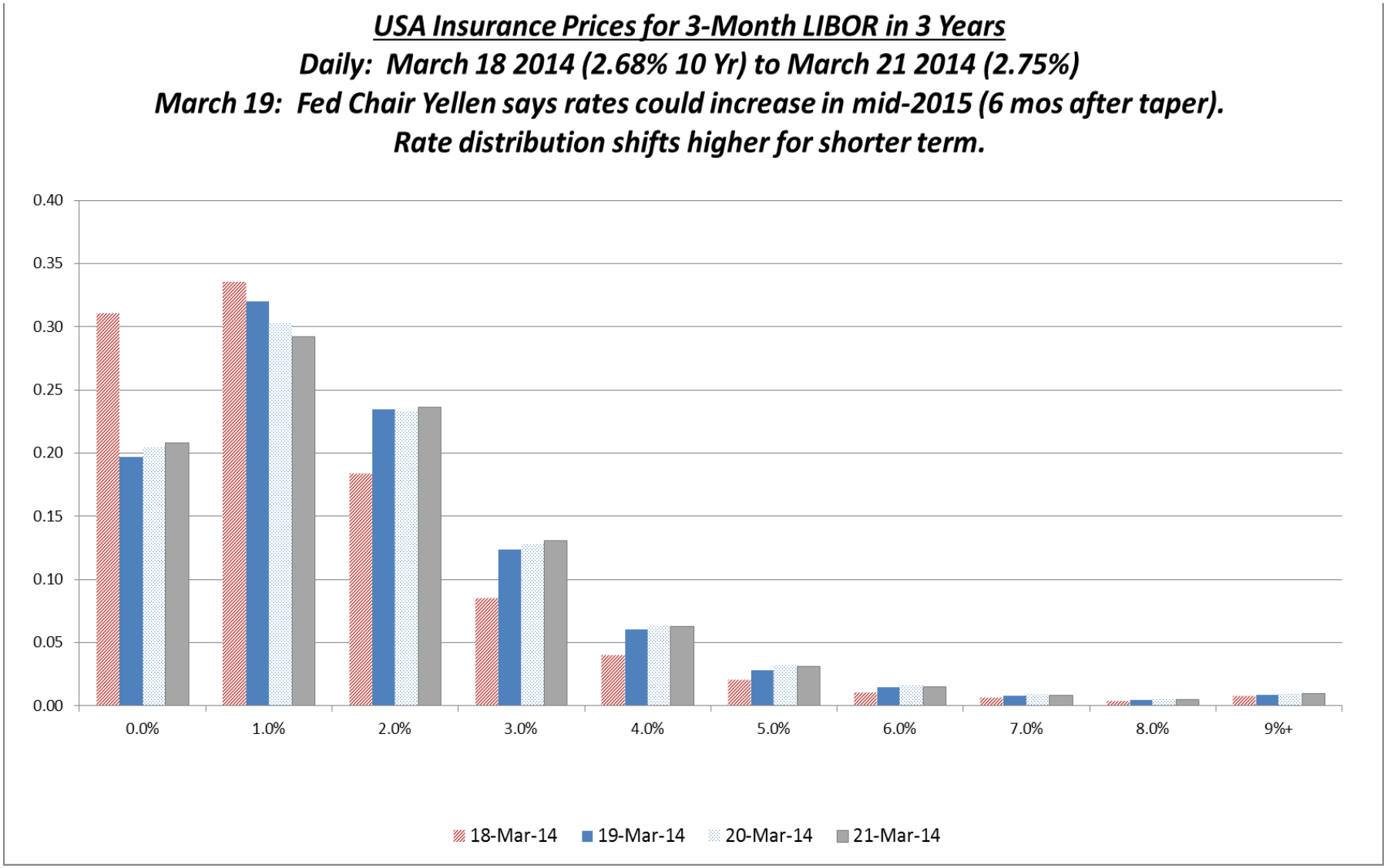
Panic during budget impasse causes Fed to commit low rates 2.5 years.



Summer 2013 Tapering Announcements: Stronger economy shifts distribution towards symmetry




USA Insurance Prices for 3-Month LIBOR in 3 Years
Daily: December 17 (2.85% 10 Yr) to Dec 31, 2013 (3.04%)
Dec 18: Bernanke Fed announces start of tapering asset purchases
Rate distribution shifts to higher rates
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.0%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
8.0%
9%+
17-Dec-13
18-Dec-13
19-Dec-13
20-Dec-13
31-Dec-13


USA Insurance Prices for 3-Month LIBOR in 3 Years
Daily: March 18 2014 (2.68% 10 Yr) to March 21 2014 (2.75%)
March 19: Fed Chair Yellen says rates could increase in mid-2015 (6 mos after taper).
Rate distribution shifts higher for shorter term.
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.0%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
8.0%
9%+
18-Mar-14
19-Mar-14
20-Mar-14
21-Mar-14

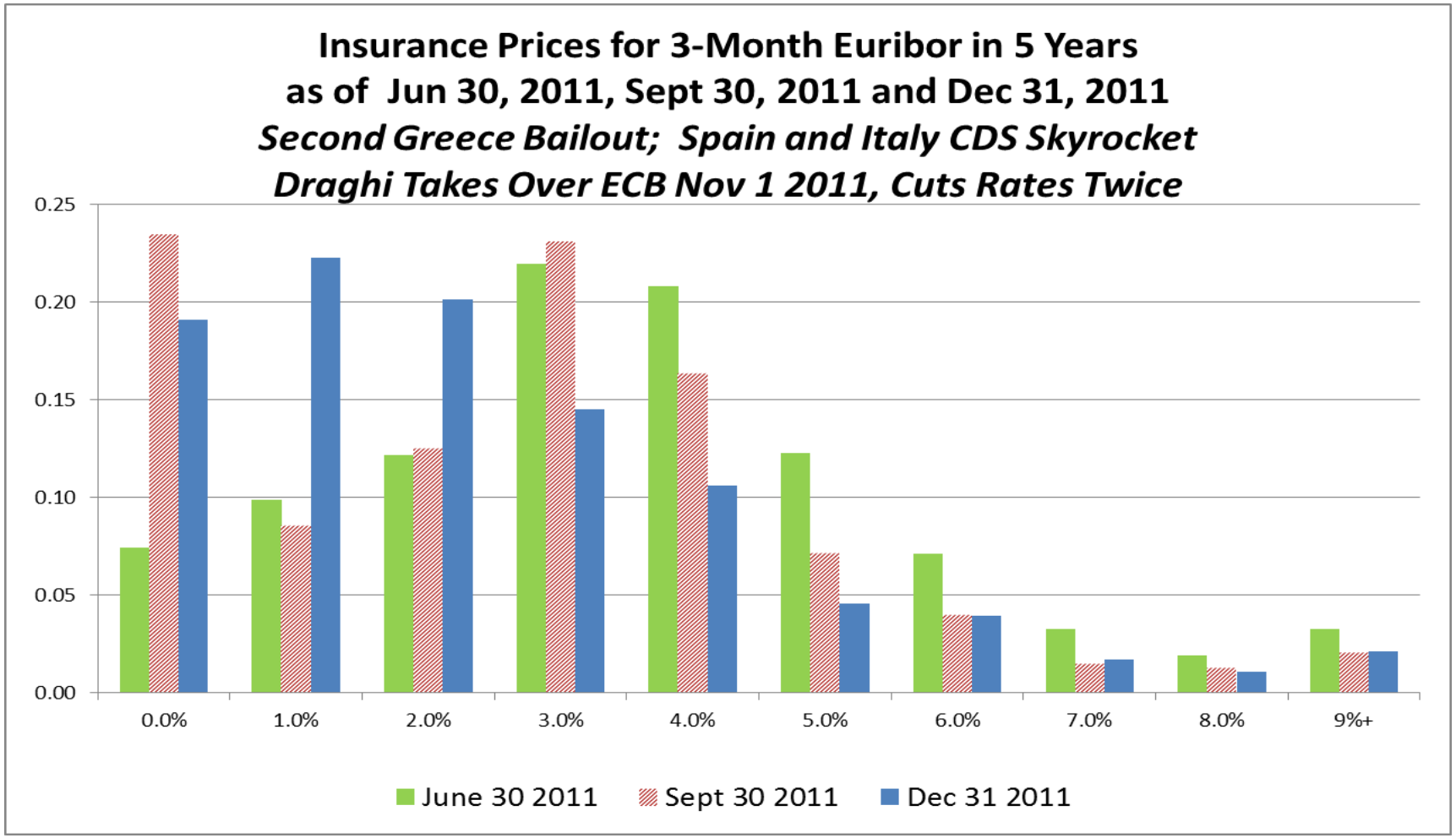
VI. Interest Rate Insurance Prices for Euribor During the Sovereign Debt Crisis 2010-2015

Key Events in the European Sovereign Debt Crisis
European Central Bank 2010-2015

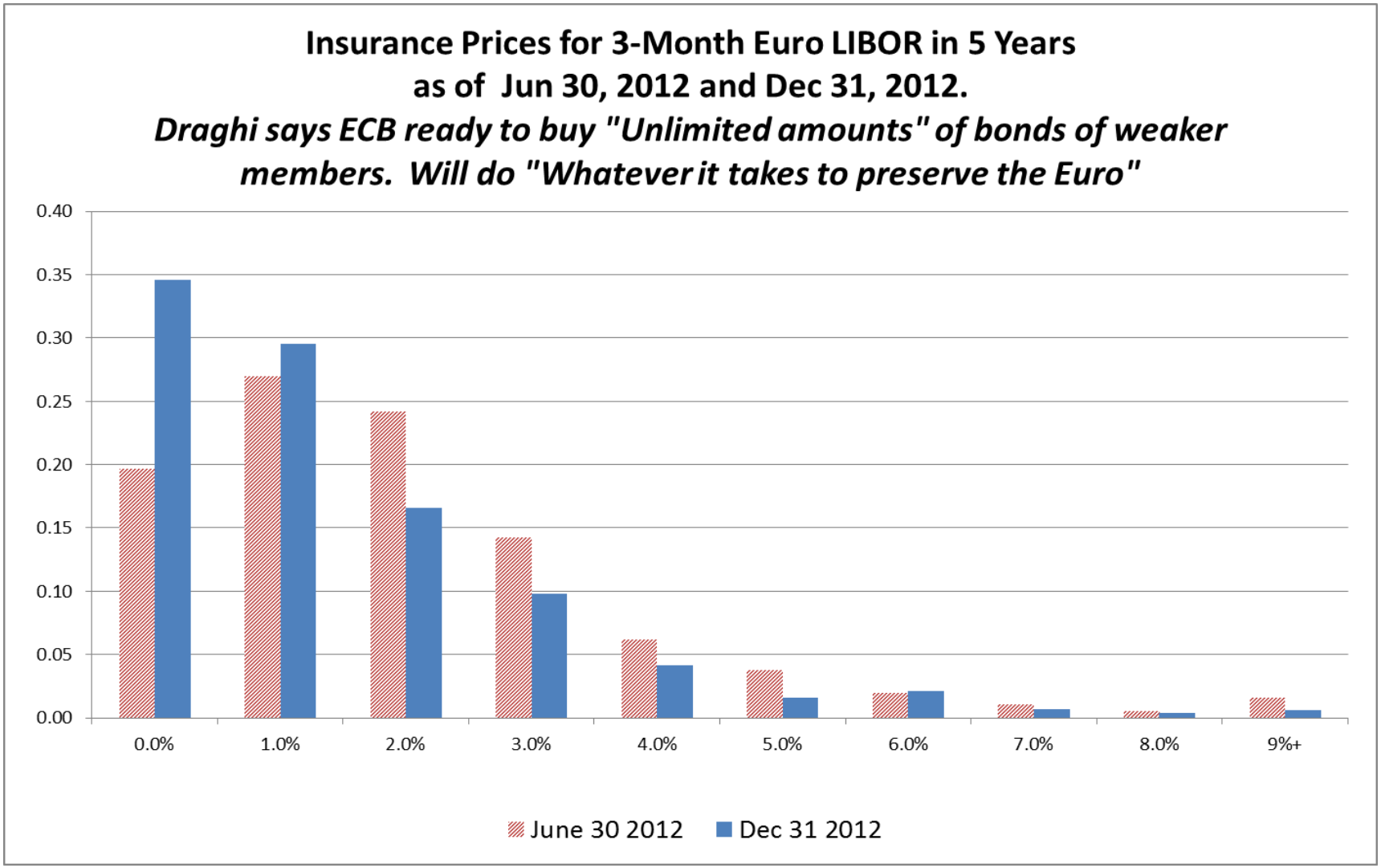
Sources: BBC,Reuters

- January-May 2010. Greek deficit revised upward from 3.7% to 12.7%. "Severe irregularities" in accounting. EU agrees to $30 billion, then $110 billion bailout of Greece. Ireland bailed out in November 2010.
- July-August 2011: Talk of Greek exit from Euro. Second bailout agreed. EC President Barroso: sovereign debt crisis spreading. Spain, Italy yields surge.
- November 1, 2011: Mario Draghi takes over European Central Bank from Jean-Claude Trichet. Draghi cuts rates twice quickly.
- September, 2012: ECB ready to buy "unlimited amounts" of bonds of weaker member countries. Draghi says ECB will do "whatever it takes to preserve the Euro." "…and believe me, it will be enough."
- May/June 2013: U.S.Fed considers "tapering" asset purchases, as economy strengthens. Long term interest rates move up sharply.
- June-October, 2014: European economies weak, inflation expectations lower. Draghi cuts rates twice to 0.05%. Announces QE, buying ABS, possibly even from Italy and Spain, up to 1 trillion Euro.
- January-March 2015: Draghi of ECB announces on January 22nd "Quantitative Easing" by massive asset purchases. Began QE March 9, 2015.

2011 Sovereign Debt Crisis: Draghi ECB cuts rates sharply. Massive shift in Euribor interest rate distribution to positive skewness like U.S.

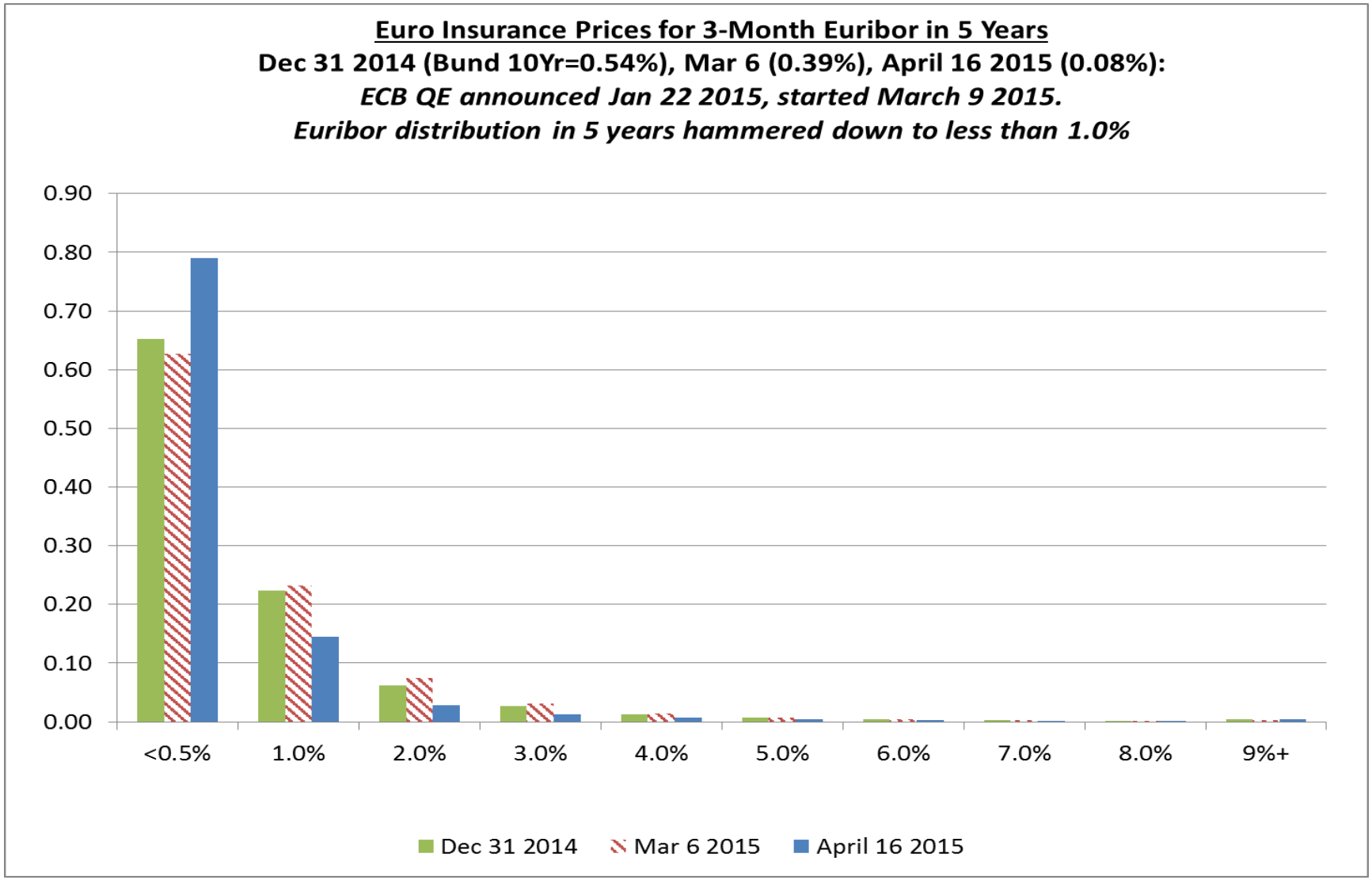


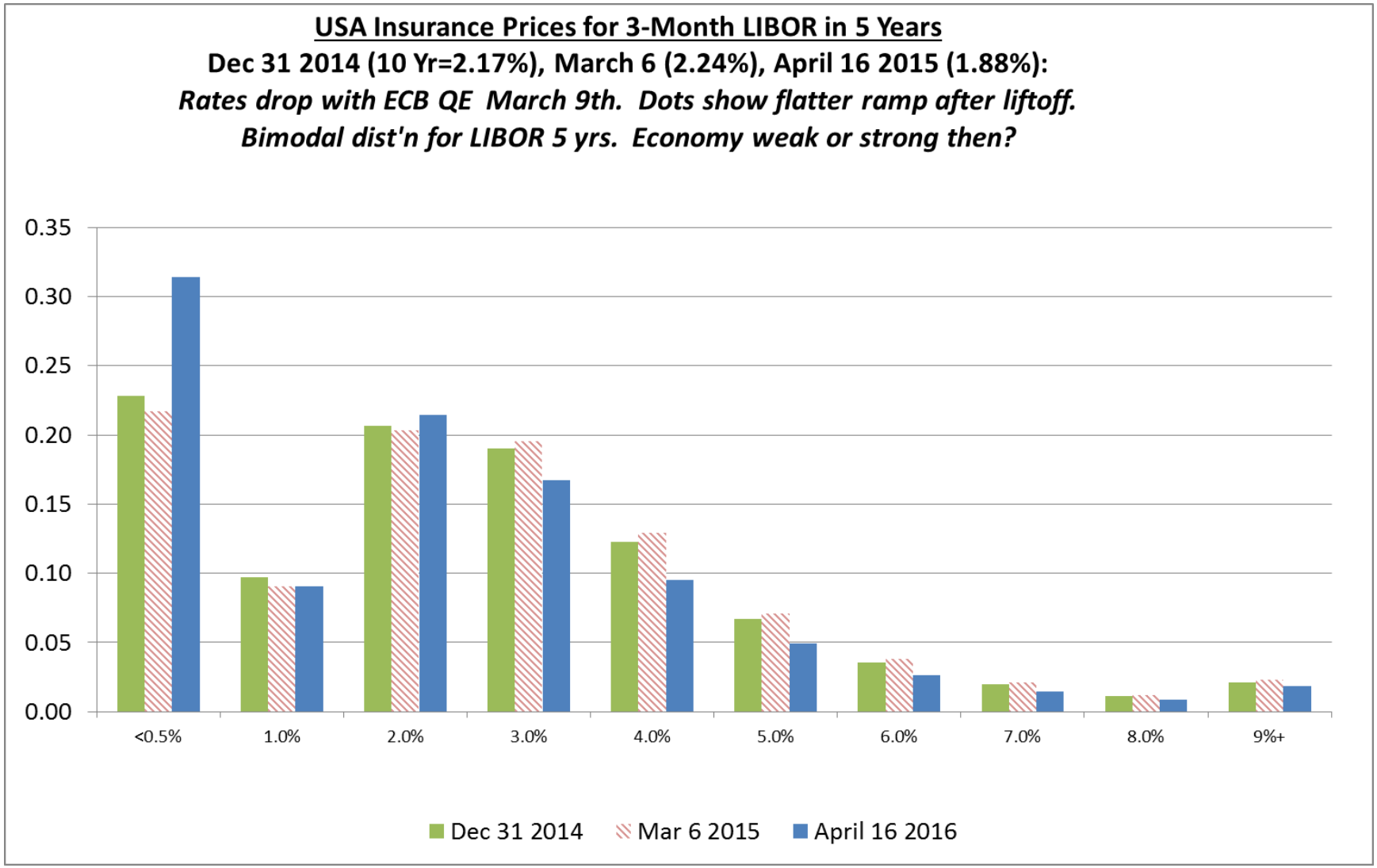
Draghi Rescues the Euro in 2012 with "Whatever it takes…"

