May 25, 2018 (2018-3)

Stock and Bond Insurance Costs Implicit in Option Prices

Douglas T. Breeden
William W. Priest Professor of Finance, Fuqua School of Business, Duke University[1]

In the first half of 2018, global GDP growth was strong and unemployment lower in America, Europe, and Asia-Pacific. Inflation is steady or increasing in all three regions, supported by rising oil prices. The USA 10-year interest yield crossed 3%, highest in 7 years and the unemployment rate dropped to 3.9%. Stock prices have seesawed, buffeted by higher interest rates and fears of a USA-China trade war, but held up by surging corporate profits. After a sharp rise in volatility in February, volatility (VIX) has dropped back from 37% to 13%. Interest rate option prices show investors expect normalization to begin in Europe, following the USA. Stock options show that the surge in risk aversion in February has subsided.

I. Global Growth, Unemployment, Inflation and Interest Rates

In the first half of 2018, global growth has continued to be strong, with uemployment rates dropping in many countries to their lowest levels since the Great Recession, as Table 1 shows. Unemployment is at 3.9% in the USA, for the first time in 18 years. Canada and Mexico are also very low, thought Brazil is still suffering. Unemployment in Europe is dropping significantly in all major countries, and Japan is down to 2.5%. Life is good (at least, much better) in many countries in the 3 major mega-economies at present!

Table 1

Global Unemployment Rates

Douglas T. Breeden, Duke University **5/25/2018 8:12**

	USA	Canada	Brazil	Mexico	France	Germany	Italy	Spain	UK	Russia	Turkey	Japan	Australia	S Korea	China	India	Indonesia
2006-Q4	4.4	6.1	0.0	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-Q4	4.8	5.9	0.0	3.7	7.4	8.5	6.4	8.6	5.2	5.9	9.4	3.8	4.3	3.2	4.0	0.0	0.0
2008-Q4	6.9	6.6	0.0	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-Q4	9.9	8.5	0.0	5.5	9.5	8.1	8.2	18.8	7.8	8.1	12.3	5.2	5.6	3.6	4.3	0.0	0.0
2010-Q4	9.5	7.7	0.0	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-Q4	8.6	7.4	0.0	5.0	9.3	6.8	9.1	22.6	8.4	6.3	8.5	4.5	5.2	3.2	4.1	0.0	0.0
2012-Q4	7.8	7.3	7.3	5.1	10.1	6.8	11.4	25.9	7.8	5.1	8.6	4.2	5.4	3.1	4.1	0.0	0.0
2013-Q4	6.9	7.1	6.9	4.7	10.1	6.8	12.3	25.8	7.2	5.5	9.1	3.9	5.8	3.1	4.0	0.0	0.0
2014-Q4	5.7	6.7	6.9	4.5	10.5	6.6	12.7	23.7	5.8	5.2	10.4	3.5	6.2	3.6	4.1	0.0	0.0
2015-Q4	5.0	7.1	9.5	4.3	10.2	6.3	11.6	20.9	5.1	5.7	10.3	3.3	5.8	3.5	4.1	0.0	0.0
2016-Q4	4.7	6.9	12.6	3.6	10.0	6.0	11.8	18.7	4.8	5.4	11.8	3.1	5.7	3.6	4.0	0.0	0.0
2017-Q4	4.1	6.0	12.0	3.4	9.1	5.8	11.1	16.6	4.2	4.9	10.1	2.7	5.5	3.7	4.0	0.0	0.0
2018-Mar/Apr	3.9	5.8	12.7	3.2	8.8	5.6	11.0	16.1	4.1	4.9	9.9	2.5	5.5	4.0	4.0	0.0	0.0

[1] I thank Song Xiao and Shijie Luo of Duke for excellent research assistance.

Real GDP growth and inflation rates are shown in the Appendix graphs A-1 to A-3. Asia-Pacific continues to lead global growth, given the strength of India and China and most other economies in Asia. UK economic growth has fallen behind that of the Eurozone and the USA, given Brexit-related uncertainty and movement of some jobs to the Eurozone, though unemployment in the UK remains very low at 4.1% and stocks are surging there.

Figure 1 shows that CPI inflation has been increasing in the past 2 years and is near the 2% goals of the USA and Europe. Figure 2 shows that oil prices have continued to increase significantly, which creates inflationary pressures. Breakeven USA inflation rates extracted from the bond market prices are shown in Figure 3 and the 10-year breakeven is at 2.15%. With such strong global growth, such low unemployment, and inflation that seems likely to build to 2%+, I continue to believe that central banks in all major economies should be steadily withdrawing stimulus and normalizing rates. The USA has been doing that for the last couple of years, and has had no ill effects, given the strong economy, strong consumers, strong jobs, strong household net worth and highly profitable firms. I think the UK, the Eurozone and Japan should all quickly follow the USA with normalization.