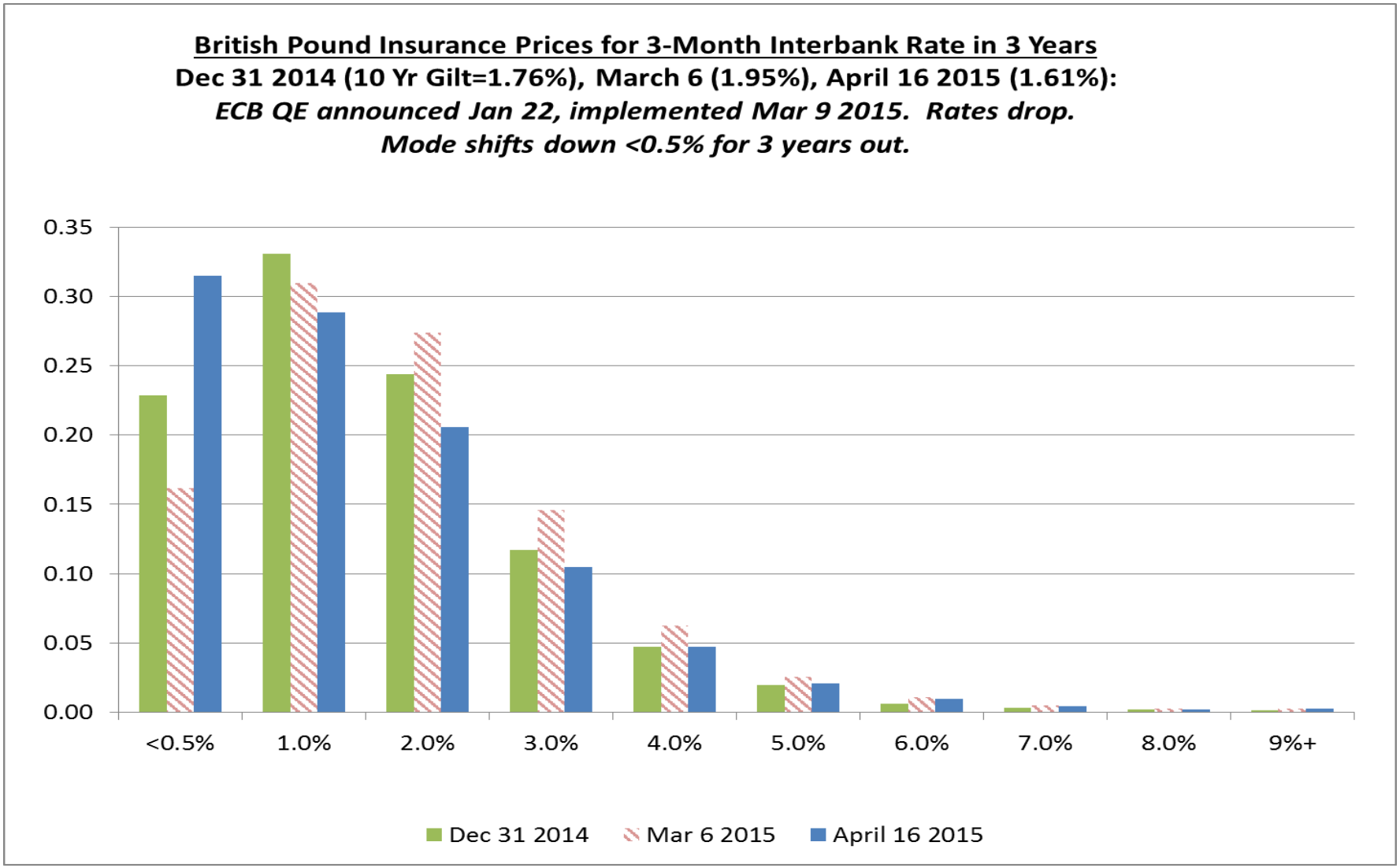


VII. 2015: Draghi's European Central Bank Massive "Quantitative Easing" Program:

ECB announced QE January 22, 2015,
implemented it starting March 9 2015,
buying massive amounts of Eurozone bonds.
Long rates drop sharply in Eurozone, UK, USA.

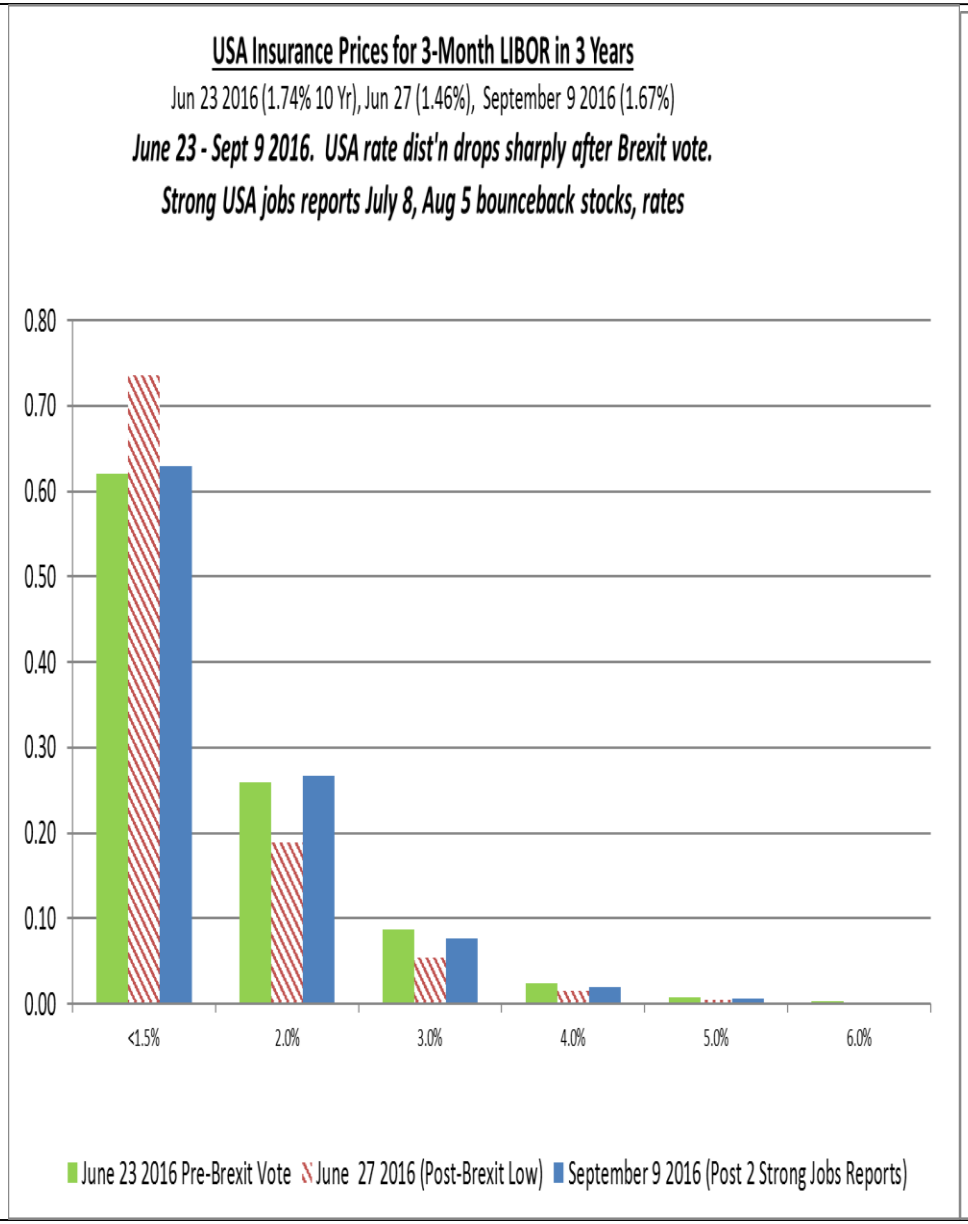

Euro Insurance Prices for 3-Month Euribor in 5 Years
Dec 31 2014 (Bund 10Yr=0.54%), Mar 6 (0.39%), April 16 2015 (0.08%):
ECB QE announced Jan 22 2015, started March 9 2015.
Euribor distribution in 5 years hammered down to less than 1.0%
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
<0.5%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
8.0%
9%+
Dec 31 2014
Mar 6 2015
April 16 2015

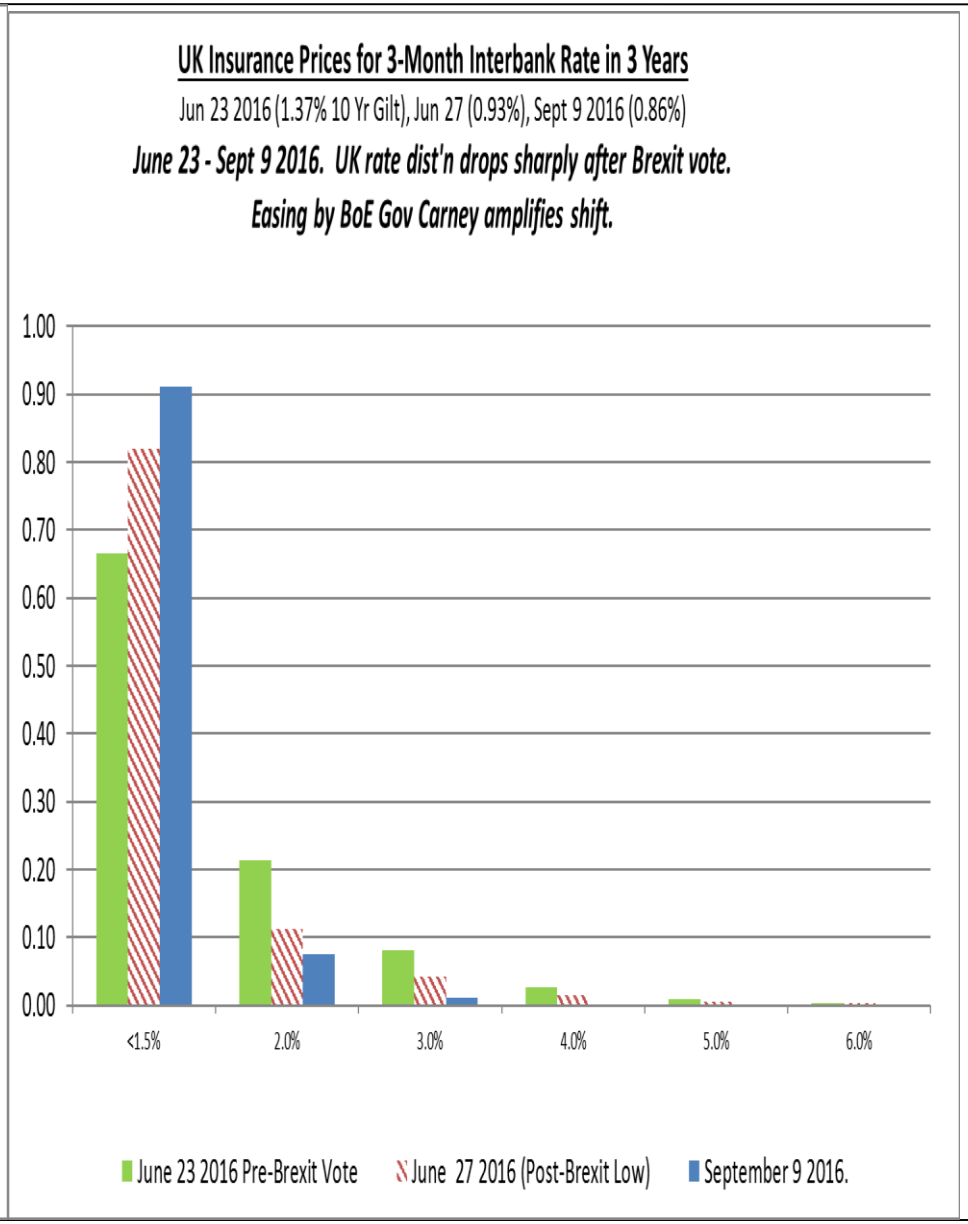

USA Insurance Prices for 3-Month LIBOR in 5 Years
Dec 31 2014 (10 Yr=2.17%), March 6 (2.24%), April 16 2015 (1.88%):
Rates drop with ECB QE March 9th. Dots show flatter ramp after liftoff.
Bimodal dist'n for LIBOR 5 yrs. Economy weak or strong then?
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
<0.5%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
8.0%
9%+
Dec 31 2014
Mar 6 2015
April 16 2016


British Pound Insurance Prices for 3-Month Interbank Rate in 3 Years
Dec 31 2014 (10 Yr Gilt=1.76%), March 6 (1.95%), April 16 2015 (1.61%):
ECB QE announced Jan 22, implemented Mar 9 2015. Rates drop.
Mode shifts down <0.5% for 3 years out.
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
<0.5%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
8.0%
9%+
Dec 31 2014
Mar 6 2015
April 16 2015

VIII. What are markets saying now in the USA and the UK?

June 23, 2016's surprise vote for Brexit roiled markets and caused rates to drop sharply. Strong actions and statements by the Bank of England's Governor, Mark Carney, continued the shift towards low rates in the UK distribution. Strong jobs reports in the USA on July 8 and on August 5, 2016, caused some bounceback in rate distributions, especially in the USA.


USA Insurance Prices for 3-Month LIBOR in 3 Years
Jun 23 2016 (1.74% 10 Yr), Jun 27 (1.46%), September 9 2016 (1.67%)
June 23 - Sept 9 2016. USA rate dist'n drops sharply after Brexit vote.
Strong USA jobs reports July 8, Aug 5 bounceback stocks, rates
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
<1.5%
2.0%
3.0%
4.0%
5.0%
6.0%
June 23 2016 Pre-Brexit Vote
June 27 2016 (Post-Brexit Low)
September 9 2016 (Post 2 Strong Jobs Reports)

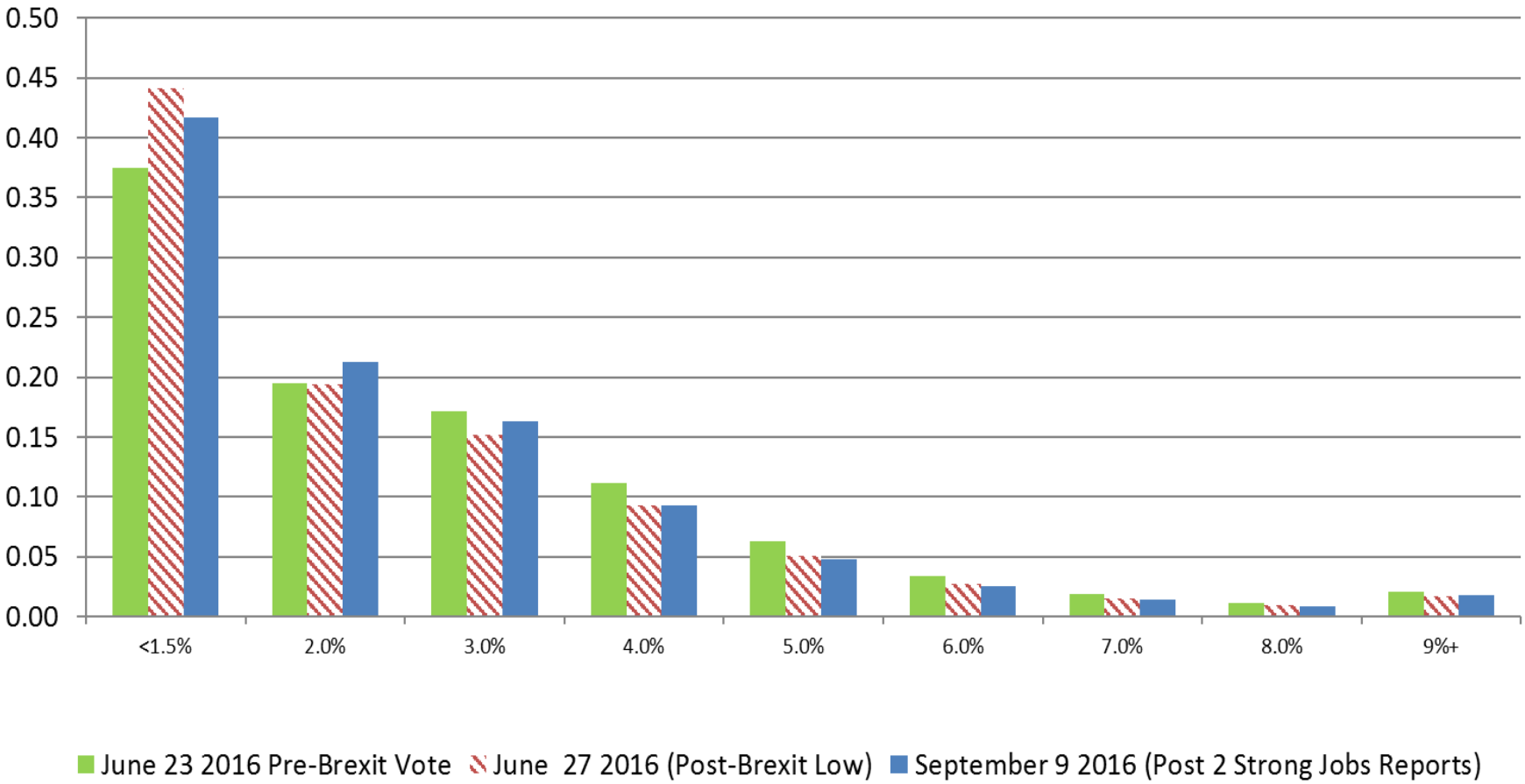

UK Insurance Prices for 3-Month Interbank Rate in 3 Years
Jun 23 2016 (1.37% 10 Yr Gilt), Jun 27 (0.93%), Sept 9 2016 (0.86%)
June 23 - Sept 9 2016. UK rate dist'n drops sharply after Brexit vote.
Easing by BoE Gov Carney amplifies shift.
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
<1.5%
2.0%
3.0%
4.0%
5.0%
6.0%
June 23 2016 Pre-Brexit Vote
June 27 2016 (Post-Brexit Low)
September 9 2016.

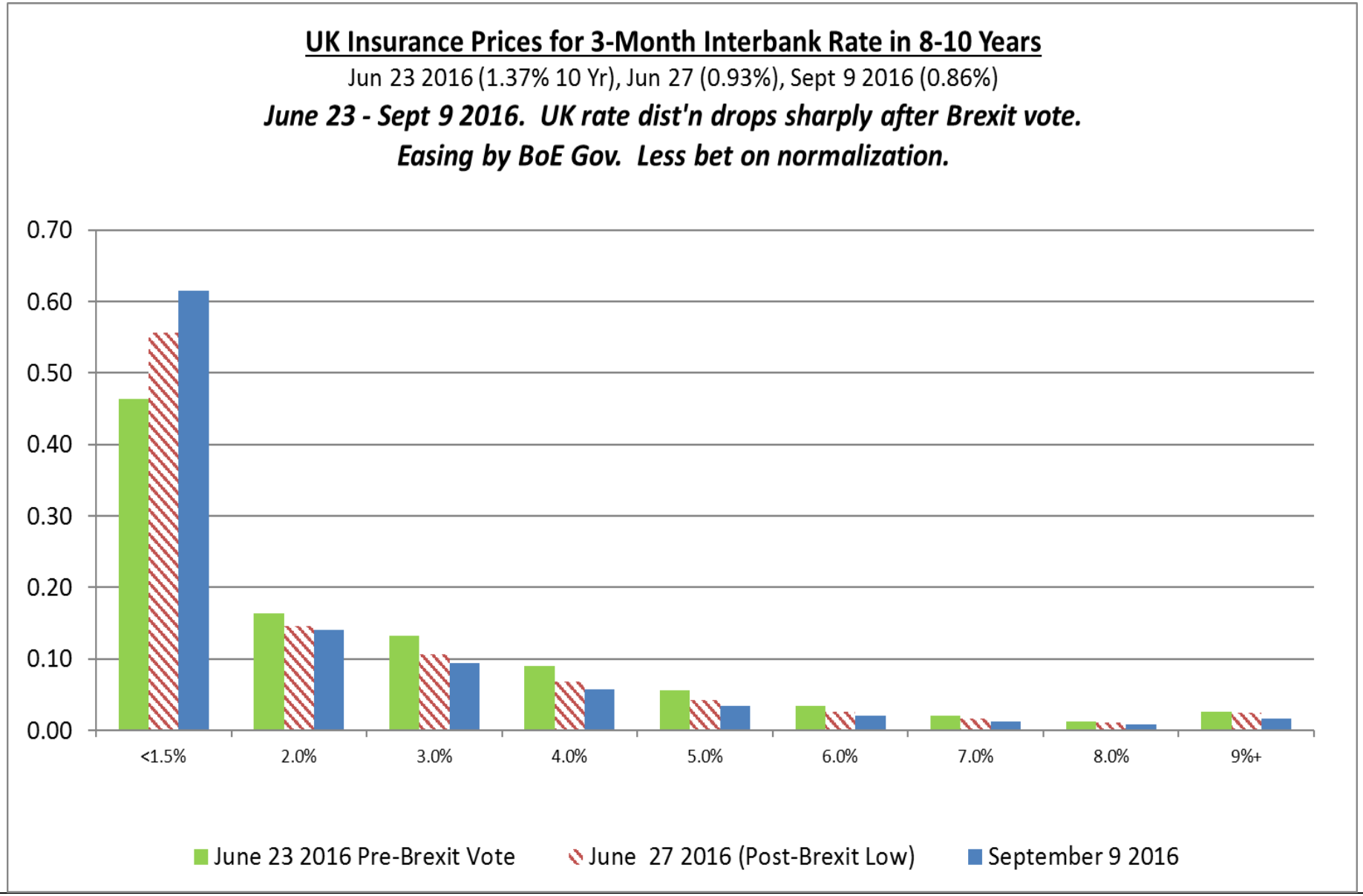
USA Insurance Prices for 3-Month LIBOR in 8-10 Years

Jun 23 2016 (1.74% 10 Yr), Jun 27 (1.46%), September 9 2016 (1.67%)

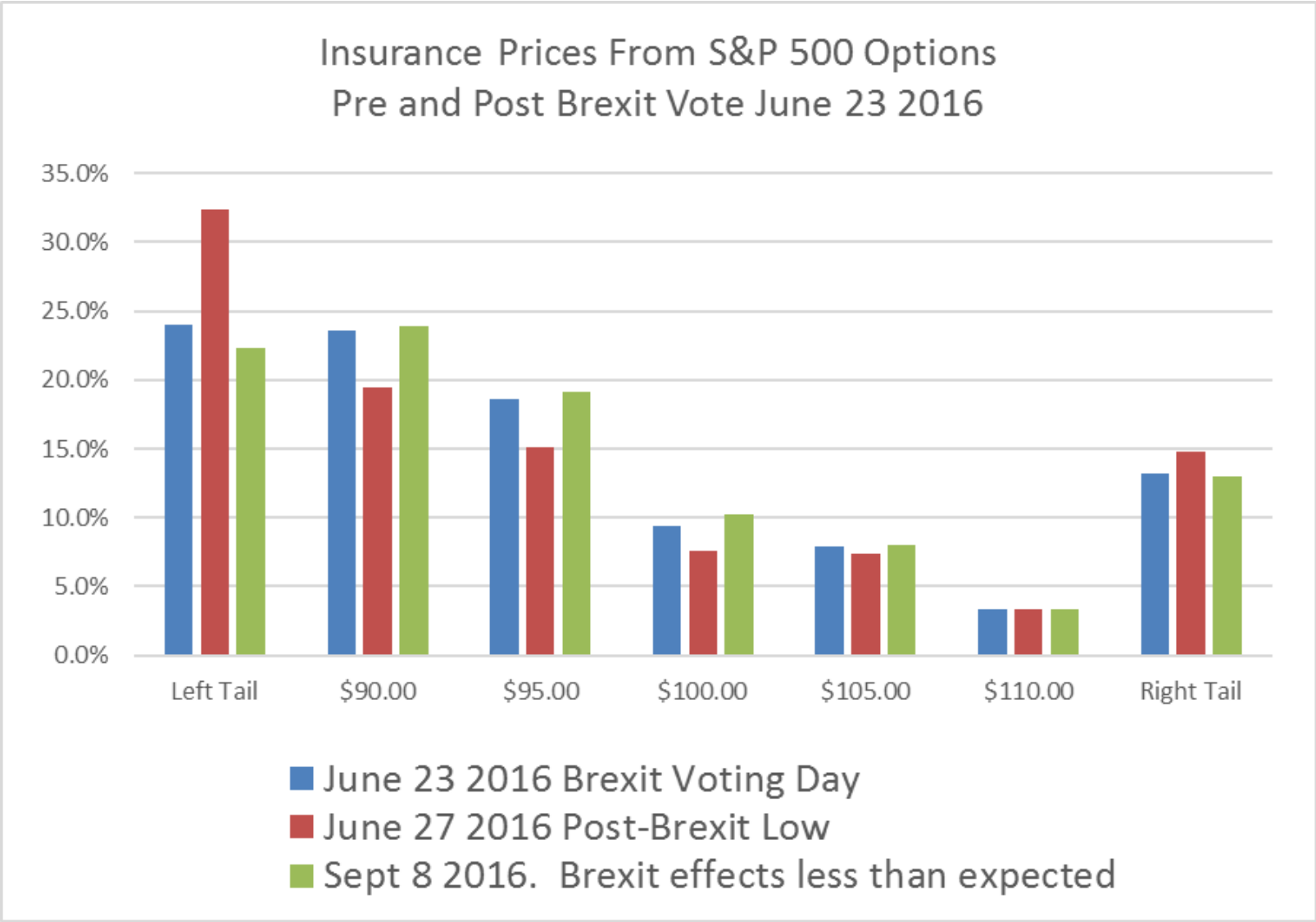
June 23 - Sept 9 2016. USA rate dist'n drops after Brexit vote.

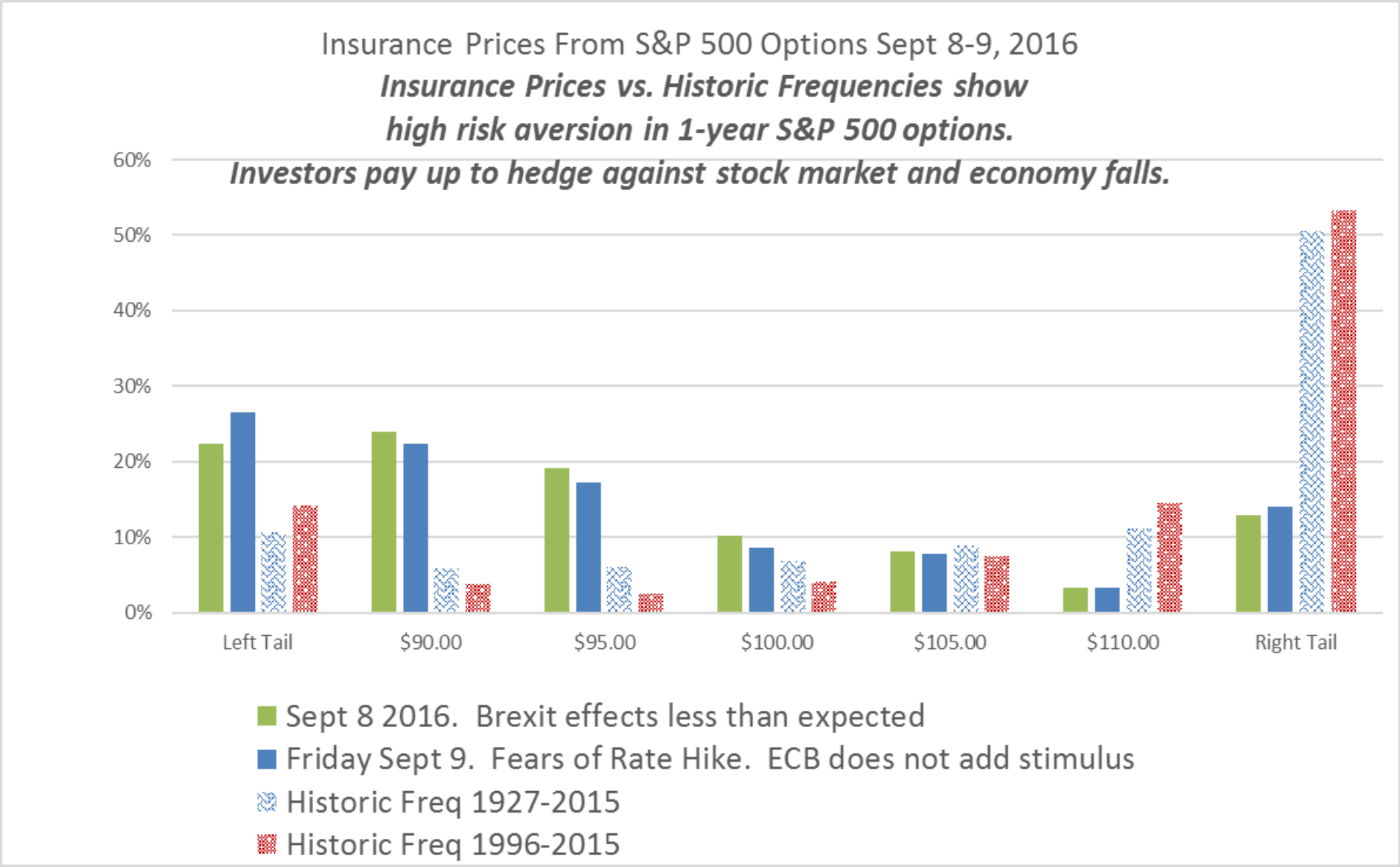
Long-term dist'n has long tail. Normalization or despressed rate?



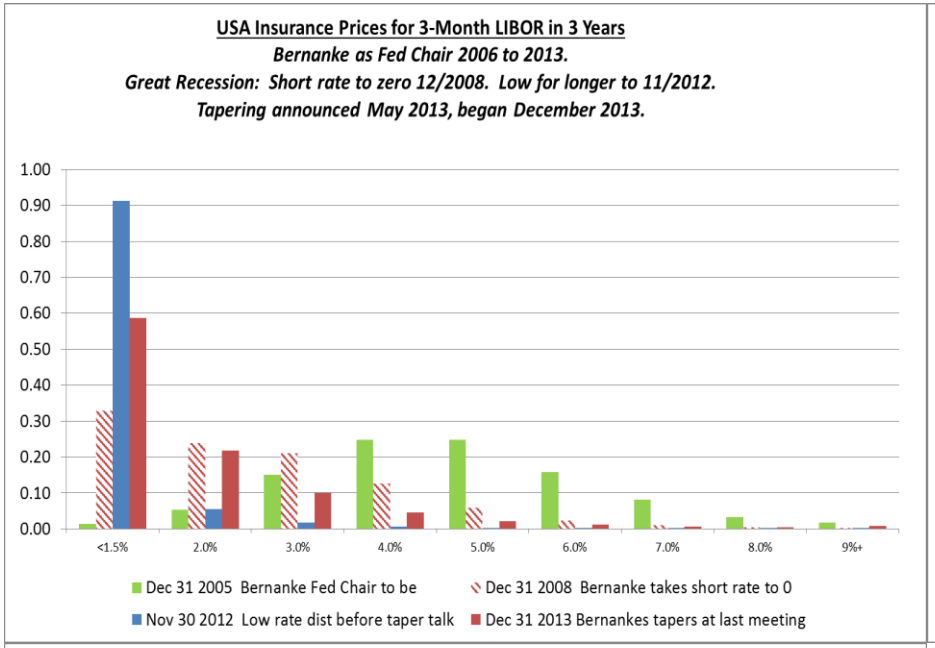

UK Insurance Prices for 3-Month Interbank Rate in 8-10 Years
Jun 23 2016 (1.37% 10 Yr), Jun 27 (0.93%), Sept 9 2016 (0.86%)
June 23 - Sept 9 2016. UK rate dist'n drops sharply after Brexit vote.
Easing by BoE Gov. Less bet on normalization.
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
<1.5%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
8.0%
9%+
June 23 2016 Pre-Brexit Vote
June 27 2016 (Post-Brexit Low)
September 9 2016

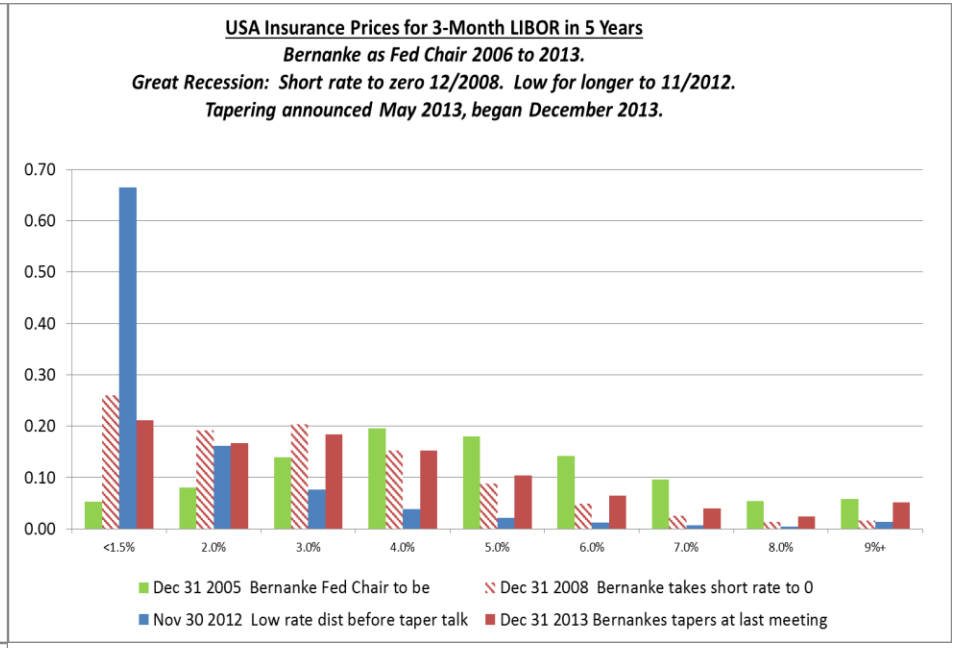
Stock options priced in increased tail risk after Brexit, now calmed.

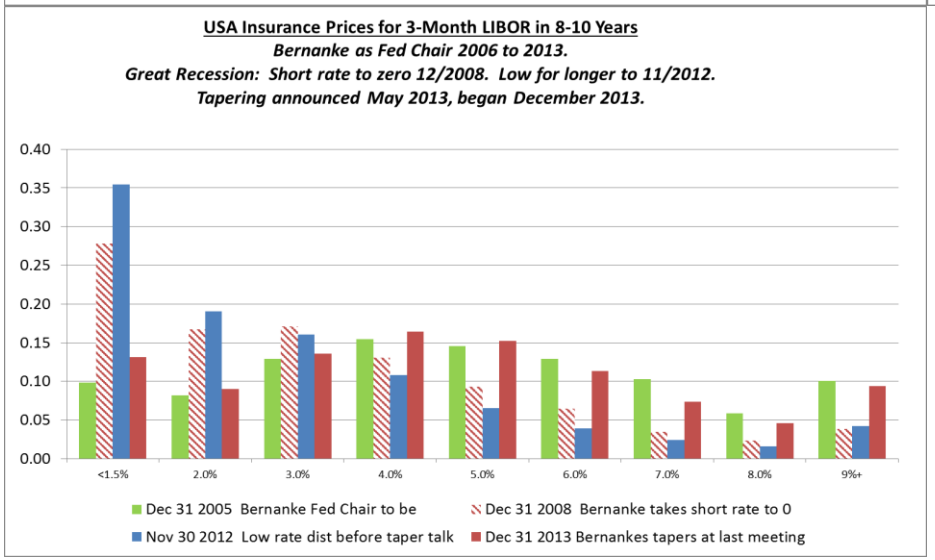



Insurance Prices From S&P 500 Options Sept 8-9, 2016
Insurance Prices vs. Historic Frequencies show
high risk aversion in 1-year S&P 500 options.
Investors pay up to hedge against stock market and economy falls.
60%
50%
40%
30%
20%
10%
0%
Left Tail
$90.00
$95.00
$100.00
$105.00
$110.00
Right Tail
Sept 8 2016. Brexit effects less than expected
Friday Sept 9. Fears of Rate Hike. ECB does not add stimulus
Historic Freq 1927-2015
Historic Freq 1996-2015

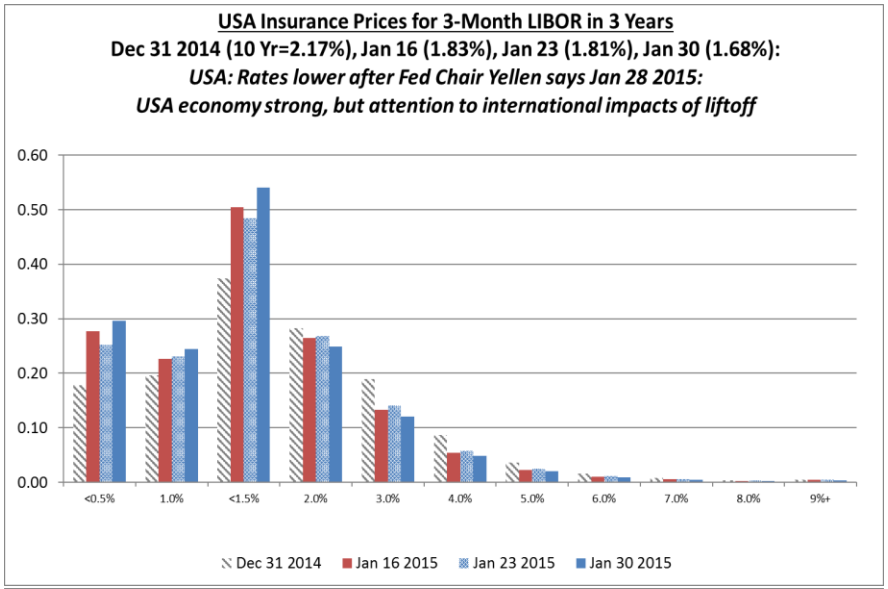
Movements in Distributions in the Bernanke Fed