Figure 1

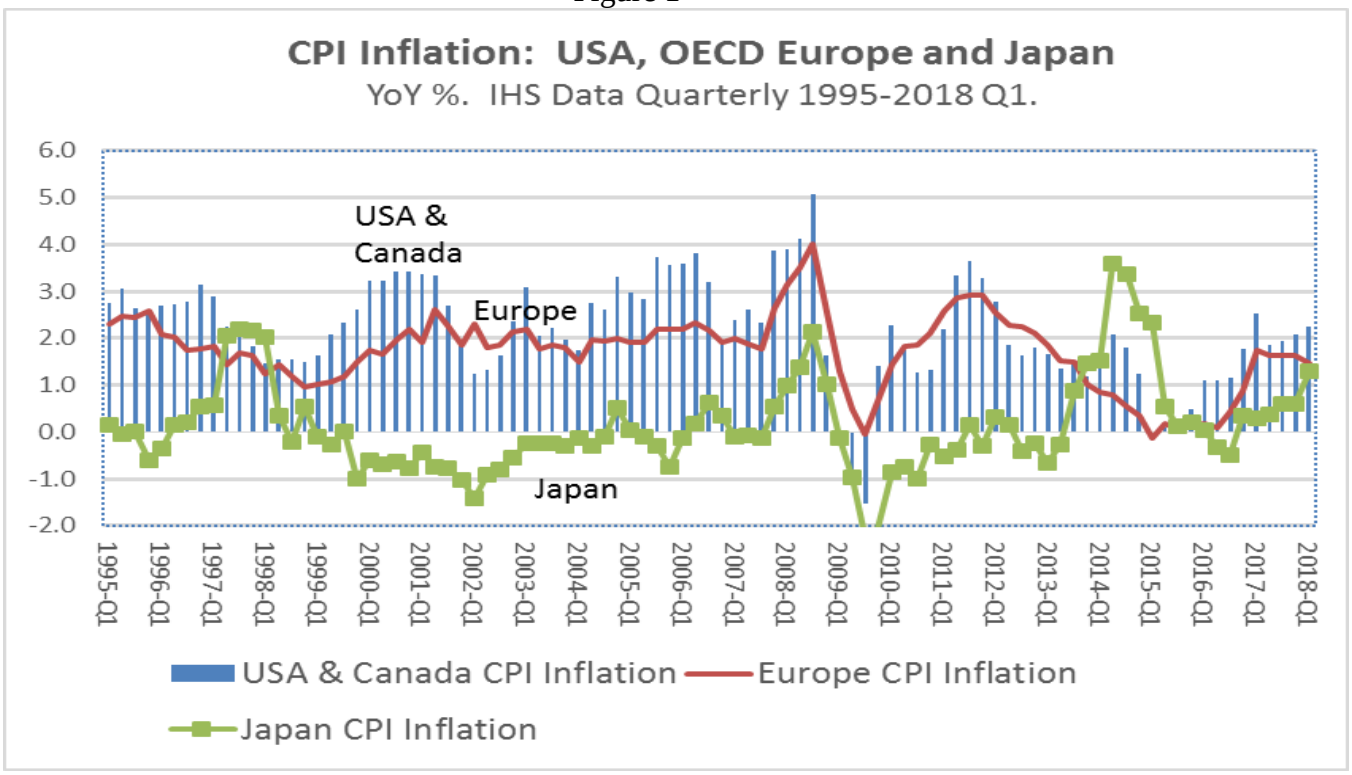


Figure 2

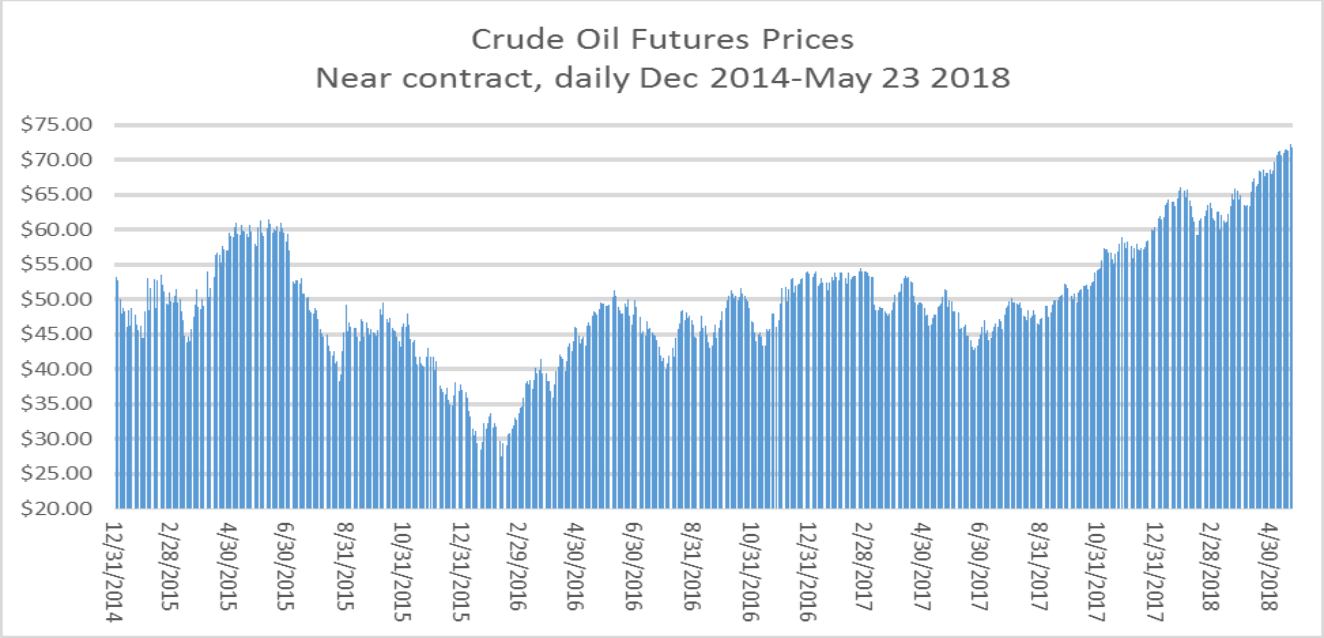
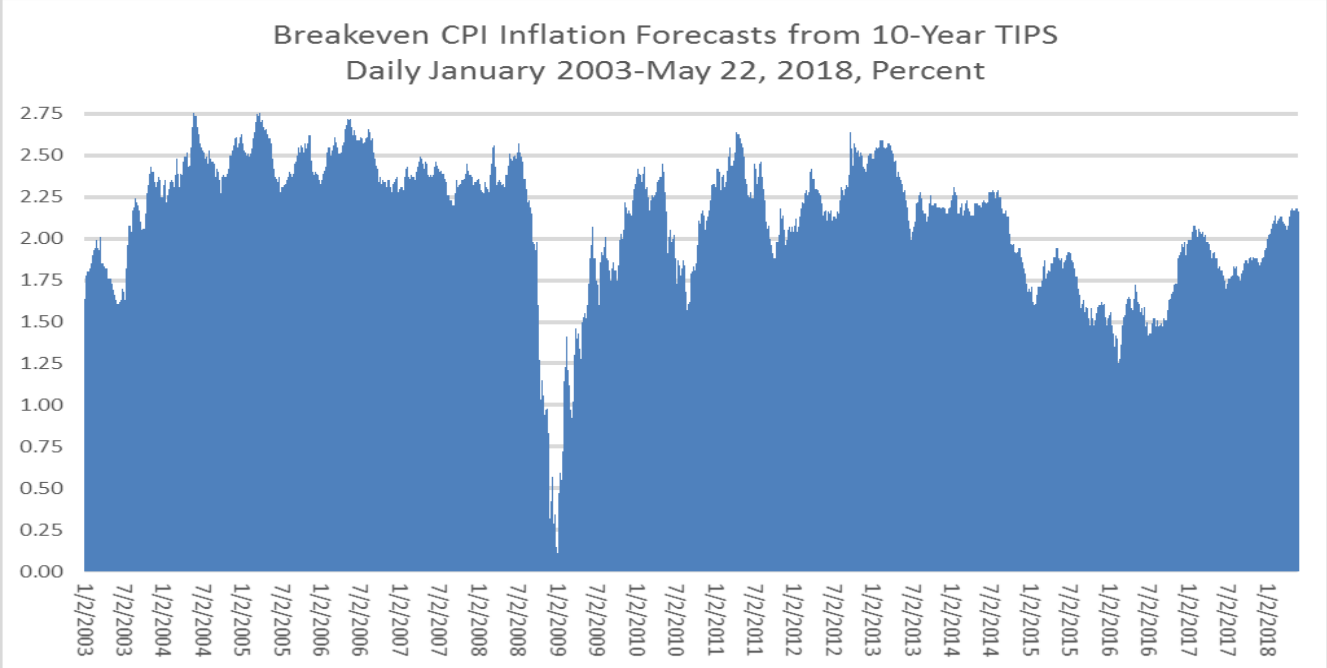


Figure 3



The steadily building short-term rate in the USA and a minor liftoff in the UK are shown in Figure 4A. Germany and Japan still have negative short rates, which seem highly inappropriate, given the strength of their economies, absence of deflation and their super-low unemployment rates. Long-term rates (Figure 4B) in the USA increased to 3.1% (highest since 2011), prior to backing off to near 3.0%. Notably, Figure 5 shows that the **real** 10-year interest rate has moved up close to 1.0%, but remains below the longer term (pre-2008) norm of about 2.0%.

Figure 4A

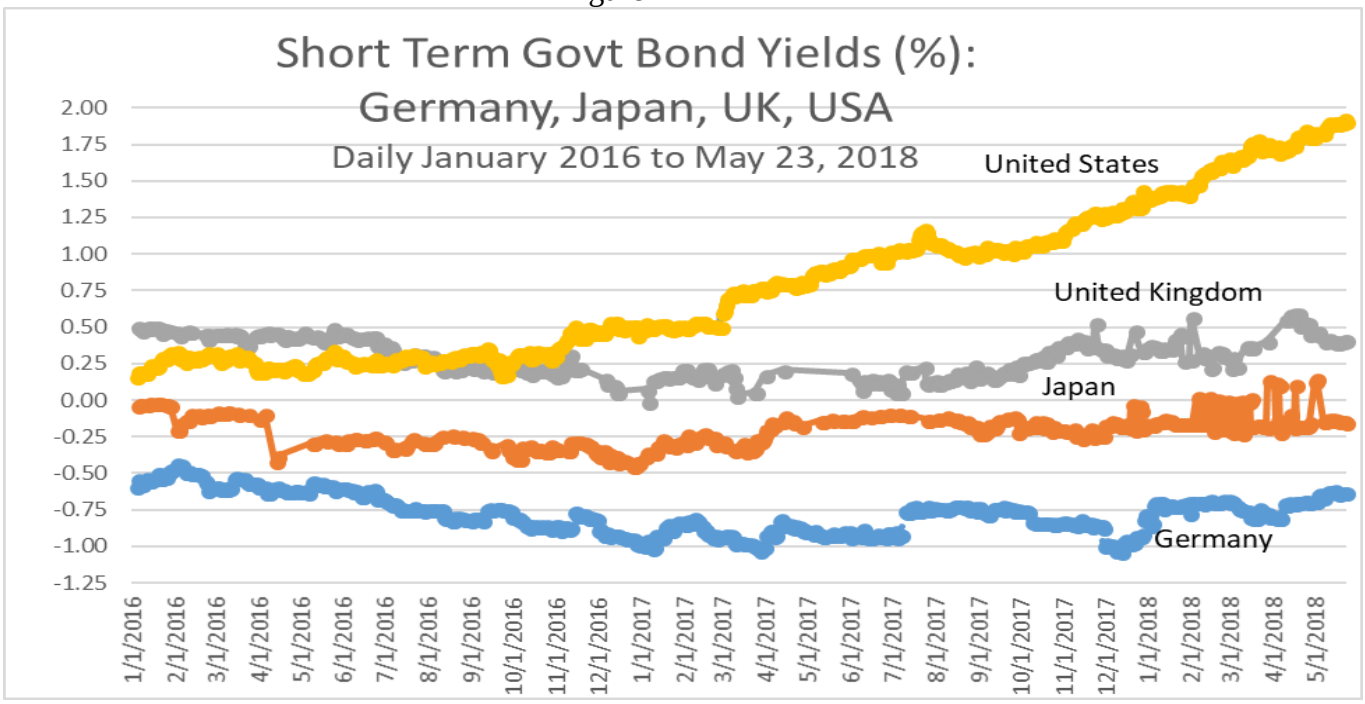


Figure 4B

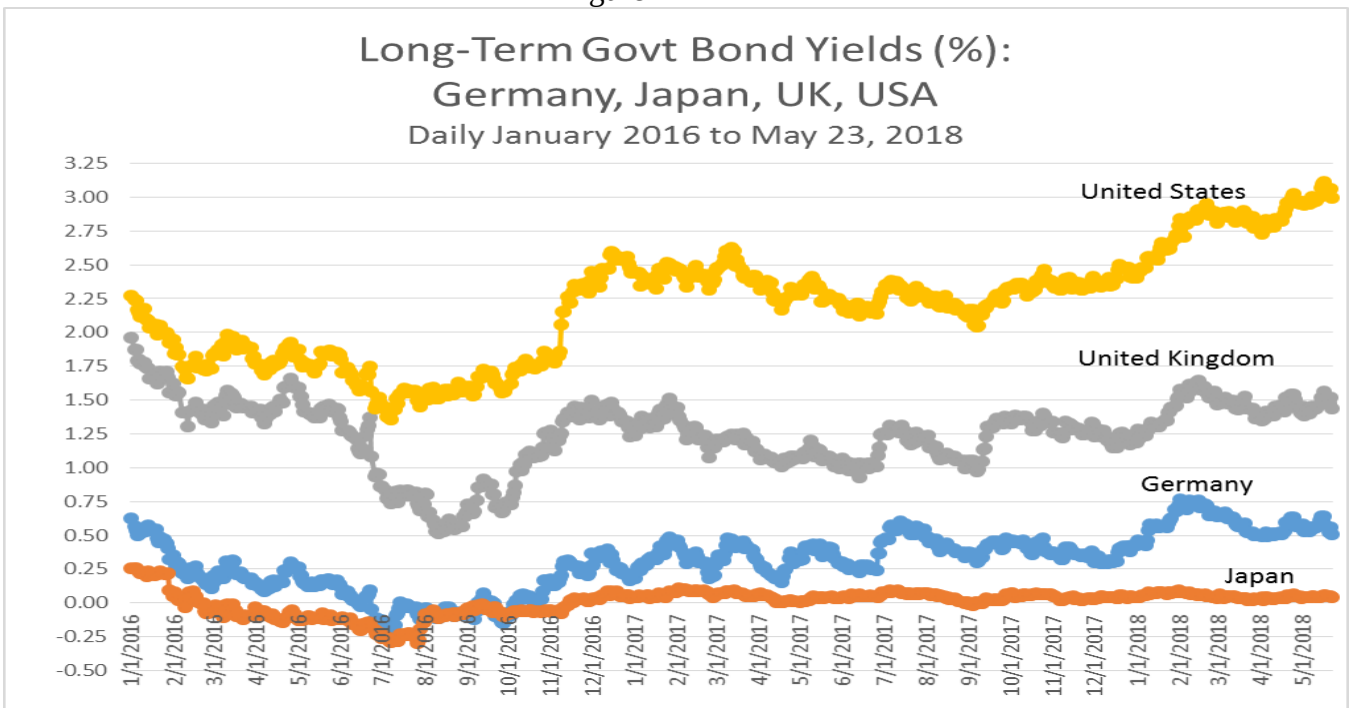
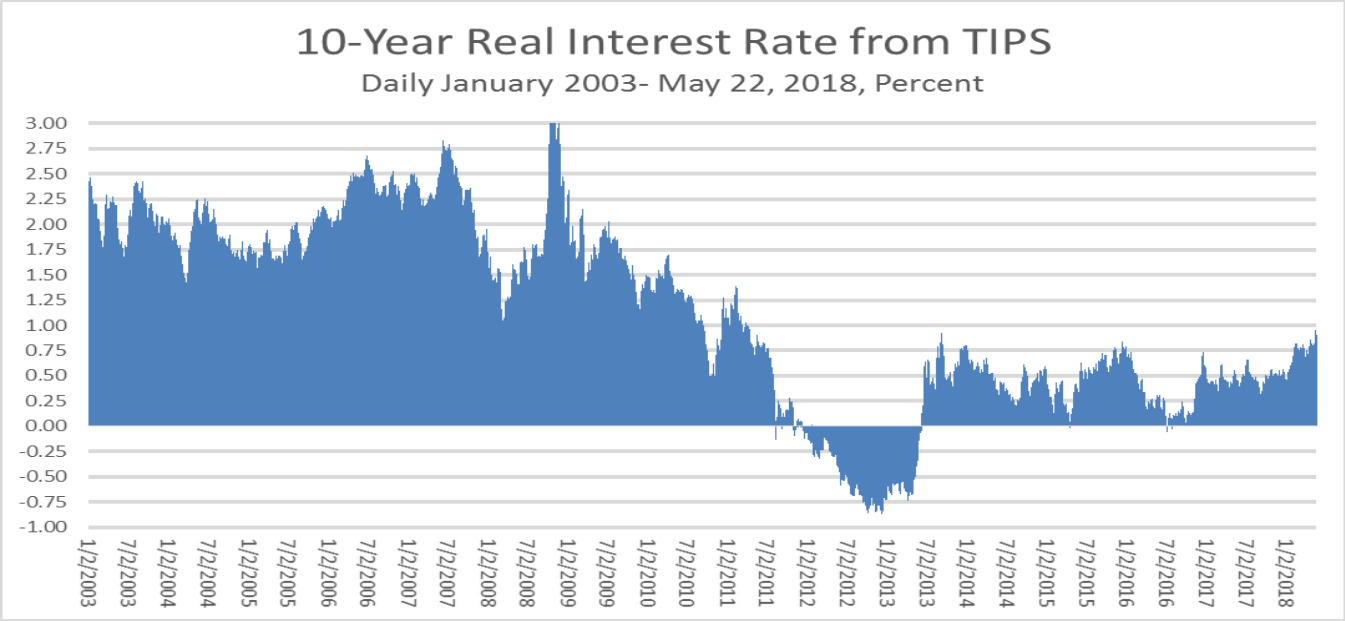


Figure 5



II. Volatility, Global Stock Prices, Corporate Bond Yields

Stock prices grew steadily in 2017 (see Figure 6),and peaked on January 26, 2018, in the USA. The last surge was fueled by President Trump's reduction of the corporate tax rate from 35% to 21% and surging corporate profits. However, on February 2nd, the US reported that wage inflation had jumped to 2.9% year-over-year, which triggered fears of inflation overshooting and accelerated interest rate increases. Stocks fell sharply by 10%, an official "correction," before bouncing back in late February and March. And then in late March and early April, President Trump announced significant tariffs on goods from China and other countries, and China retalatiated by announcing tariffs on soybeans and other US exports. Stocks fell sharply again, before the US softened its position, given some concessions by China to open its markets more and to reduce its trade surplus by buying more US goods. As stocks bounced back and the US announced a pause in imposing its announced tariffs, stocks continued to firm. As Table 2 shows, the net effect is that USA stocks have recovered to where they are now **up** 2.2% on the year, as of May 23rd. Thus, stocks have held up well, given all of the back and forth.

Volatility surged in February after the wage inflation announcement, going from a VIX of 11% to 37% in one day, as shown in Figure 7. However, after that, markets calmed and volatility dropped back as stock prices rose. And then with the trade war rhetoric in late March/early April, volatility surged again, while stock prices fell. As conciliatory moves were made by China and the US and announced tariffs were not implemented, volatility once again calmed, dropping to 13.4% at present. While this level of the VIX, (a forecast by option markets of the annualized percentage volatility of the S&P500) is above that in 2017, the current level of 13.4% is in line with history for the past two decades and is even back below the very long term average. Thus, options investors continue to show confidence that stock prices will not be as volatile as the 50-year norm, which is more nearly 15% volatility.