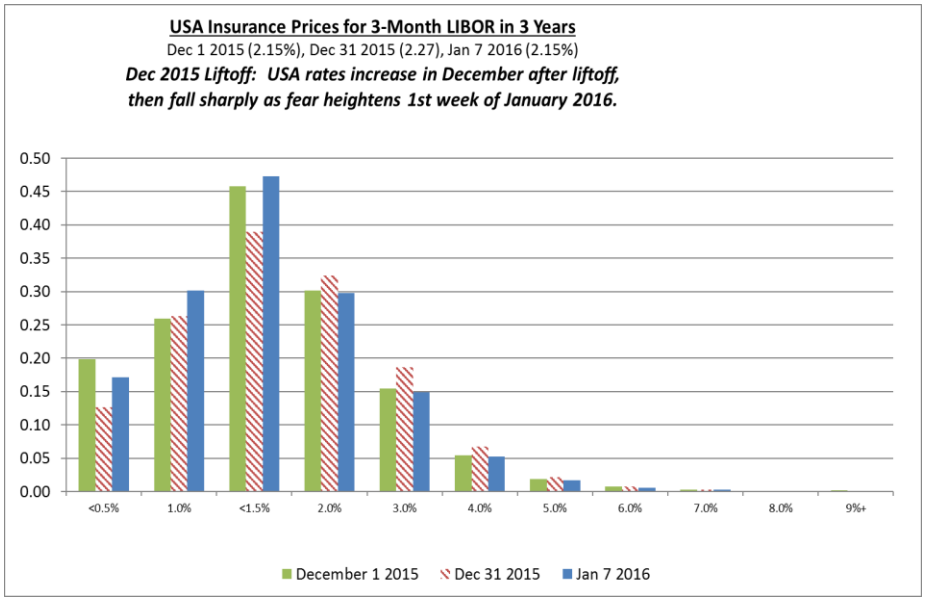


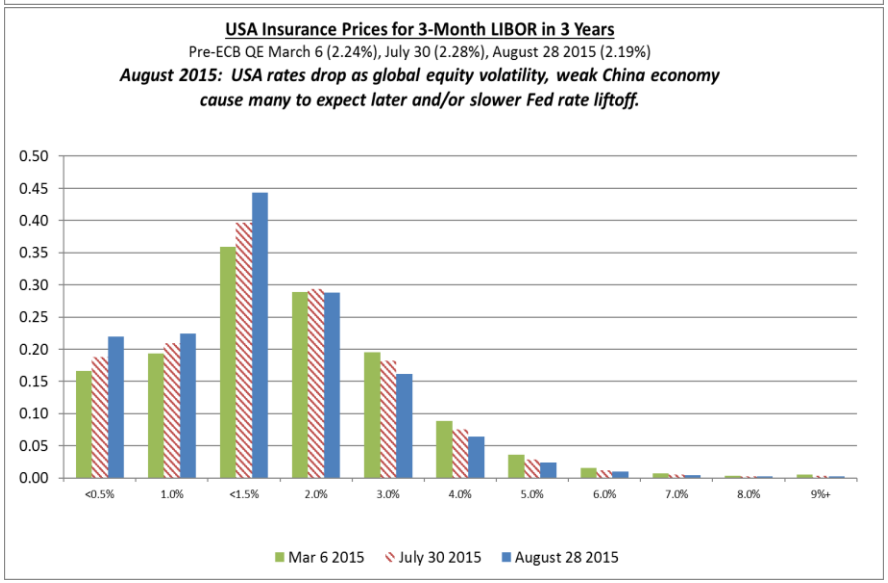


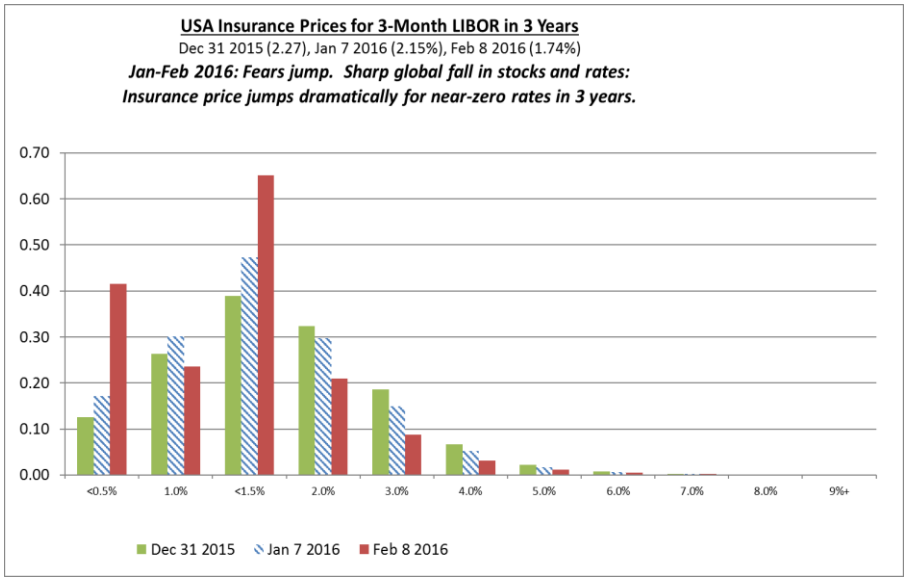


Movements in Distributions in the Yellen Fed







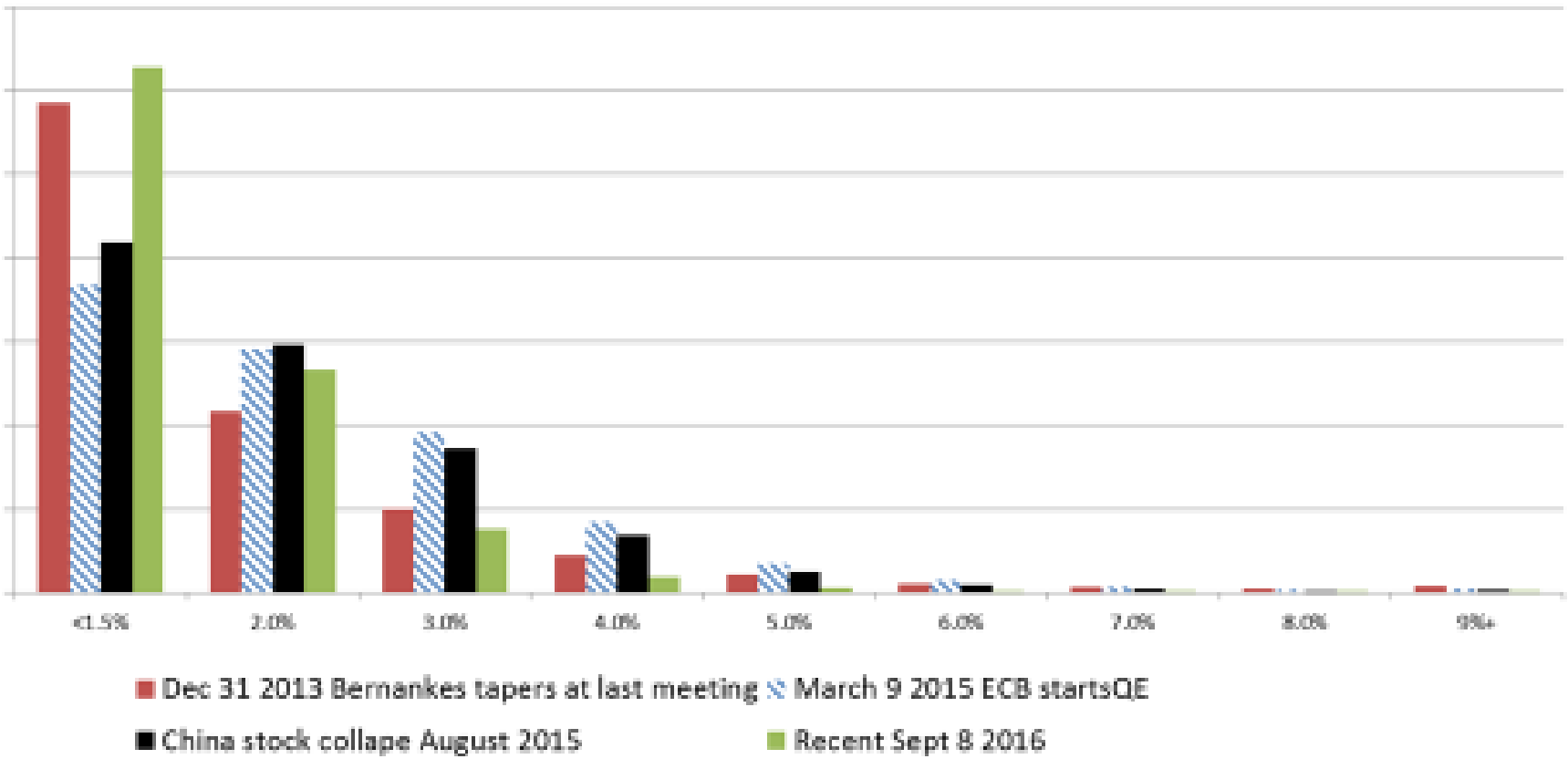


USA Insurance Prices for 3-Month LIBOR in 5 Years

Yellen as Fed Chair Feb 1 2014 to Present (Sept 2016)

Tapering began December 2013. ECB starts massive QE March 9, 2015

China stock collapse August 2015. Dovish Fed to Sept 2016.



IX. Selected Graphs and Data Pertinent to the Appropriate Level of Central Bank Intervention and Interest Rates Today

Today vs:
2008/2009 America and Asia
and 2011-2013 for Europe

Massive unemployment in Great Recession and Sovereign Debt Crisis.

Global Unemployment Rates

Douglas T. Breeden, Duke University and Amundi Smith Breeden 9/13/2016 18:25

	United States	Canada	Brazil	Mexico	France	Germany	Italy	Spain	United Kingdom	Russia	Turkey	Japan	Australia	South Korea	China	India	Indonesia
2006-Q4	4.4	6.1	9.9	3.8	8.3	10.1	6.5	8.3	5.5	6.8	8.8	4.0	4.5	3.4	4.1	0.0	0.0
2007-Q1	4.5	6.2	9.6	3.9	8.4	9.5	6.0	8.2	5.5	6.5	8.8	4.0	4.5	3.2	4.1	0.0	0.0
2007-Q2	4.5	6.1	9.5	3.6	8.1	9.1	5.9	8.0	5.4	6.2	9.1	3.8	4.3	3.3	4.1	0.0	0.0
2007-Q3	4.7	5.9	9.3	3.6	8.0	8.8	6.3	8.2	5.3	6.1	9.3	3.7	4.3	3.2	4.0	0.0	0.0
2007-Q4	4.8	5.9	8.7	3.7	7.4	8.5	6.3	8.6	5.2	5.9	9.4	3.8	4.4	3.2	4.0	0.0	0.0
2008-Q1	5.0	6.0	8.3	3.9	7.2	8.0	6.5	9.3	5.2	6.2	9.3	3.9	4.1	3.0	4.0	0.0	0.0
2008-Q2	5.3	6.0	7.7	3.7	7.3	7.8	6.8	10.4	5.4	5.7	9.4	4.0	4.2	3.1	4.0	0.0	0.0
2008-Q3	6.0	6.1	7.8	3.9	7.4	7.6	6.7	11.6	5.9	6.3	10.1	4.0	4.2	3.2	4.0	0.0	0.0
2008-Q4	6.9	6.6	7.9	4.5	7.7	7.6	6.9	13.8	6.4	7.2	11.4	4.1	4.4	3.3	4.1	0.0	0.0
2009-Q1	8.3	7.8	8.4	5.0	8.6	7.9	7.3	16.6	7.0	8.3	13.0	4.6	5.3	3.4	4.1	0.0	0.0
2009-Q2	9.3	8.5	8.2	5.5	9.2	8.3	7.4	17.8	7.8	8.7	13.8	5.1	5.7	3.8	4.2	0.0	0.0
2009-Q3	9.6	8.6	7.9	5.8	9.2	8.2	7.9	18.2	7.9	8.4	13.2	5.4	5.7	3.7	4.3	0.0	0.0
2009-Q4	9.9	8.5	7.9	5.5	9.5	8.1	8.2	18.8	7.8	8.1	12.3	5.2	5.5	3.6	4.3	0.0	0.0
2010-Q1	9.8	8.2	7.2	5.4	9.4	8.0	8.5	19.2	8.0	8.0	11.9	5.0	5.3	4.2	4.2	0.0	0.0
2010-Q2	9.6	8.0	6.9	5.4	9.3	7.8	8.5	19.9	7.9	7.6	11.2	5.1	5.3	3.4	4.2	0.0	0.0
2010-Q3	9.5	8.1	6.6	5.2	9.2	7.6	8.1	20.0	7.8	7.3	10.9	5.1	5.1	3.7	4.1	0.0	0.0
2010-Q4	9.5	7.7	6.2	5.5	9.2	7.4	8.3	20.2	7.9	6.9	10.4	5.0	5.1	3.5	4.1	0.0	0.0
2011-Q1	9.0	7.7	6.2	5.2	9.2	7.3	8.0	20.5	7.8	6.9	9.6	4.7	5.0	3.7	4.1	0.0	0.0
2011-Q2	9.1	7.5	6.0	5.4	9.1	7.1	8.0	20.8	7.9	6.7	9.6	4.7	5.0	3.4	4.1	0.0	0.0
2011-Q3	9.0	7.3	6.0	5.3	9.2	7.0	8.4	21.7	8.3	6.6	8.8	4.5	5.2	3.3	4.1	0.0	0.0
2011-Q4	8.6	7.4	5.7	5.0	9.4	6.8	9.2	22.6	8.4	6.3	8.5	4.5	5.2	3.2	4.1	0.0	0.0
2012-Q1	8.3	7.5	5.7	5.1	9.5	6.8	10.0	23.6	8.2	5.8	8.5	4.5	5.2	3.4	4.1	0.0	0.0
2012-Q2	8.2	7.3	5.6	4.9	9.7	6.8	10.6	24.5	8.1	5.5	8.3	4.4	5.1	3.2	4.1	0.0	0.0
2012-Q3	8.0	7.3	5.3	4.8	9.8	6.8	10.8	25.3	7.9	5.3	8.3	4.2	5.2	3.1	4.1	0.0	0.0
2012-Q4	7.8	7.3	5.4	5.0	10.1	6.8	11.4	25.9	7.8	5.1	8.6	4.2	5.3	3.1	4.1	0.0	0.0
2013-Q1	7.7	7.2	5.4	5.0	10.3	6.9	11.9	26.3	7.9	5.4	8.8	4.2	5.5	3.2	4.1	0.0	0.0
2013-Q2	7.5	7.1	5.6	5.0	10.4	6.9	12.1	26.2	7.7	5.5	9.0	4.0	5.7	3.1	4.1	0.0	0.0
2013-Q3	7.3	7.1	5.4	4.9	10.3	6.8	12.2	26.1	7.6	5.5	9.2	3.9	5.7	3.1	4.1	0.0	0.0
2013-Q4	6.9	7.1	5.1	4.7	10.1	6.8	12.4	25.8	7.2	5.5	9.1	3.9	5.8	3.1	4.0	0.0	0.0
2014-Q1	6.7	7.0	4.9	5.0	10.2	6.8	12.8	25.3	6.8	5.2	9.3	3.6	5.9	3.5	4.1	0.0	0.0
2014-Q2	6.2	7.0	4.7	4.9	10.1	6.7	12.4	24.7	6.3	5.1	9.8	3.6	6.0	3.6	4.1	0.0	0.0
2014-Q3	6.1	7.0	4.8	4.9	10.4	6.7	12.6	24.1	6.0	5.1	10.3	3.6	6.2	3.5	4.1	0.0	0.0
2014-Q4	5.7	6.7	5.0	4.5	10.5	6.6	12.8	23.7	5.8	5.2	10.4	3.5	6.2	3.5	4.1	0.0	0.0
2015-Q1	5.6	6.8	5.7	4.4	10.4	6.5	12.3	23.2	5.6	5.4	10.3	3.5	6.2	3.6	4.1	0.0	0.0
2015-Q2	5.4	6.8	6.4	4.4	10.4	6.4	12.2	22.5	5.6	5.6	10.4	3.4	6.1	3.8	4.0	0.0	0.0
2015-Q3	5.2	7.0	7.4	4.3	10.5	6.4	11.6	21.6	5.3	5.5	10.2	3.4	6.2	3.6	4.0	0.0	0.0
2015-Q4	5.0	7.0	8.1	4.3	10.2	6.3	11.6	21.0	5.1	5.7	10.3	3.3	5.8	3.5	4.1	0.0	0.0
2016-Q1	4.9	7.2	10.1	4.2	10.2	6.2	11.6	20.5	5.1	5.6	10.0	3.2	5.8	3.8	4.0	0.0	0.0
2016-Q2	4.9	6.9	9.9	3.9	10.2	6.1	11.6	20.1	5.0	5.7	9.8	3.2	5.7	3.7	4.0	0.0	0.0

GDP Contracted Sharply in Great Recession and Sovereign Debt Crisis

Last 4 Quarters Real GDP Growth (YoY)

Douglas T. Breeden, Duke University and Amundi Smith Breeden

9/13/2016 18:25

	United States	Canada	Brazil	Mexico	France	Germany	Italy	Spain	United Kingdom	Russia	Turkey	Japan	Australia	South Korea	China	India	Indonesia
2006-Q4	2.4	1.5	4.8	3.9	2.4	5.0	2.6	4.1	1.1	8.3	5.9	2.1	3.1	4.7	12.8	9.8	6.1
2007-Q1	1.2	1.4	5.1	3.2	2.4	4.4	2.3	4.1	1.8	8.2	7.6	2.6	4.4	4.6	14.1	10.7	6.1
2007-Q2	1.7	2.3	6.6	2.8	2.3	3.5	1.7	3.8	2.3	8.8	3.7	2.4	5.1	5.7	14.5	8.9	6.7
2007-Q3	2.3	2.4	6.0	3.0	2.6	3.3	1.2	3.6	2.9	8.7	3.4	2.1	4.8	5.1	14.2	10.8	6.7
2007-Q4	1.9	2.2	6.6	3.5	2.2	2.3	0.1	3.6	3.3	10.1	4.3	1.6	3.8	6.5	13.9	9.0	5.8
2008-Q1	1.1	1.6	6.5	2.6	1.7	2.7	0.7	3.0	2.4	11.0	6.7	1.3	3.4	5.2	11.4	7.8	4.7
2008-Q2	0.8	1.0	5.9	2.0	0.6	1.8	-0.1	2.3	1.0	8.9	2.6	0.0	2.9	4.0	10.3	6.3	6.2
2008-Q3	-0.3	1.4	7.1	1.4	-0.1	0.5	-1.3	0.6	-1.4	5.0	1.1	-0.7	2.7	3.8	9.7	2.0	6.9
2008-Q4	-2.8	0.1	1.0	-1.3	-1.9	-1.8	-3.5	-1.3	-4.4	-1.6	-7.0	-4.8	1.5	-1.6	7.3	0.4	5.8
2009-Q1	-3.5	-2.3	-2.7	-5.3	-3.9	-6.9	-7.1	-3.3	-6.1	-7.5	-14.9	-9.2	1.4	-1.9	7.0	4.5	4.9
2009-Q2	-4.1	-3.7	-1.8	-6.7	-3.5	-6.6	-6.9	-4.3	-5.7	-9.4	-8.0	-6.5	1.7	-1.0	8.4	6.7	4.2
2009-Q3	-3.3	-4.0	-1.2	-4.7	-3.0	-5.7	-5.2	-3.8	-4.0	-7.6	-2.2	-5.5	1.2	1.0	9.9	8.9	4.1
2009-Q4	-0.2	-1.8	5.3	-1.2	-1.0	-3.0	-2.7	-2.9	-1.4	-3.5	5.6	-0.6	2.7	4.9	11.6	13.3	5.6
2010-Q1	1.6	1.7	9.1	4.1	1.2	2.4	0.6	-1.0	0.8	2.2	12.3	5.1	2.0	7.1	12.2	9.8	6.1
2010-Q2	2.7	3.4	8.5	6.6	1.9	4.4	1.9	0.0	2.1	4.7	10.0	4.4	2.1	7.4	10.8	9.5	6.8
2010-Q3	3.1	3.6	7.0	5.4	2.2	4.6	1.9	0.4	2.6	4.8	6.1	5.9	2.4	5.5	9.9	11.3	6.2
2010-Q4	2.7	3.6	5.7	4.5	2.2	4.5	2.2	0.6	2.3	5.0	9.2	3.6	2.7	6.1	9.9	10.5	6.5
2011-Q1	1.9	3.1	5.0	4.2	2.8	5.6	2.0	-0.2	2.3	3.2	11.9	0.1	2.0	4.8	10.1	9.5	6.5
2011-Q2	1.7	2.8	4.7	3.6	2.1	3.7	1.5	-0.8	1.3	3.4	9.1	-1.6	2.5	3.7	10.1	4.8	6.3
2011-Q3	1.2	3.5	3.5	4.2	2.0	3.3	0.5	-1.2	1.2	3.9	9.5	-0.5	3.1	3.4	9.5	4.4	6.0
2011-Q4	1.7	3.1	2.6	4.2	1.5	2.4	-1.1	-1.7	1.3	4.3	5.3	0.3	3.1	2.9	8.7	3.7	5.9
2012-Q1	2.8	2.4	1.6	3.9	0.4	1.0	-2.3	-2.2	1.2	5.4	2.5	3.3	4.4	2.6	8.0	4.5	6.1
2012-Q2	2.5	2.6	1.0	4.5	0.3	0.9	-3.2	-2.5	1.0	4.3	2.6	3.5	3.8	2.4	7.7	7.3	6.2
2012-Q3	2.4	1.4	2.6	3.3	0.2	0.7	-3.2	-2.7	1.8	3.3	2.0	0.3	3.2	2.1	7.6	5.7	5.9
2012-Q4	1.3	0.7	2.6	3.4	0.0	0.2	-2.7	-3.1	1.3	1.5	1.5	0.0	2.7	2.1	8.0	5.3	5.9
2013-Q1	1.3	1.7	3.0	3.1	0.0	-0.4	-2.7	-2.7	1.5	0.8	2.7	0.1	1.8	2.2	7.9	6.2	5.5
2013-Q2	1.0	1.8	3.8	0.6	0.9	0.5	-2.0	-2.1	2.1	1.2	4.6	1.1	2.0	2.7	7.7	7.2	5.6
2013-Q3	1.7	2.3	2.8	1.6	0.6	0.7	-1.4	-1.5	1.7	1.2	4.6	2.1	2.0	3.2	8.0	6.8	5.5
2013-Q4	2.7	3.1	2.5	1.1	0.9	1.6	-0.9	-0.3	2.4	1.9	4.6	2.1	2.3	3.5	7.6	6.4	5.6
2014-Q1	1.6	2.2	2.5	1.1	0.9	2.4	-0.1	0.4	2.6	0.8	4.9	2.4	3.0	3.9	7.4	7.0	5.1
2014-Q2	2.4	2.7	-0.4	3.0	0.4	1.3	-0.2	1.2	3.1	1.1	2.3	-0.4	2.7	3.5	7.5	7.9	5.0
2014-Q3	2.9	2.5	-1.0	2.3	0.7	1.2	-0.4	1.7	3.1	0.9	2.0	-1.5	2.6	3.3	7.1	6.8	5.0
2014-Q4	2.5	2.4	-0.6	2.6	0.6	1.6	-0.4	2.1	3.5	0.1	2.9	-0.9	2.3	2.7	7.1	7.1	5.0
2015-Q1	3.3	2.0	-2.2	2.5	1.3	1.1	0.1	2.7	2.9	-2.8	2.3	-0.9	2.3	2.4	7.0	7.3	4.7
2015-Q2	3.0	1.0	-2.9	2.3	1.1	1.8	0.6	3.2	2.3	-4.5	3.7	0.7	2.1	2.2	7.0	7.4	4.7
2015-Q3	2.2	1.0	-4.4	2.6	1.1	1.7	0.8	3.4	2.0	-3.7	4.0	1.8	2.7	2.8	6.9	7.4	4.7
2015-Q4	1.9	0.3	-5.9	2.4	1.4	1.3	1.1	3.5	1.8	-3.8	5.6	0.8	2.9	3.1	6.8	8.1	5.0
2016-Q1	1.6	1.1	-5.1	2.8	1.4	1.8	1.0	3.4	2.0	-1.2	4.8	0.0	3.1	2.8	6.7	7.4	4.9
2016-Q2	1.2	0.9	-3.8	2.8	1.4	1.7	0.8	3.2	2.2	-1.2	***4.8***	0.8	***3.1***	3.2	6.7	7.1	5.1