Figure 6

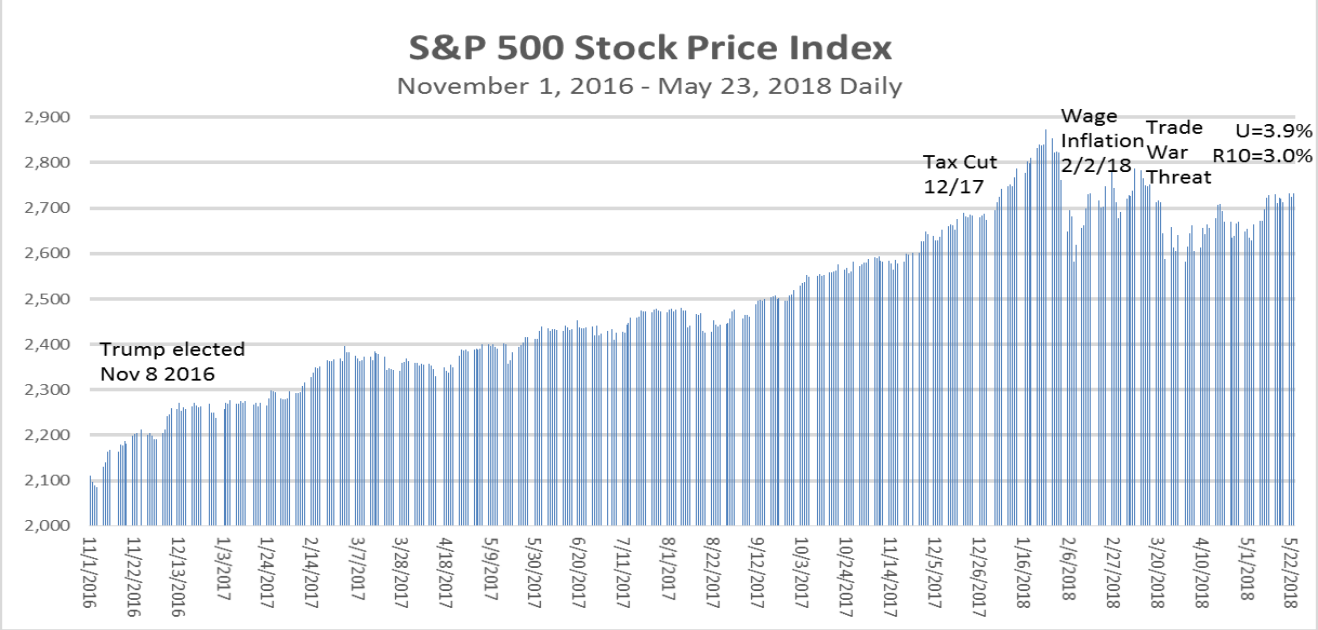


Figure 7

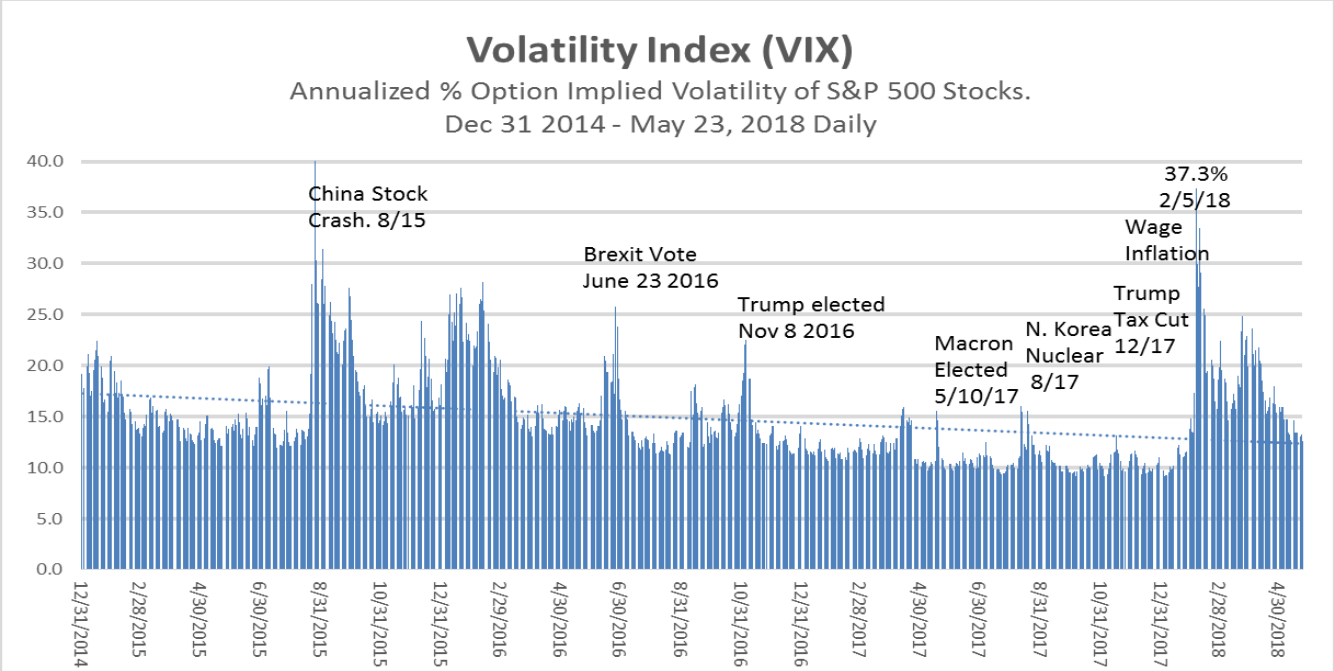
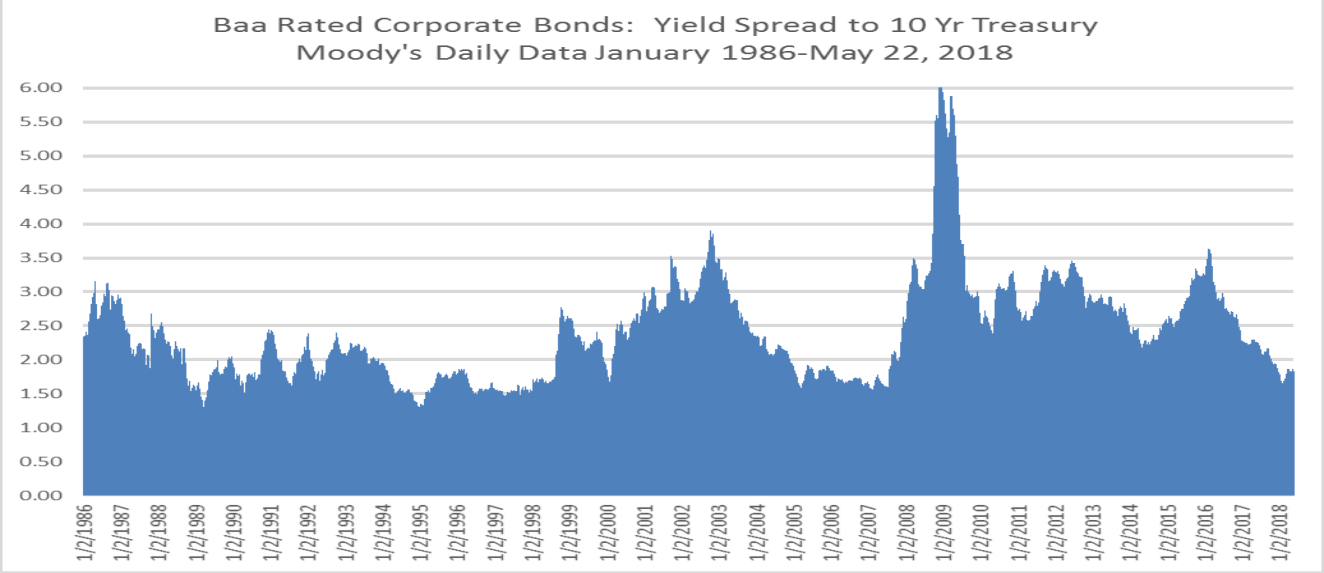


Figure 8 shows that in early 2018 the credit risk premium on Baa-rated corporate bonds (over 10-year US Treasury notes), had fallen to near the lowest level of the past 30 years, as firms are very healthy and profitable, on average, volatility was very low and stock prices are high. The credit option was well out of the money for more firms than normal that are rated Baa. However, after the February surge in volatility and fall in stock prices, credit spreads widened. Also, issuance of risky debt by firms has increased, which likely also increased yield spreads. Nonetheless, credit risk spreads on Baa and junk bonds remain historically very low.

Figure 8



Next, let's look at some stock market fundamentals – earnings growth and forecasted P/E ratios, as given in Table 2:

Table 2

						Global Stock Market Valuation: 17 Trillion Dollar GDP Economies							
5/25/2018 8:02				YTD		Bloomberg Data with Prices as of close May 23, 2018							
	Stock	Stock	5-Year	**%Price Ch**	%Price Chg	**StkPrice**	**Forward 12 Month Earnings Forecast**			**%Chg**	**Fwd 12m**	**Fwd 12m**	**Fwd 12m**
	Price	Price	Hi Price	**12/31/2017**	12/31/2016	**Off High**	EPS Fwd 12	EPS Fwd 12	EPS Fwd 12	**EPS Fcst**	**P/E**	**P/E**	**P/E**
Americas	**5/23/2018**	12/31/2017		**5/23/2018**	5/23/2018		**5/23/2018**	12/31/2017	12/30/2016	***YTD***	**5/23/2018**	**12/31/2017**	########
United States	**2,733**	2,674	2,873	**2.2%**	22.1%	**-4.9%**	163.3	143.3	127.3	**14%**	**16.7**	**18.7**	**17.6**
Canada	**16,134**	16,209	16,413	**-0.5%**	5.5%	**-1.7%**	1053.7	977.6	875.8	**8%**	**15.3**	**16.6**	**17.5**
Brazil	**80,867**	76,402	85,531	**5.8%**	34.3%	**-5.5%**	6691.0	5678.7	4966.5	**18%**	**12.1**	**13.5**	**12.1**
Mexico	**45,777**	49,354	51,080	**-7.2%**	0.3%	**-10.4%**	2950.1	2814.8	2685.7	**5%**	**15.5**	**17.5**	**17.0**
Europe													
France	**5,566**	5,313	5,566	**4.8%**	14.5%	**0.0%**	381.1	348.6	322.5	**9%**	**14.6**	**15.2**	**15.1**
Germany	**12,977**	12,918	13,340	**0.5%**	13.0%	**-2.7%**	980.0	965.6	839.5	**1%**	**13.2**	**13.4**	**13.7**
Italy	**22,912**	21,853	24,157	**4.8%**	19.1%	**-5.2%**	1889.4	1590.4	950.0	**19%**	**12.1**	**13.7**	**20.2**
Spain	**10,025**	10,044	11,885	**-0.2%**	7.2%	**-15.6%**	770.7	754.7	615.7	**2%**	**13.0**	**13.3**	**15.2**
United Kingdom	**7,788**	7,688	7,788	**1.3%**	9.0%	**0.0%**	562.0	508.5	476.5	**11%**	**13.9**	**15.1**	**15.0**
Russia	**1,175**	1,154	1,287	**1.8%**	1.9%	**-8.7%**	188.5	205.8	151.1	**-8%**	**6.2**	**5.6**	**7.6**
Turkey	**101,892**	115,333	120,702	**-11.7%**	30.4%	**-15.6%**	14176.0	13056.5	8852.7	**9%**	**7.2**	**8.8**	**8.8**
Asia/Pacific													
Japan	**22,690**	22,765	23,632	**-0.3%**	18.7%	**-4.0%**	1374.0	1263.6	1041.2	**9%**	**16.5**	**18.0**	**18.4**
Australia	**6,033**	6,065	6,077	**-0.5%**	6.5%	**-0.7%**	390.1	367.7	344.3	**6%**	**15.5**	**16.5**	**16.5**
South Korea	**2,472**	2,467	2,575	**0.2%**	22.0%	**-4.0%**	263.2	259.5	195.0	**1%**	**9.4**	**9.5**	**10.4**
China	**3,169**	3,307	5,178	**-4.2%**	2.1%	**-38.8%**	265.1	251.3	231.3	**5%**	**12.0**	**13.2**	**13.4**
India	**34,345**	34,057	36,050	**0.8%**	29.0%	**-4.7%**	1757.4	1629.4	1607.8	**8%**	**19.5**	**20.9**	**16.6**
Indonesia	**5,792**	6,356	6,661	**-8.9%**	9.4%	**-13.0%**	393.0	348.6	331.7	**13%**	**14.7**	**18.2**	**16.0**
Averages				**-0.7%**	14.4%	**-8.0%**				**8%**	**13.4**	**14.6**	**14.8**
10- Year TreasYld	3.06	2.40											
VIX	13.4	11.0											

Table 2 shows that the higher stock prices have been well-supported by higher forecasted earnings for the next 12 months. Just since December 2017, earnings forecasts for the next 12 months have grown by double digits in Italy (19%), Brazil (18%), USA (14%), in Indonesia (13%), and the UK (11%), as well as 9% in France and Japan, and 8% in Canada, Russia and India. So, despite relatively "high" stock prices, forward P/E ratios have actually **dropped** in almost all of our 17 TDE countries since the end of last year. Among advanced economies, forward P/E ratios and real earnings yields in Europe and Asia continue to make stocks look cheaper there than in the USA. Very low P/E ratios in Russia, Turkey and other emerging markets likely reflect political risks and concerns about accounting quality and liquidity and are not complete barometers of true investment value. For the year to date in 2018, stock prices globally are on average almost flat, with an average loss of just 0.7%, led by losses of 12% in Turkey, 9% in Indonesia and 7% in Mexico. Brazil, France and Italy lead the gains with 6%, 5% and 5%, respectively. The YTD gains in Italy are notable, given the recent political shakeup, where right-wing and anti-establishment leaders won and are forming the new government.