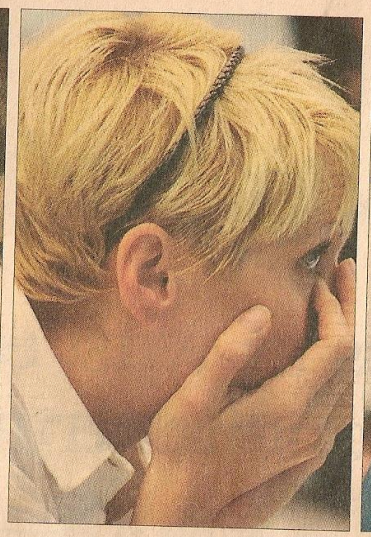
FT WEEKEND

FINANCIAL TIMES | Saturday October 11 / Sunday October 12 20

Market crash shakes world

How the world's markets fell this week...

Tokyo	Frankfurt	London	New York
▼ 24.3%	▼ 21.6%	▼ 21.1%	▼ 18%



US stocks suffer worst week since Depression

7.7 per cent fall at the opening in New York, US stock indices staged a late rally and closed

"The events we've seen this week represent a once-in-a-generation increase in risk aversion

and establish strong depositor protection. The precise form of these commitments would differ

including the idea of creating a central clearing house for inter-bank loans that would

The day in summary

More Lehman pa
The new losses looming thanks to the bankrupt bank
Markets, Pages 16-1

The crash in Eng
How to tell your CD from your CFD and the Libor OIS-sprea
www.ft.com/crisis

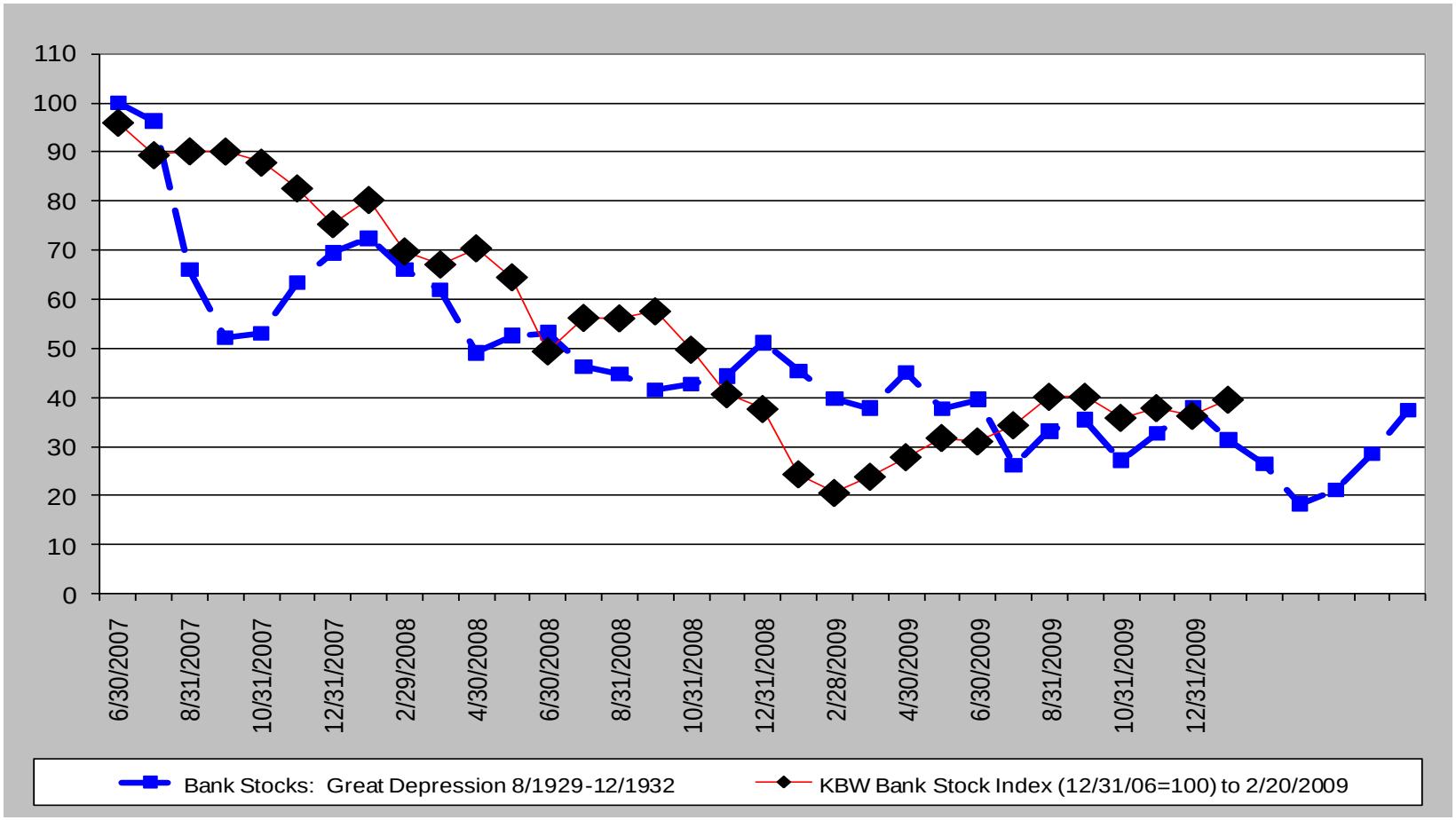
The new gold rus
As markets crash, demand for the precious metal soar
www.ft.com/markets

The new panic
It's not about faith in banks, but faith in governments to save them

Financial Panic of 2008/2009:

Bank Stocks Fell 80%, as Much As In the Great Depression

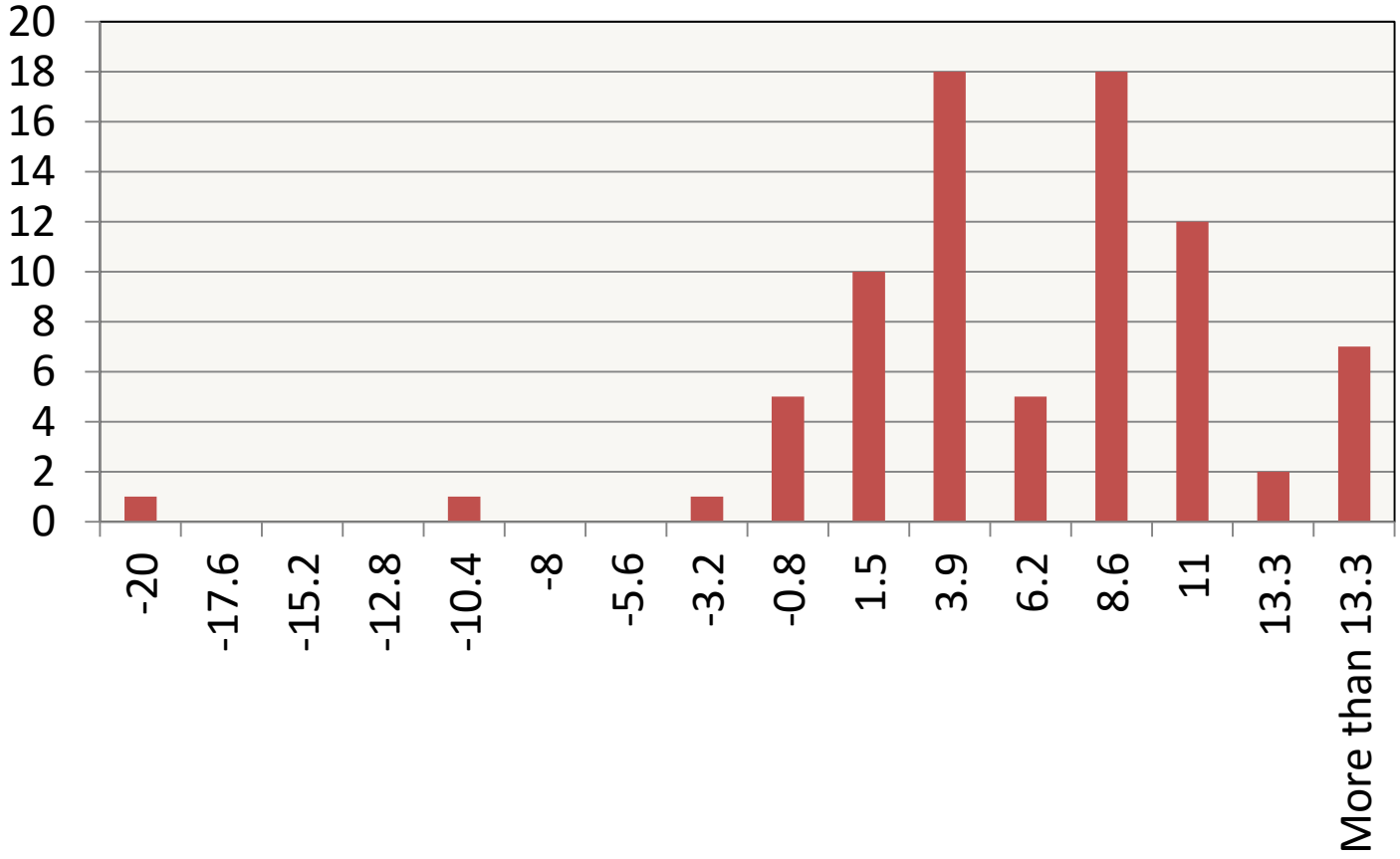
End of Month, June 2007- Jan 2010 vs. Aug 1929- Aug1933

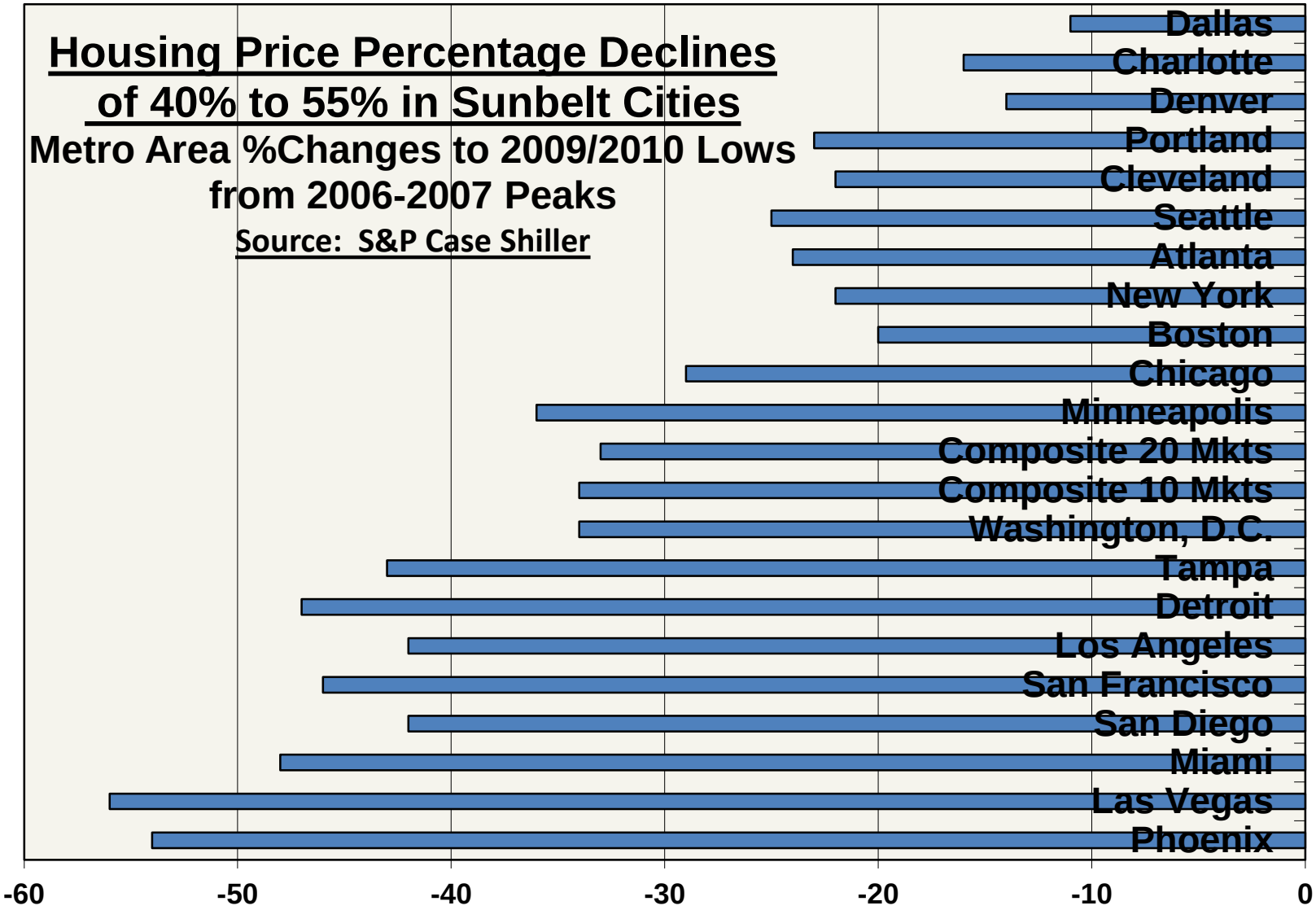


Frequency of Housing Price 4-Quarter % Changes

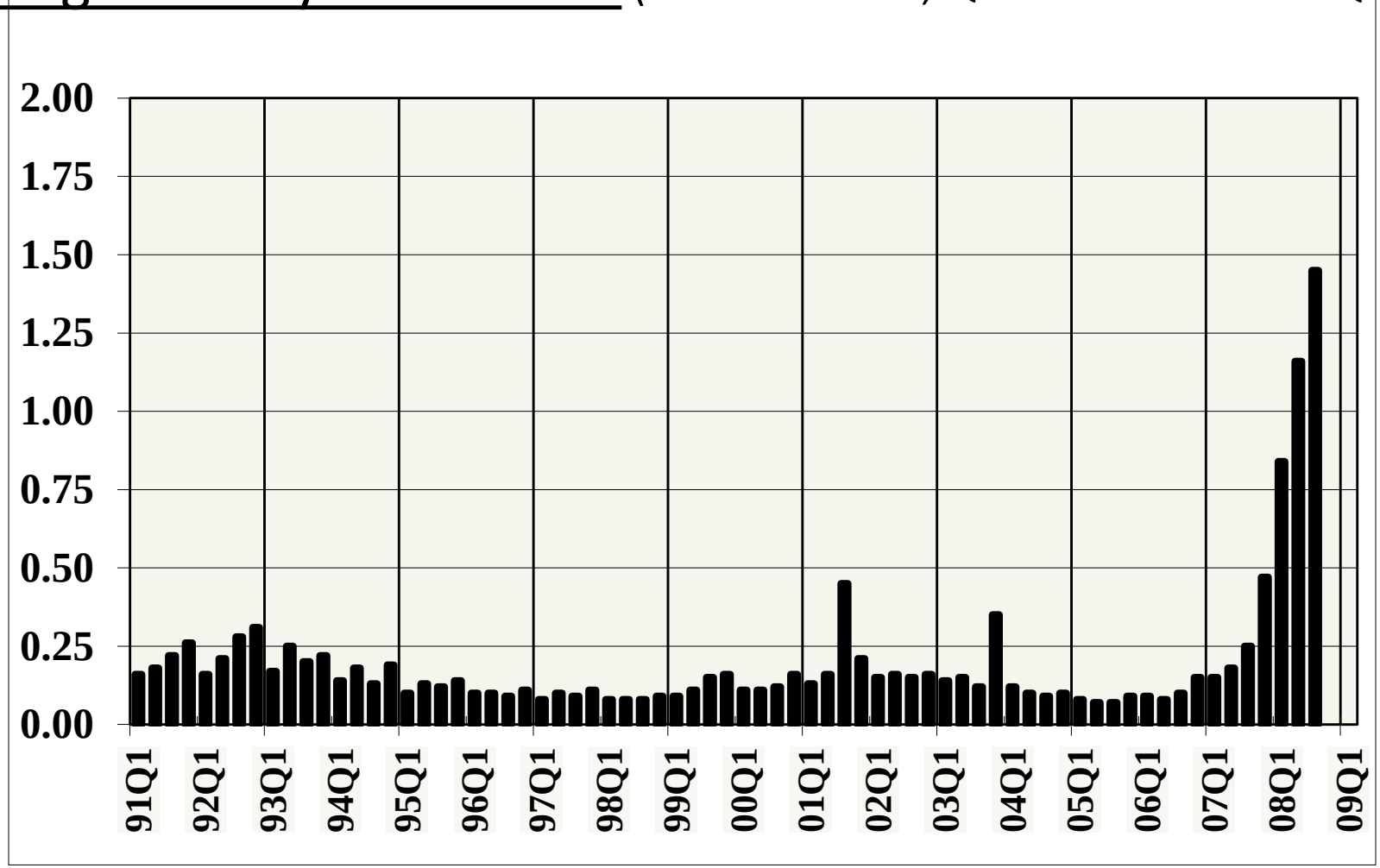
6 Sigma Event in 2008/2009, Down 20%.

Source: S&P Case Shiller 1987-2009. Sigma=3.2% 1987-2007:

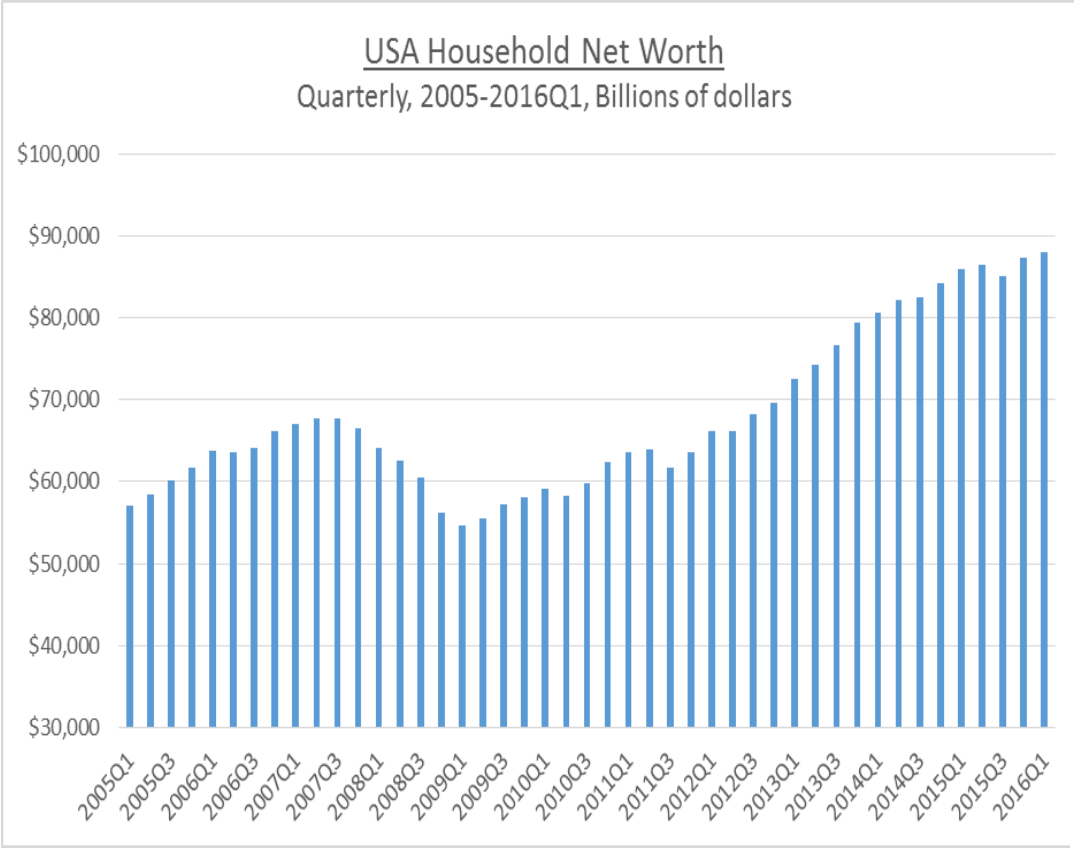


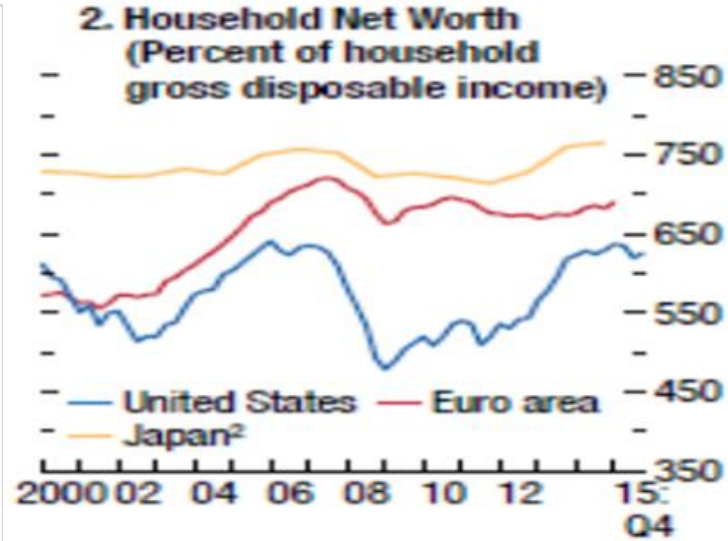

Housing Price Percentage Declines
of 40% to 55% in Sunbelt Cities
Metro Area %Changes to 2009/2010 Lows
from 2006-2007 Peaks
Source: S&P Case Shiller
Dallas
Charlotte
Denver
Portland
Cleveland
Seattle
Atlanta
New York
Boston
Chicago
Minneapolis
Composite 20 Mkts
Composite 10 Mkts
Washington, D.C.
Tampa
Detroit
Los Angeles
San Francisco
San Diego
Miami
Las Vegas
Phoenix
-60
-50
-40
-30
-20
-10
0

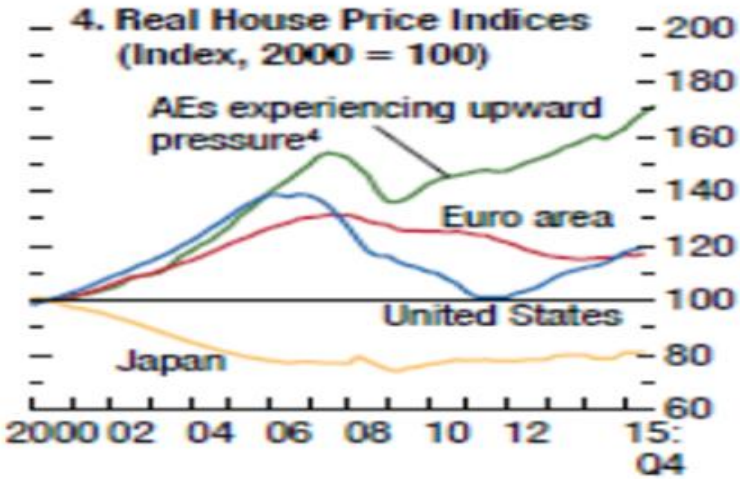
Banks' Net Chargeoffs Hit Historic High on Loans on Single Family Real Estate (Annualized Pct, Quarters 1991-2008 Q3)



With Fed Support, Household Net Worth Bounced Back to New Highs.



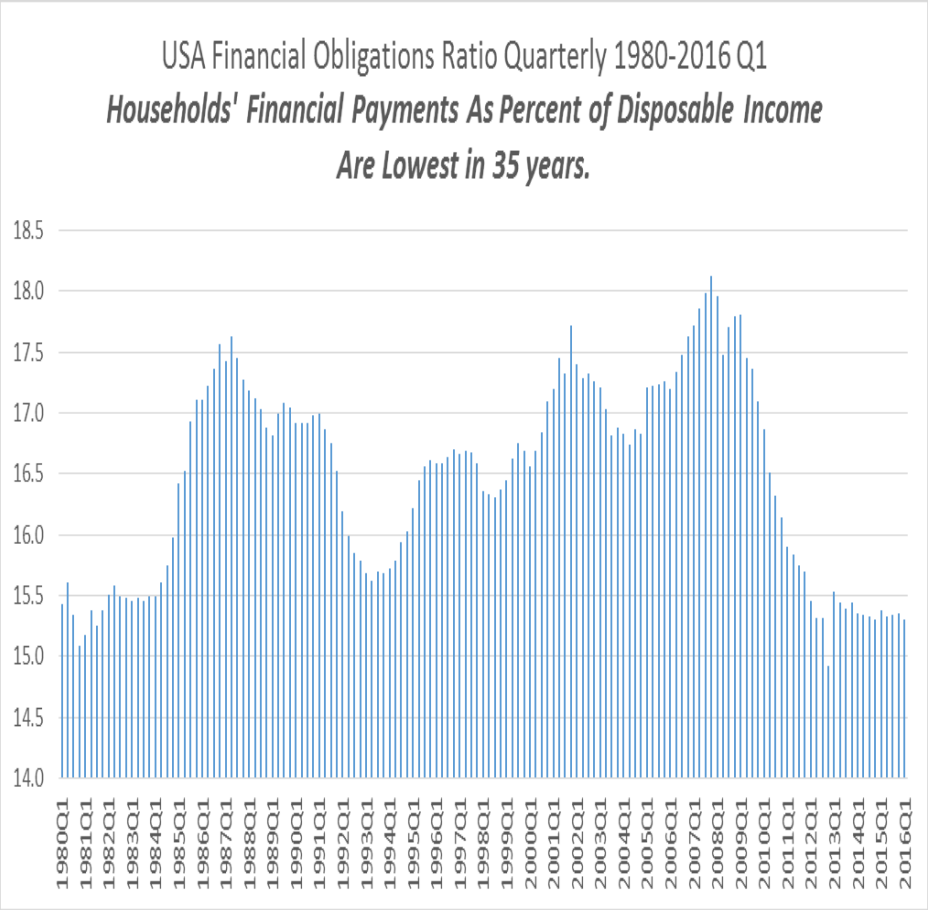


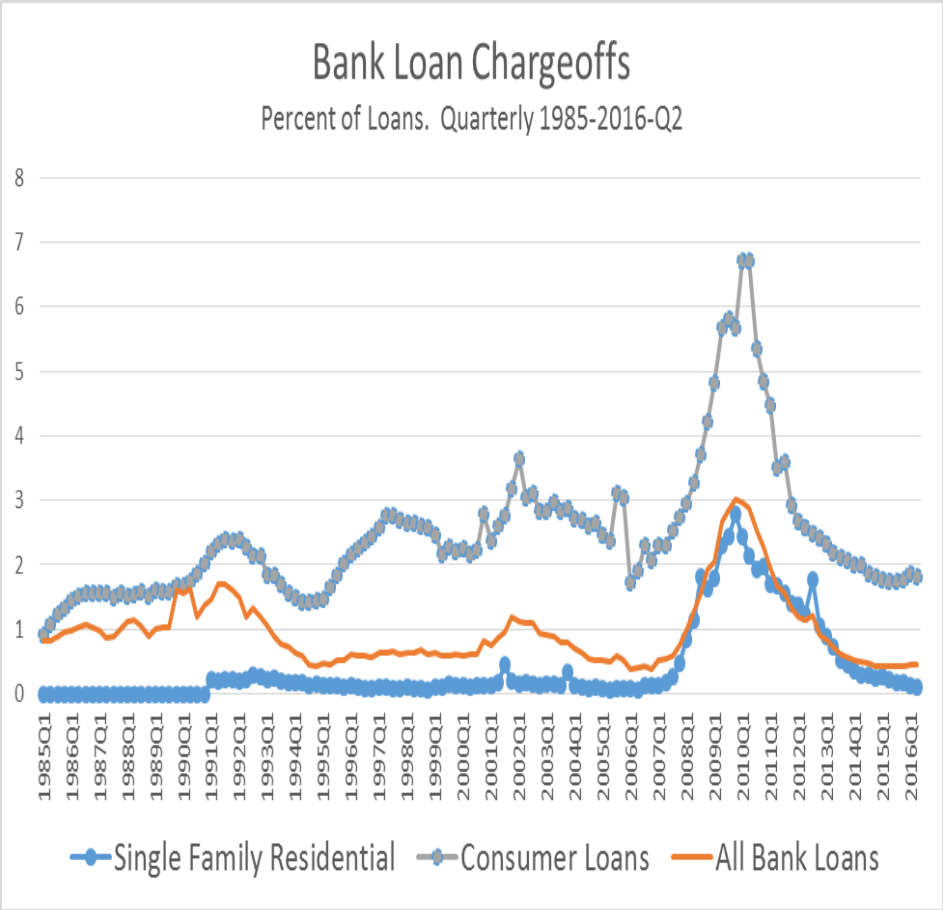


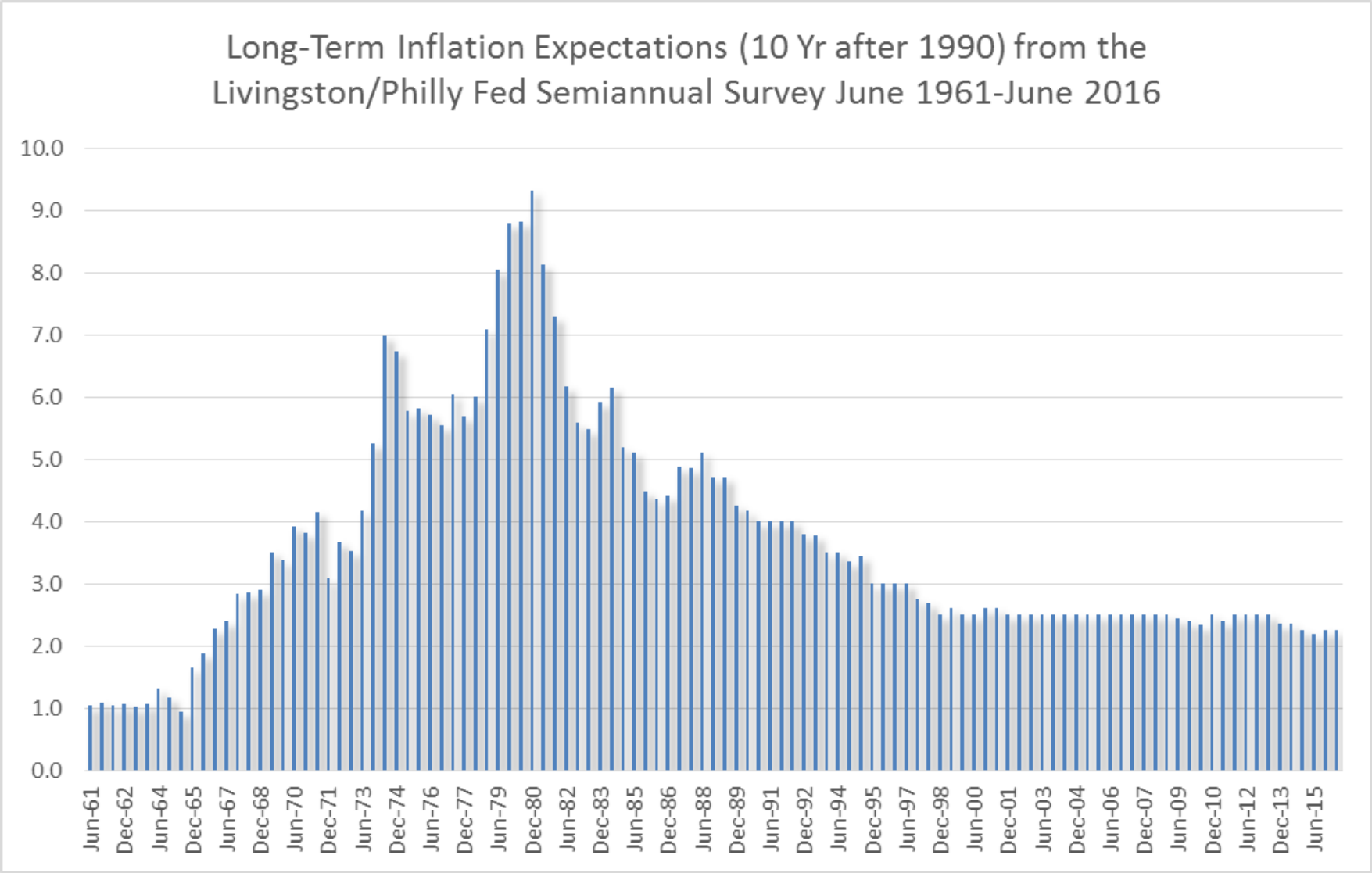
Sources: Above: USA Federal Reserve data.
Right: IMF World
Economic Outlook, April 2016.

Benefits of Fed Intervention in the financial crisis:

Loans were refinanced at lower rates, affordable. Households got many payments back on schedule, fewer defaults and chargeoffs to banks.






Long-Term Inflation Expectations (10 Yr after 1990) from the Livingston/Philly Fed Semiannual Survey June 1961-June 2016
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Jun-61
Dec-62
Jun-64
Dec-65
Jun-67
Dec-68
Jun-70
Dec-71
Jun-73
Dec-74
Jun-76
Dec-77
Jun-79
Dec-80
Jun-82
Dec-83
Jun-85
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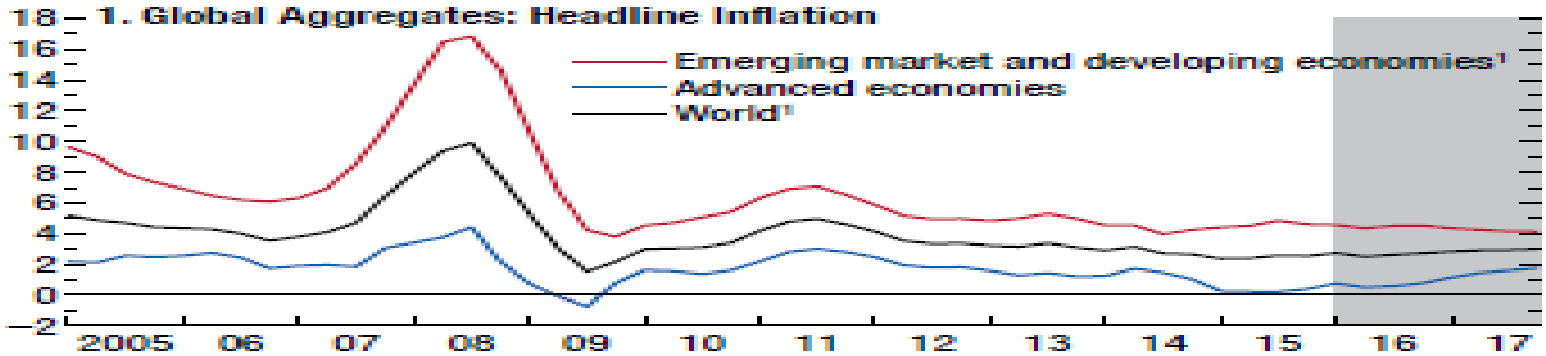
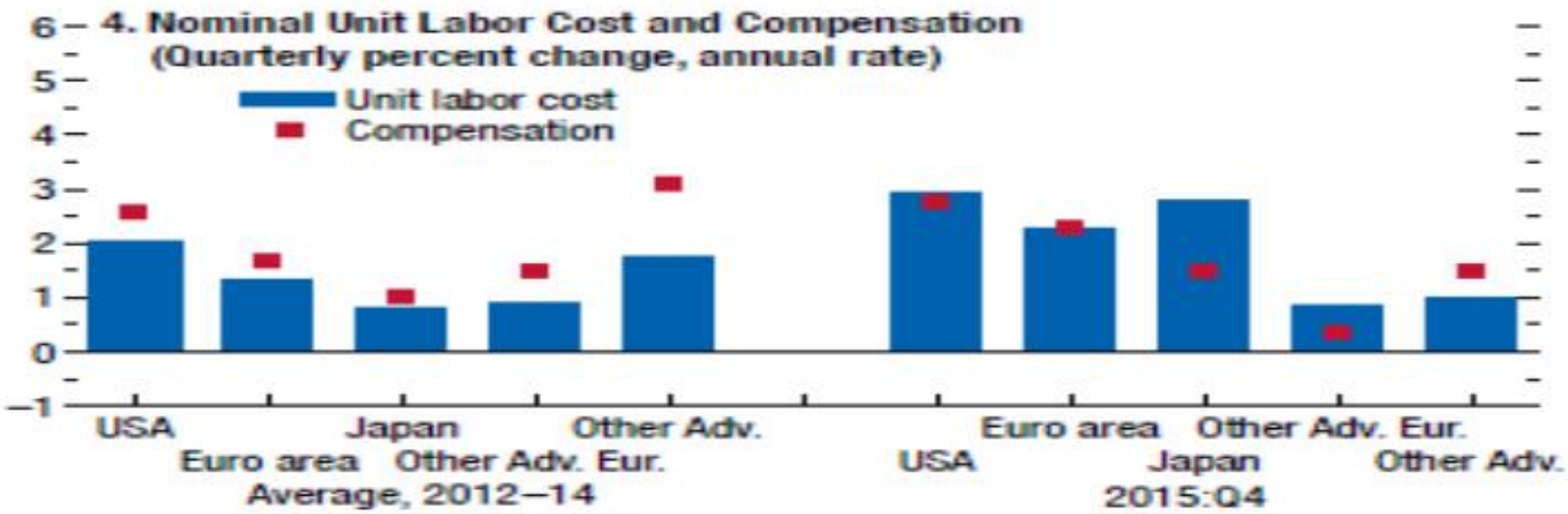
Jun-94
Dec-95
Jun-97
Dec-98
Jun-00
Dec-01
Jun-03
Dec-04
Jun-06
Dec-07
Jun-09
Dec-10
Jun-12
Dec-13
Jun-15

Figure 1.2. Global Inflation

(Year-over-year percent change, unless noted otherwise)

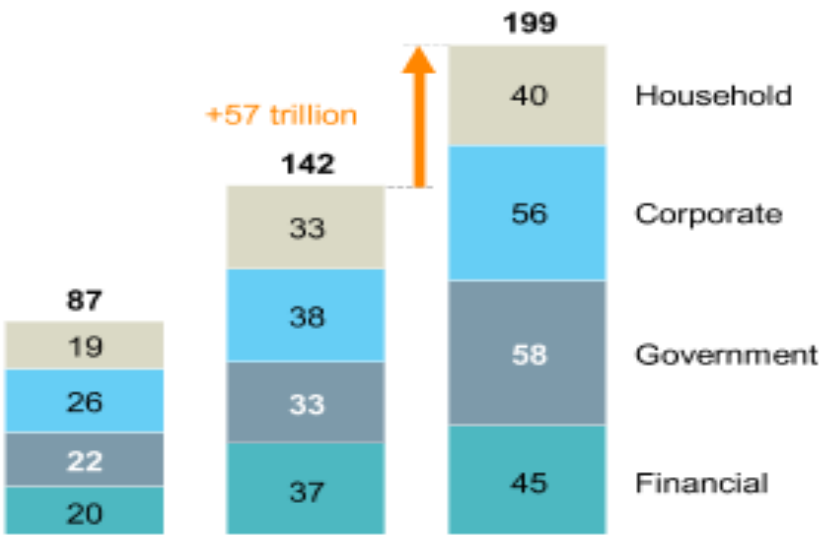
Headline inflation has declined further in advanced economies, mostly reflecting the decline in the price of oil. In emerging market economies, lower commodity prices have also contributed to lowering headline inflation, but sizable currency depreciation has led to offsets on the upside in some economies.