III. USA: Interest Rate Insurance Prices for USA LIBOR 3, 5, and 10 Years Out

Let's turn to our usual graphic analysis of the interest rate insurance prices that are implicit in the prices of caps and floors, using the technique of Breeden and Litzenberger (1978, 2014). Using prices from Bloomberg Financial Markets and their volatility cube calculations, we see in Figures 9A-9C the prices for USA interest rate insurance for 3-month LIBOR rates in 3, 5 and 8-10 years. Figure 9A shows the dramatic change in the insurance price distribution that has occurred over both the last 18 and 6 months, as the US and global economies gained strength and the Fed raised rates again in March and is expected to raise again in June. The pre-election distribution was very stacked at near-zero rates and had positive skewness, but no symmetry. In great contrast, the distribution at present is much more symmetric, the mode is 3%, the price of 3% bets has doubled and the price of 4% bets has quadrupled. This is what I hoped would happen, as the distribution moves much as it did back in 2013 when Chairman Bernanke first promised tapering.

Figure 9B shows that the 5-year distribution has also moved to a more symmetric shape with a mode of 3% to 4%, all higher than previously. Note that the price for the recessionary, low-rate scenario for 5 years out has dropped sharply in the past 6 months. However, Figure 9C shows that the markets appear to be showing some concern and risk aversion for a possible fall back into recession over the 8-10 year horizon. Two more points are notable for the long-term, 8-10 year insurance price distribution. First, it has a longer tail, showing some tail risk for rates of 6% on up to 9% LIBOR. Secondly, it is bimodal, in that the prices for low rates (0-1.5%) and for the 3% rate range are both higher than for the 2% rate range. This indicates that the market is pricing in two alternative regimes, one with a fall back into recession and one where we have normalization and higher rates.