Global debt has increased by $57 trillion since 2007, outpacing world GDP growth

Global stock of debt outstanding by type[1]
$ trillion, constant 2013 exchange rates



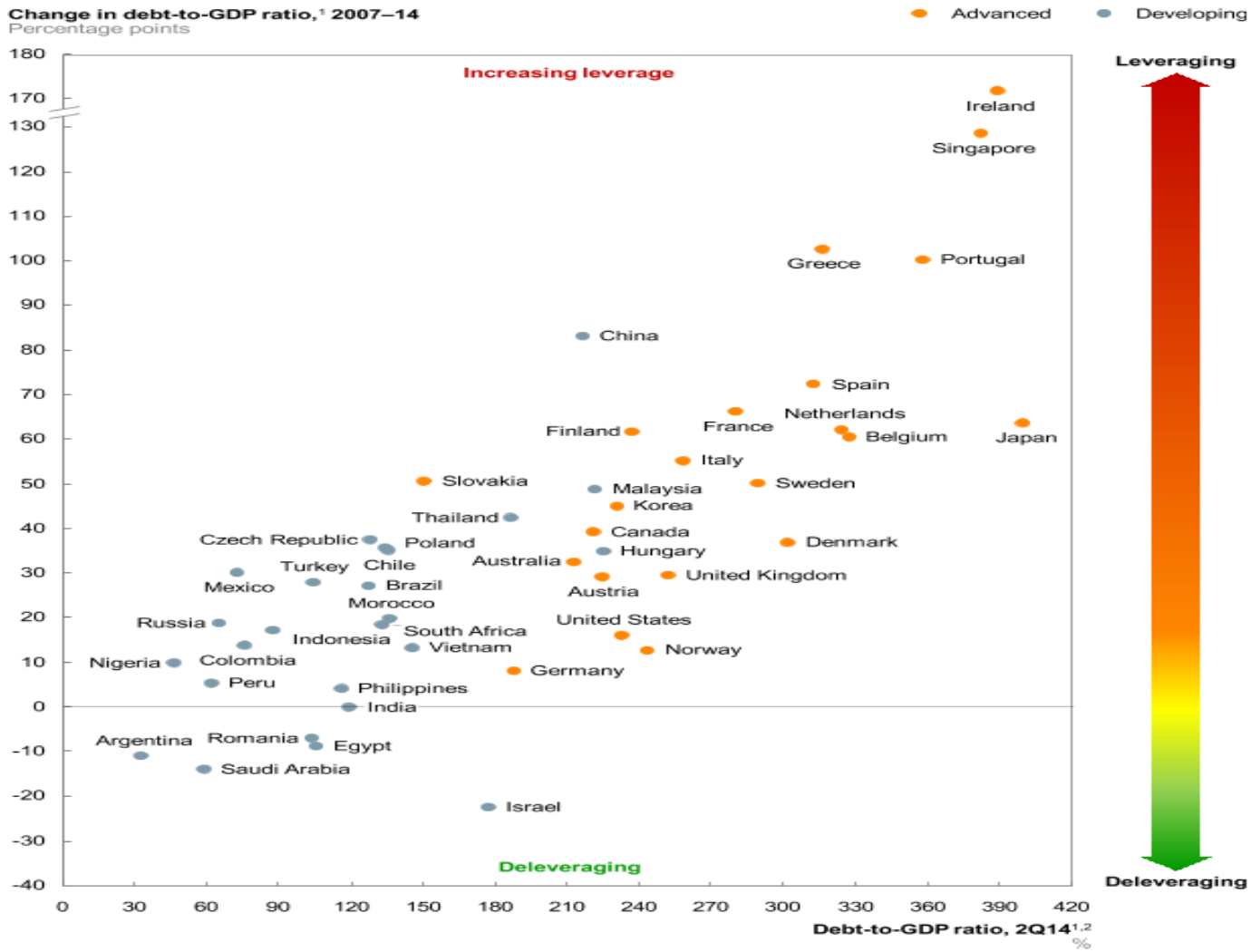
	Compound annual growth rate (%)	
	2000–07	2007–14[1]
	7.3	5.3
Household	8.5	2.8
Corporate	5.7	5.9
Government	5.8	9.3
Financial	9.4	2.9

	4Q00	4Q07	2Q14[1]
Total debt as % of GDP	246	269	286

1 2Q14 data for advanced economies and China; 4Q13 data for other developing economies.
NOTE: Numbers may not sum due to rounding.

SOURCE: Haver Analytics; national sources; *World economic outlook*, IMF; BIS; McKinsey Global Institute analysis

The ratio of debt to GDP has increased in all advanced economies since 2007



1 Debt owed by households, non-financial corporates, and governments.
2 2Q14 data for advanced economies and China; 4Q13 data for other developing economies.

SOURCE: Haver Analytics; national sources; McKinsey Global Institute analysis

Change in debt-to-GDP ratio since 2007 by country

Ranked by real economy debt-to-GDP ratio, 2Q14[1]

Advanced economy ↕ Leveraging
Developing economy ↕ Deleveraging

Rank	Country	Debt-to-GDP ratio[1] %	Real economy debt change, 2007–14 Percentage points: Total	Government	Corporate	Household	Financial sector debt change
1	Japan	400	64	63	2	-1	6
2	Ireland	390	172	93	90	-11	-25
3	Singapore	382	129	22	92	15	23
4	Portugal	358	100	83	19	-2	38
5	Belgium	327	61	34	15	11	4
6	Netherlands	325	62	38	17	7	38
7	Greece	317	103	70	13	20	1
8	Spain	313	72	92	-14	-6	-2
9	Denmark	302	37	22	7	8	37
10	Sweden	290	50	1	31	18	37
11	France	280	66	38	19	10	15
12	Italy	259	55	47	3	5	14
13	United Kingdom	252	30	50	-12	-8	2
14	Norway	244	13	-16	16	13	16
15	Finland	238	62	29	17	15	24
16	United States	233	16	35	-2	-18	-24
17	South Korea	231	45	15	19	12	2
18	Hungary	225	35	15	21	-1	10
19	Austria	225	29	23	6	0	-21
20	Malaysia	222	49	17	16	16	6
21	Canada	221	39	18	6	15	-6
22	China	217	83	13	52	18	41
23	Australia	213	33	23	-1	10	-8
24	Germany	188	8	17	-2	-6	-16
25	Thailand	187	43	11	6	26	21
26	Israel	178	-22	-4	-21	3	-2
27	Slovakia	151	51	28	8	14	-5
28	Vietnam	146	13	10	-1	5	2
29	Morocco	136	20	8	7	5	3
30	Chile	136	35	6	20	9	9
31	Poland	134	36	14	9	13	9
32	South Africa	133	19	18	2	-2	-3
33	Czech Republic	128	37	19	9	9	4
34	Brazil	128	27	3	15	9	13
35	India	120	0	-5	6	-1	5
36	Philippines	116	4	-3	9	-2	-5
37	Egypt	106	-9	9	-18	0	-8
38	Turkey	104	28	-4	22	10	11
39	Romania	104	-7	26	-35	1	-4
40	Indonesia	88	17	-5	17	6	-2
41	Colombia	76	14	1	8	5	3
42	Mexico	73	30	19	10	1	-1
43	Russia	65	19	3	9	7	-4
44	Peru	62	5	-10	11	5	2
45	Saudi Arabia	59	-14	-15	2	-1	-8
46	Nigeria	46	10	7	1	2	-1
47	Argentina	33	-11	-14	1	2	-5

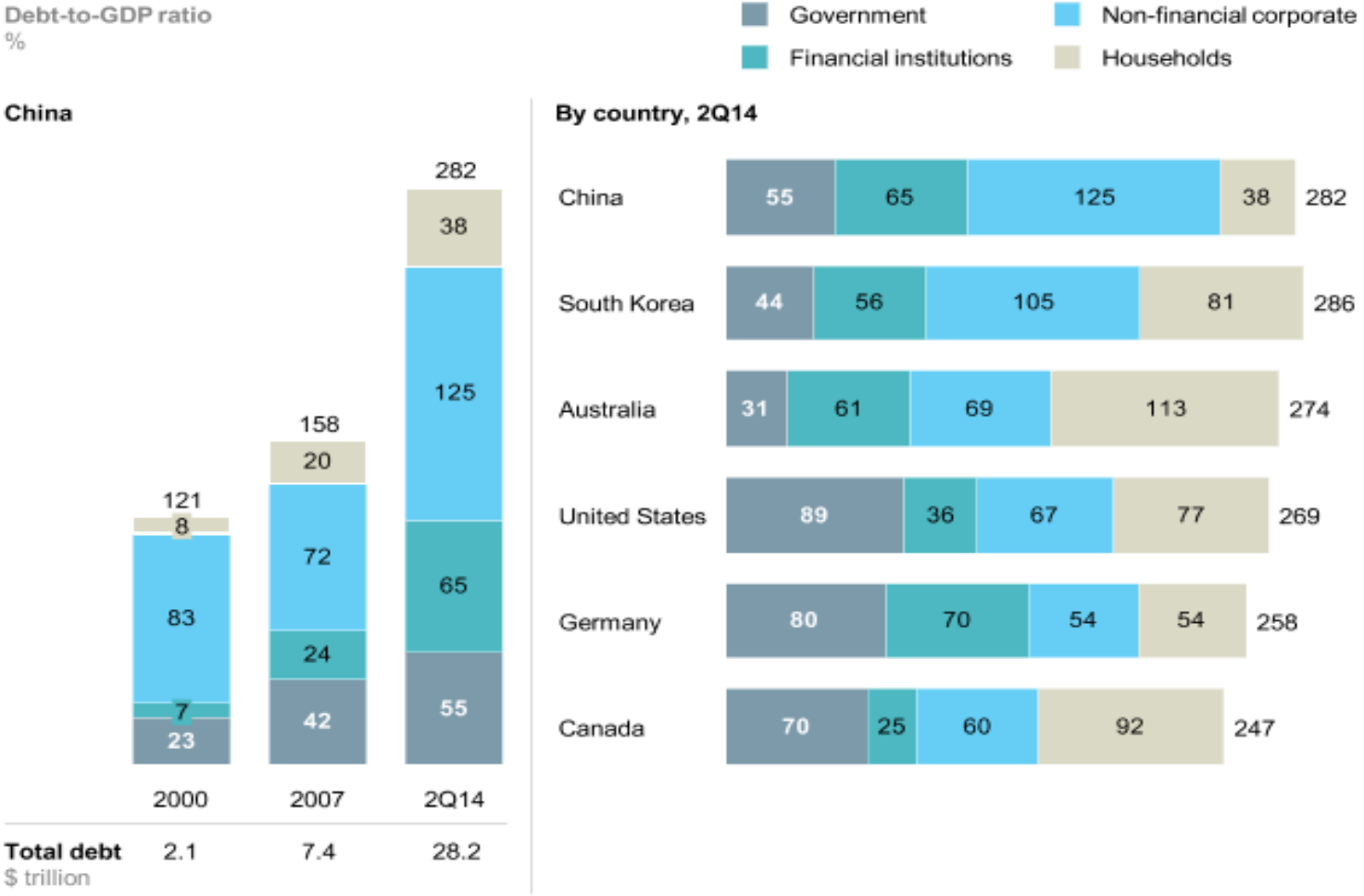
1 Includes debt of households, non-financial corporations, and government; 2Q14 data for advanced economies and China; 2013 data for other developing economies.

NOTE: Numbers may not sum due to rounding.

SOURCE: *World economic outlook*, IMF; BIS; Haver Analytics; national central banks; McKinsey Global Institute analysis

Exhibit E7

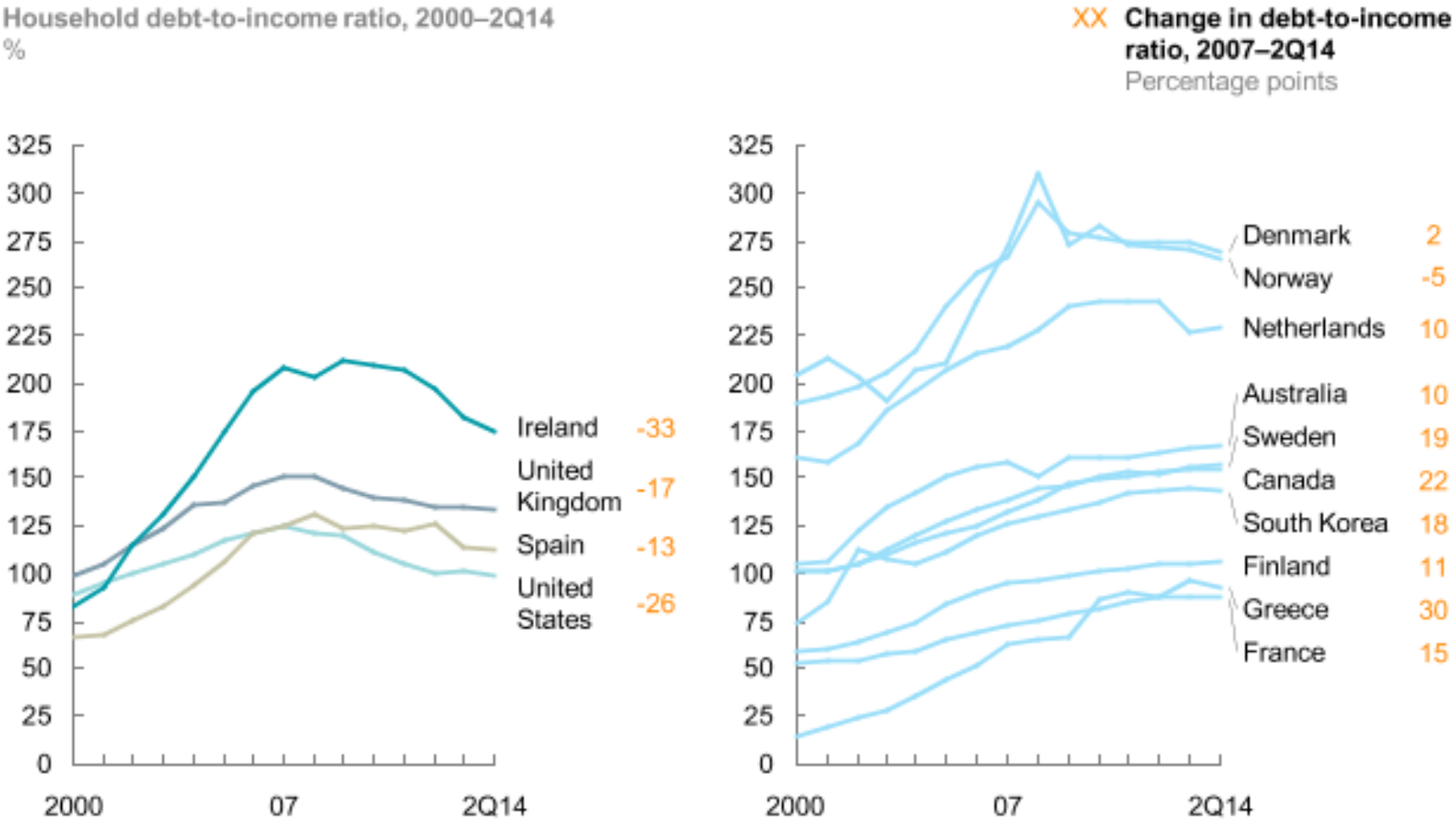
China's debt reached 282 percent of GDP in 2014, higher than debt levels in some advanced economies



NOTE: Numbers may not sum due to rounding.

SOURCE: MGI Country Debt database; McKinsey Global Institute analysis

Households in the hard-hit countries have deleveraged, but household debt has continued to grow in most advanced economies



SOURCE: Haver Analytics; national central banks; McKinsey Global Institute analysis

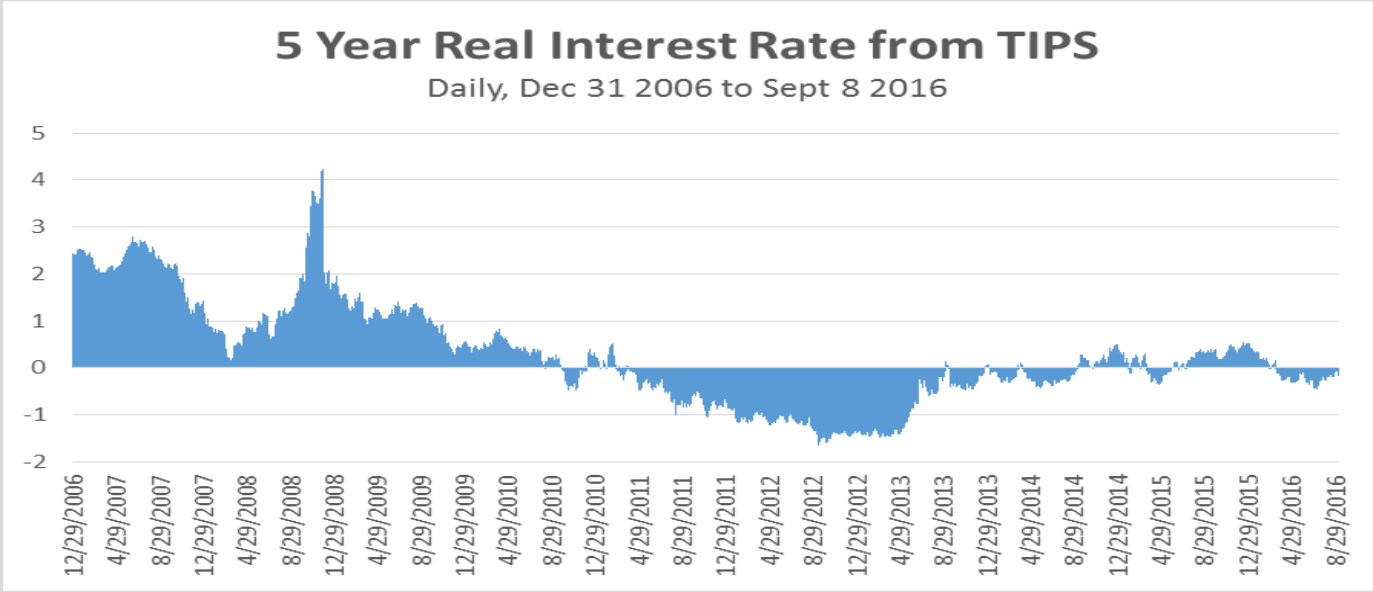
Even After Brexit Growth Reductions, IMF Forecasts Show Positive Growth for 2017 for every major economy. New normal.

IMF World Economic Update
July 2016, Post Brexit Vote

Table 1. Overview of the *World Economic Outlook* Projections

(Percent change unless noted otherwise)

	Year over Year						Q4 over Q4 2/		
			Projections		Difference from April 2016 WEO Projections 1/			Projections	
	2014	2015	2016	2017	2016	2017	2015	2016	2017
World Output	**3.4**	**3.1**	**3.1**	**3.4**	**–0.1**	**–0.1**	**3.0**	**3.2**	**3.5**
Advanced Economies	**1.9**	**1.9**	**1.8**	**1.8**	**–0.1**	**–0.2**	**1.8**	**1.8**	**1.9**
United States	2.4	2.4	2.2	2.5	–0.2	0.0	2.0	2.5	2.3
Euro Area	0.9	1.7	1.6	1.4	0.1	–0.2	1.7	1.4	1.5
Germany	1.6	1.5	1.6	1.2	0.1	–0.4	1.3	1.5	1.3
France	0.6	1.3	1.5	1.2	0.4	–0.1	1.4	1.3	1.4
Italy	–0.3	0.8	0.9	1.0	–0.1	–0.1	1.1	1.0	1.0
Spain	1.4	3.2	2.6	2.1	0.0	–0.2	3.5	1.8	2.5
Japan	0.0	0.5	0.3	0.1	–0.2	0.2	0.8	0.6	0.2
United Kingdom	3.1	2.2	1.7	1.3	–0.2	–0.9	1.8	1.2	1.5
Canada	2.5	1.1	1.4	2.1	–0.1	0.2	0.3	1.8	2.2
Other Advanced Economies 3/	2.8	2.0	2.0	2.3	–0.1	–0.1	2.2	2.0	2.6
Emerging Market and Developing Economies	**4.6**	**4.0**	**4.1**	**4.6**	**0.0**	**0.0**	**4.1**	**4.4**	**4.9**
Commonwealth of Independent States	1.1	–2.8	–0.6	1.5	0.5	0.2	–3.4	–0.3	1.8
Russia	0.7	–3.7	–1.2	1.0	0.6	0.2	–4.0	–0.3	1.8
Excluding Russia	1.9	–0.6	1.0	2.5	0.1	0.2	. . .	. . .	. . .
Emerging and Developing Asia	6.8	6.6	6.4	6.3	0.0	0.0	6.8	6.3	6.3
China	7.3	6.9	6.6	6.2	0.1	0.0	6.8	6.5	6.1
India 4/	7.2	7.6	7.4	7.4	–0.1	–0.1	8.1	7.4	7.4
ASEAN-5 5/	4.6	4.8	4.8	5.1	0.0	0.0	4.8	4.5	5.3
Emerging and Developing Europe	2.8	3.6	3.5	3.2	0.0	–0.1	4.1	3.3	3.0
Latin America and the Caribbean	1.3	0.0	–0.4	1.6	0.1	0.1	–1.4	0.0	2.1
Brazil	0.1	–3.8	–3.3	0.5	0.5	0.5	–5.9	–1.2	1.1
Mexico	2.2	2.5	2.5	2.6	0.1	0.0	2.4	2.4	2.8
Middle East, North Africa, Afghanistan, and Pakistan	2.7	2.3	3.4	3.3	0.3	–0.2	. . .	. . .	. . .
Saudi Arabia	3.6	3.5	1.2	2.0	0.0	0.1	1.8	1.0	2.4
Sub-Saharan Africa	5.1	3.3	1.6	3.3	–1.4	–0.7	. . .	. . .	. . .
Nigeria	6.3	2.7	–1.8	1.1	–4.1	–2.4	. . .	. . .	. . .
South Africa	1.6	1.3	0.1	1.0	–0.5	–0.2	0.2	0.4	1.1
Memorandum									
Low-Income Developing Countries	6.0	4.5	3.8	5.1	–0.9	–0.4	. . .	. . .	. . .
World Growth Based on Market Exchange Rates	2.7	2.5	2.5	2.8	0.0	–0.1	2.3	2.6	2.8


5 Year Real Interest Rate from TIPS
Daily, Dec 31 2006 to Sept 8 2016
5
4
3
2
1
0
-1
-2
12/29/2006
4/29/2007
8/29/2007
12/29/2007
4/29/2008
8/29/2008
12/29/2008
4/29/2009
8/29/2009
12/29/2009
4/29/2010
8/29/2010
12/29/2010
4/29/2011
8/29/2011
12/29/2011
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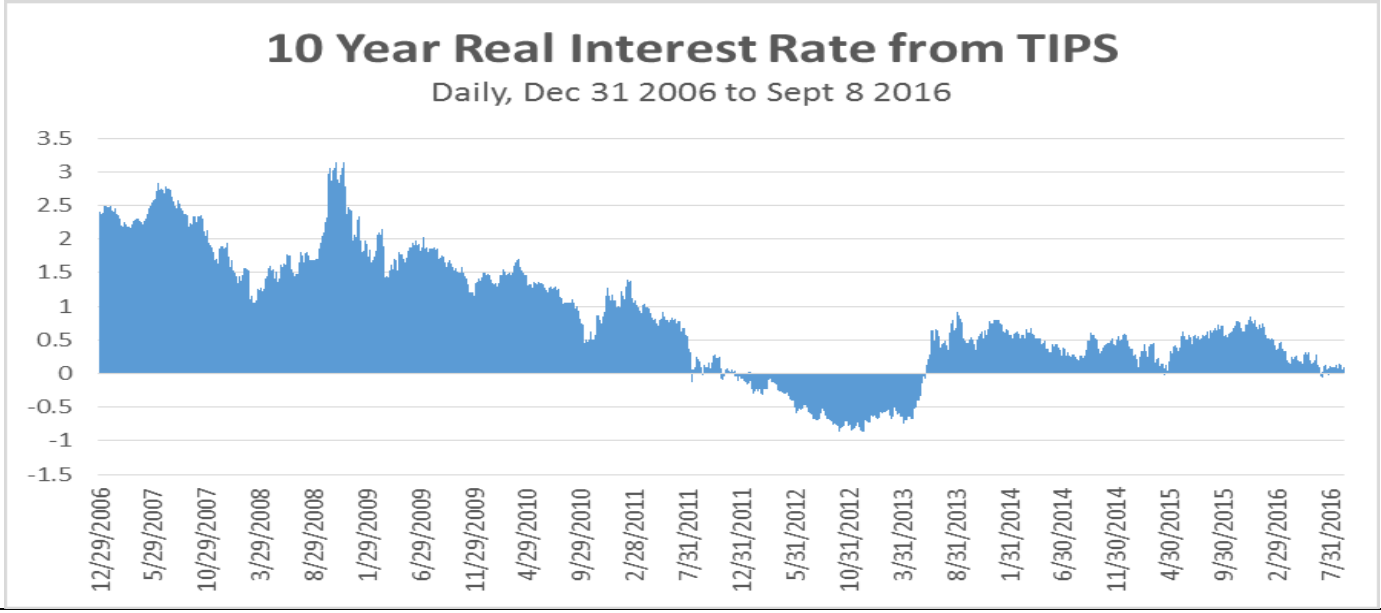
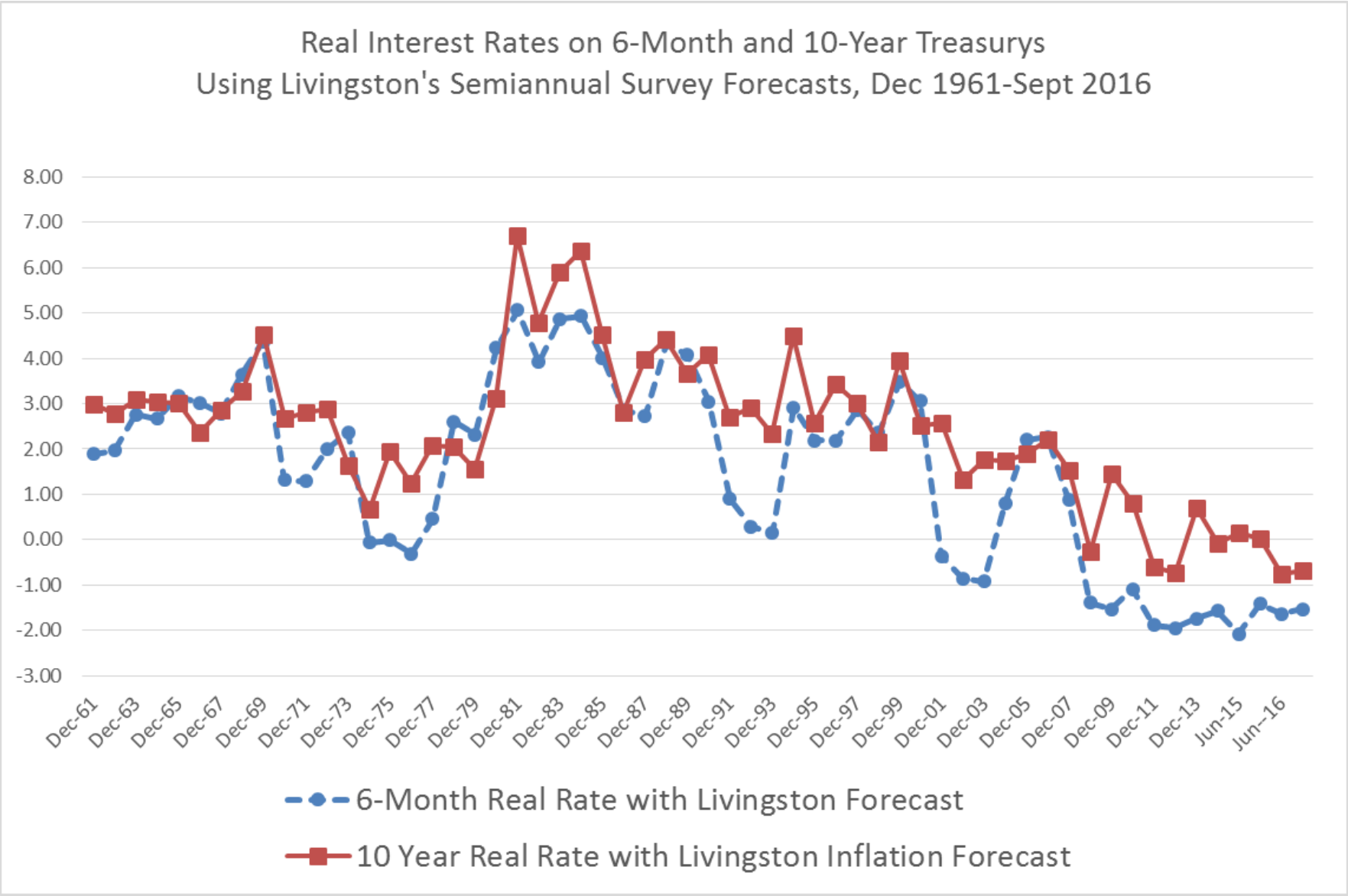
8/29/2015
12/29/2015
4/29/2016
8/29/2016


10 Year Real Interest Rate from TIPS
Daily, Dec 31 2006 to Sept 8 2016
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
12/29/2006
5/29/2007
10/29/2007
3/29/2008
8/29/2008
1/29/2009
6/29/2009
11/29/2009
4/29/2010
9/29/2010
2/28/2011
7/31/2011
12/31/2011
5/31/2012
10/31/2012
3/31/2013
8/31/2013
1/31/2014
6/30/2014
11/30/2014
4/30/2015
9/30/2015
2/29/2016
7/31/2016


Real Interest Rates on 6-Month and 10-Year Treasurys
Using Livingston's Semiannual Survey Forecasts, Dec 1961-Sept 2016
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
Dec-61
Dec-63
Dec-65
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Dec-69
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Dec-11
Dec-13
Jun-15
Jun--16
6-Month Real Rate with Livingston Forecast
10 Year Real Rate with Livingston Inflation Forecast

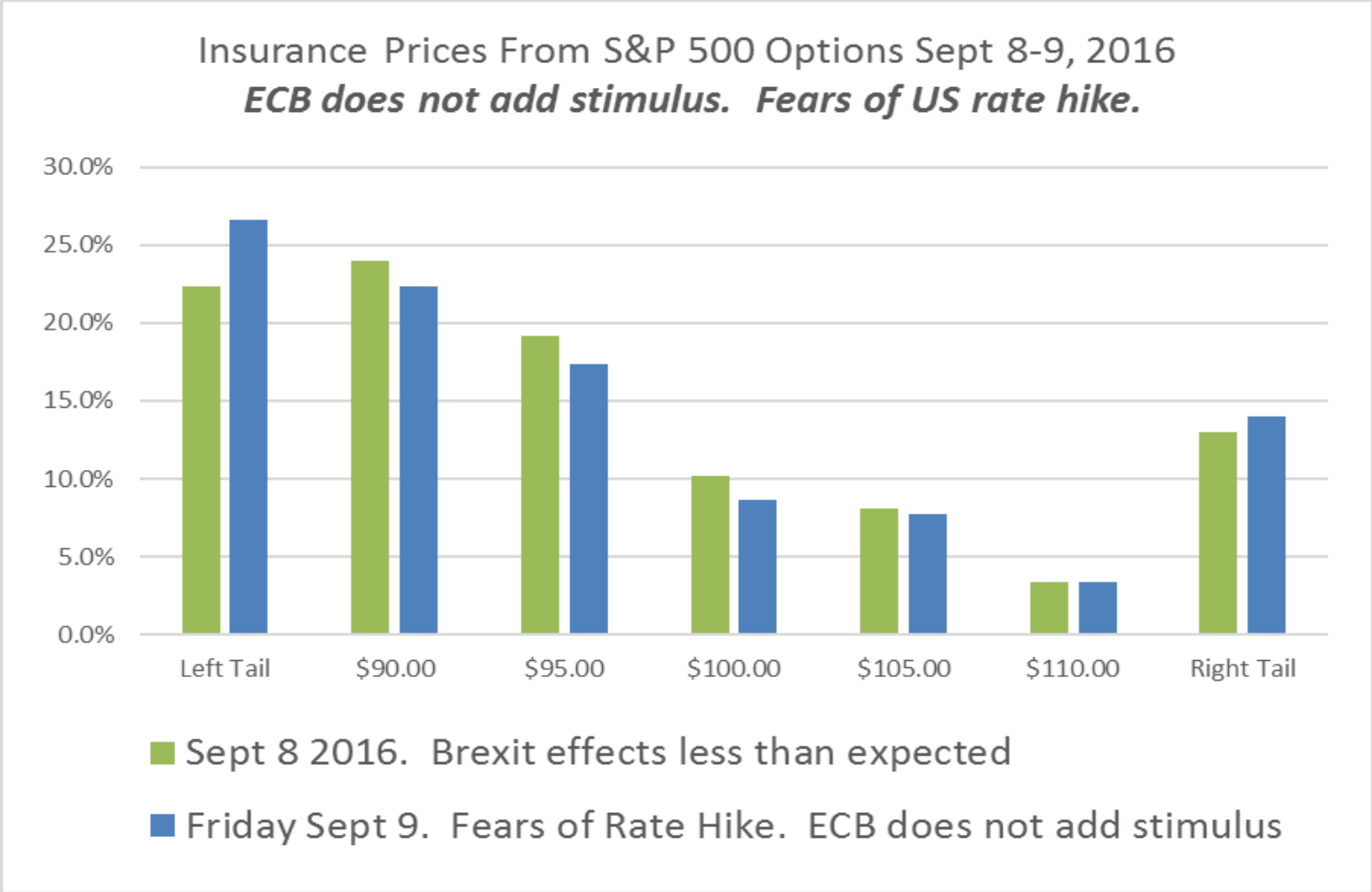
Issues with Massive Central Bank Intervention, Ultra Low Rates

- Since December 2008, real interest rates have been the lowest in 50 years. Low rates allowed troubled borrowers to refinance, reduce payments, get current. Combined with jobs growth, consumption spending stronger.
- Ultra low rates have not stimulated much borrowing to invest or consume, as stated reasons of weak economies make firms, individuals want to save.
- There are multiple equilibria possible on rates. Ultra low rate equilibrium is not a good one. Liquidity trap limits potency, flexibility of tools.
- Quantitative easing only works for short time. Not good for government to own large fractions of debt or equity. Healthier for risk to be priced properly and give rewards sufficient for firms to want to buy assets.

Issues with Massive Central Bank Intervention, Ultra Low Rates

- Many economies have aging populations. In the USA, 10,000 people retire every day now, as boomers retire.
- Ultra low rates are directly harmful to retirees and to pensions, endowments, insurance companies and banks (think of European banks at present). Large increases in costs of insurance are harmful and surely unintended consequences. As Bill Gross said in the FT, we are harming the financial engine of the economy.
- Government should only intervene in extraordinary circumstances. Not now. Asia, Americas, Europe, Africa all growing now. Time to normalize. Economic growth will be slower as people retire. That's ok. Lower unemployment.
- Focus on fiscal policy, structural impediments. Legal, regulatory costs of business. Profits are good and necessary for firms to hire and grow.

Maybe some central bankers share these worries…
Beginning of global rate normalization? A sign of strength.



X. Conclusions

1. The "Great Recession" in the USA and the "Sovereign Debt Crisis" in Europe show dramatic moves in distributions for rates after Central Bank interventions. Symmetric distributions shifted to highly positively skewed ones.

2. USA "lifted off" from zero rates in December 2015, given the relatively strong USA economy. Despite liftoff, US stock market is near all-time highs. Strong job market brought the unemployment rate down to 4.9%. However, markets are worried about economy in 5 years, as the "bipolar" rate distribution shows.

3. January-March 2015 Weakness in Europe caused European Central Bank President Mario Draghi to announce a massive "Quantitative Easing" program of asset purchases. Rates dropped sharply after that implementation. German Bund 10-year yield down from 0.38% to 0.09% and negative levels in 2016.

4. The U.K. vote for "Brexit" on June 23, 2016, roiled markets for a bit, with interest rates and the British Pound falling sharply. Stock prices dropped sharply, especially in the Eurozone, but have bounced back in most countries, partially due to strong jobs reports in the U.S. for June-July 2016. The Bank of England reduced its policy rate 25 basis points and prepared strong stimulus measures to combat weakness expected with Brexit and the uncertainties of negotiations with the EU. The insurance price distributions reflect lower rates anticipated in the UK for years.

5. Conditions now show not one of 17 TDEs forecasted by the IMF to be in recession in 2017. USA, Japan, Germany, UK, and Spain have unemployment rates that are substantially down from their Great Recession and Sovereign Debt Crisis highs. Time for central banks to withdraw gradually.

6. Countries with households who reduced debt, such as USA, UK, Ireland and Spain, are doing the best. We do not need to stimulate borrowing beyond consumers' prudently chosen levels.

Douglas T. Breeden is the William W. Priest Professor of Finance and former Dean of Duke University's Fuqua School of Business. He also served on faculties at Chicago Booth, Stanford and North Carolina, where he was the Dalton McMichael Professor of Finance. He was the Fischer Black Visiting Professor of Financial Economics at MIT's Sloan School in 2011-2013, winning an "Outstanding Teacher" award.

Breeden published seminal research on insurance prices implicit in option prices, the Consumption CAPM, and hedging mortgage securities. His current research is "A Stocks, Bonds, Consumers Leading Indicator" and (with Robert Litzenberger) "Central Bank Policy Impacts on the Distribution of Future Interest Rates," which won a Roger Murray Prize from the Q-Group. He has presented this research recently to central bank meetings in the USA, England, France and Italy, as well as at the International Monetary Fund.

Breeden was Associate Editor of 5 top journals. He was also Founding Editor and Editor for 10 years of the Journal of Fixed Income. He was elected to the Board of Directors of the American Finance Association and in 2010 a lifetime Fellow. The International Association for Quantitative Finance named Breeden "Financial Engineer of the Year 2013" for being an "industry pioneer."

Breeden holds a Ph.D. in Finance from Stanford and an S.B. from M.I.T. He served on the MIT President's Council, the Sloan School Visiting Committee and the Stanford Business School Advisory Council. He was named an Honorary Professor of the Chinese Academy of Sciences and served on the Boards of Goethe Business School in Germany and the Financial Management Association. He is on the Board of Trustees of Commonfund. Breeden is a Senior Research Consultant for Amundi Smith Breeden, a money management firm that he co-founded.

This research information and data is presented for informational purposes only. The views presented are subject to change and do not necessarily represent Amundi Smith Breeden's views. This information is not to be considered investment advice.