Figure 9A

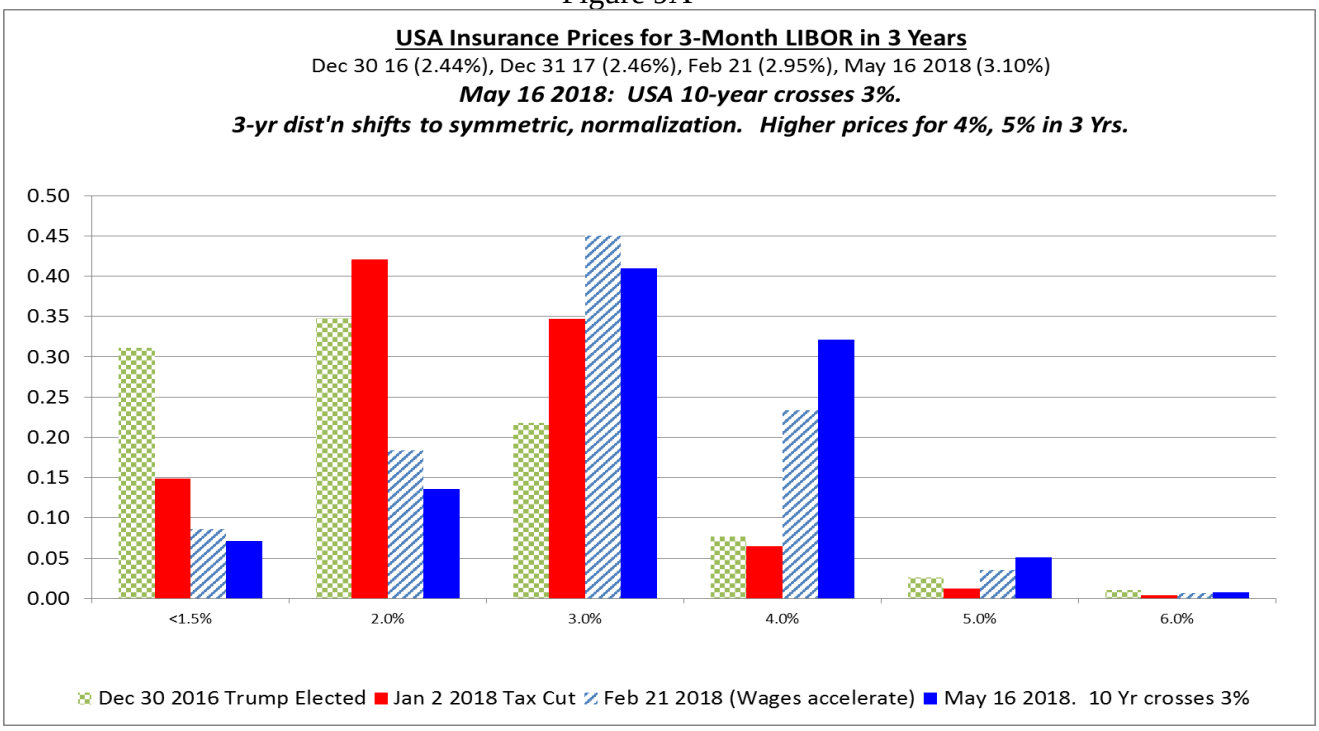


Figure 9B

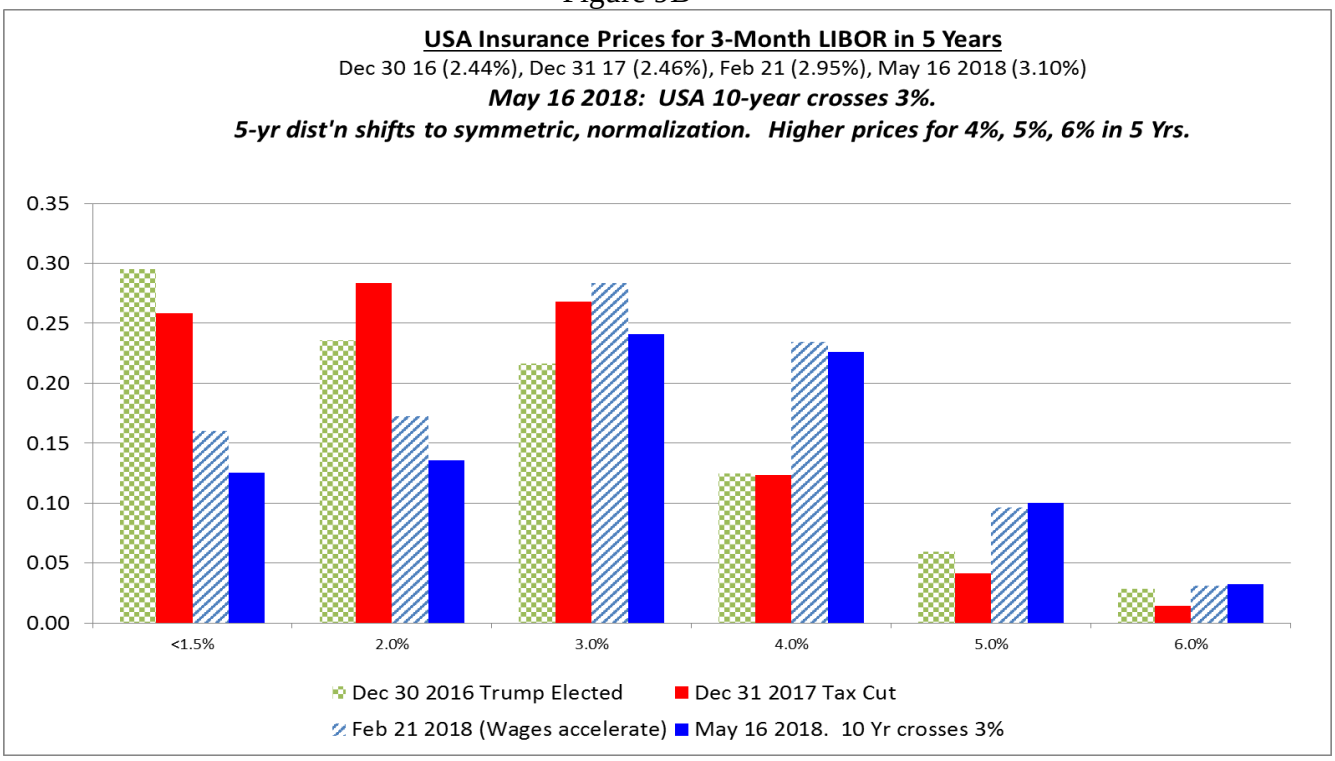
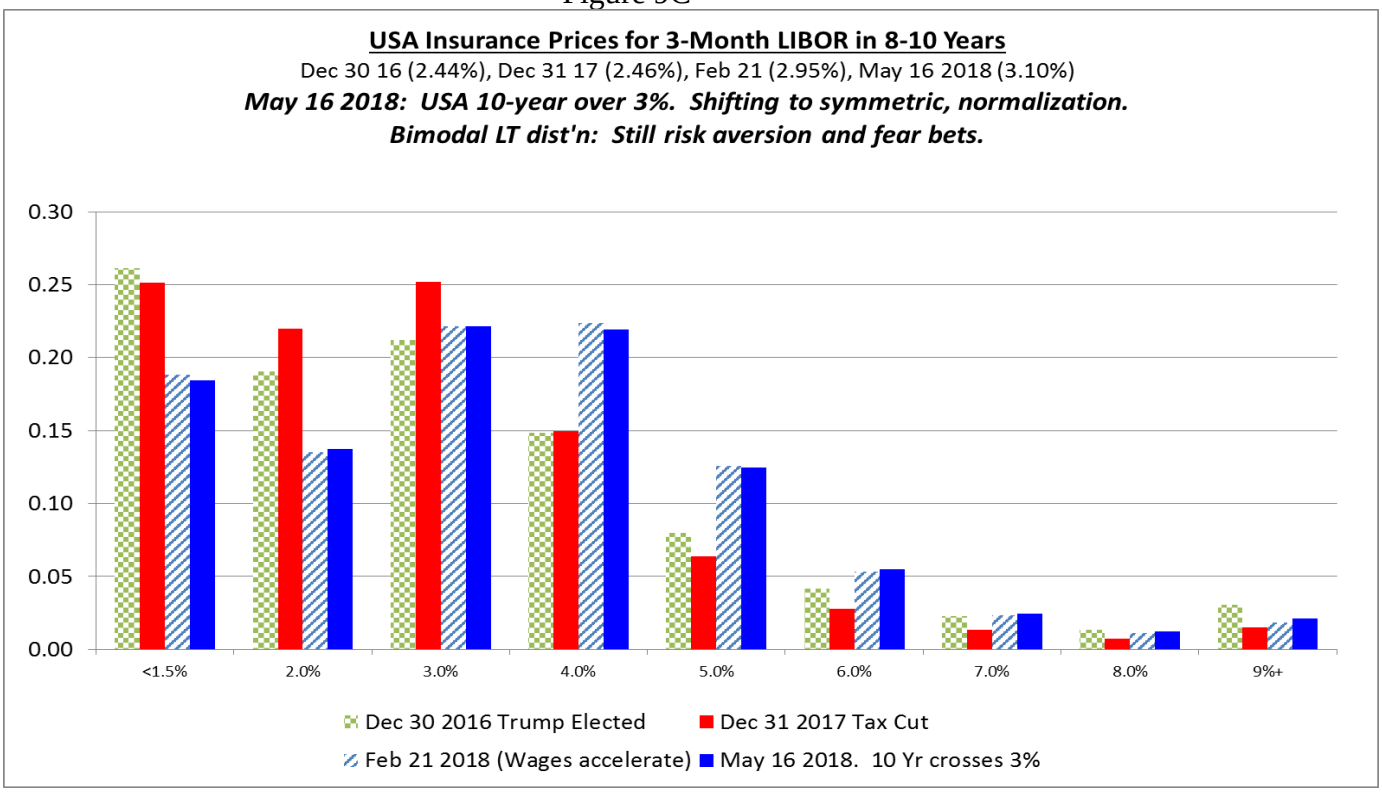


Figure 9C



IV. Euro Area: Interest Rate Insurance Prices for Euribor 3, 5, nd 8-10 Years Out

Figures 10A-10C give the options markets' pricing of insurance payoffs on Euribor in 3, 5, and 8-10 years, respectively. Draghi's ECB continues to conduct stimulus, but the quantity was halved starting in January 2018, given the strong Euro Area economy and the absence of deflationary concerns. See Figure 1 for the firming up on inflation in the Euro Area in the past 2 years. As has been true for more than a year, for Euribor 3 years out, almost all of the betting is on Euribor less than 1.5%, given the ECB's commitment to very low rates at present.

For 5 years out, the value bets on Euribor below 1.5% in 5 years have decreased noticeably since the start of the year, but remain very high. Surely this reflects some fear and risk aversion to changes in Italy and to Brexit negotiations and other political changes, as well as objective probabilities of near-zero rates due to the ECB's slowness in withdrawing stimulus and increasing rates.

The Euro area's long-term, 8-10 year distribution shows a surprising surge in the price of the fear scenario. Indeed, it is so large that I suspect it is a data error from the Bloomberg data. Previously, it was "bimodal" in the sense that about 50% of value was bet on the very low rate fear scenario and about 50% was bet on rates of 2% or more that reflect normalization. We shall see in future analysis if this jump in the price of the fear scenario for long-term Euribor is an aberration, as I suspect.

Figure 10A

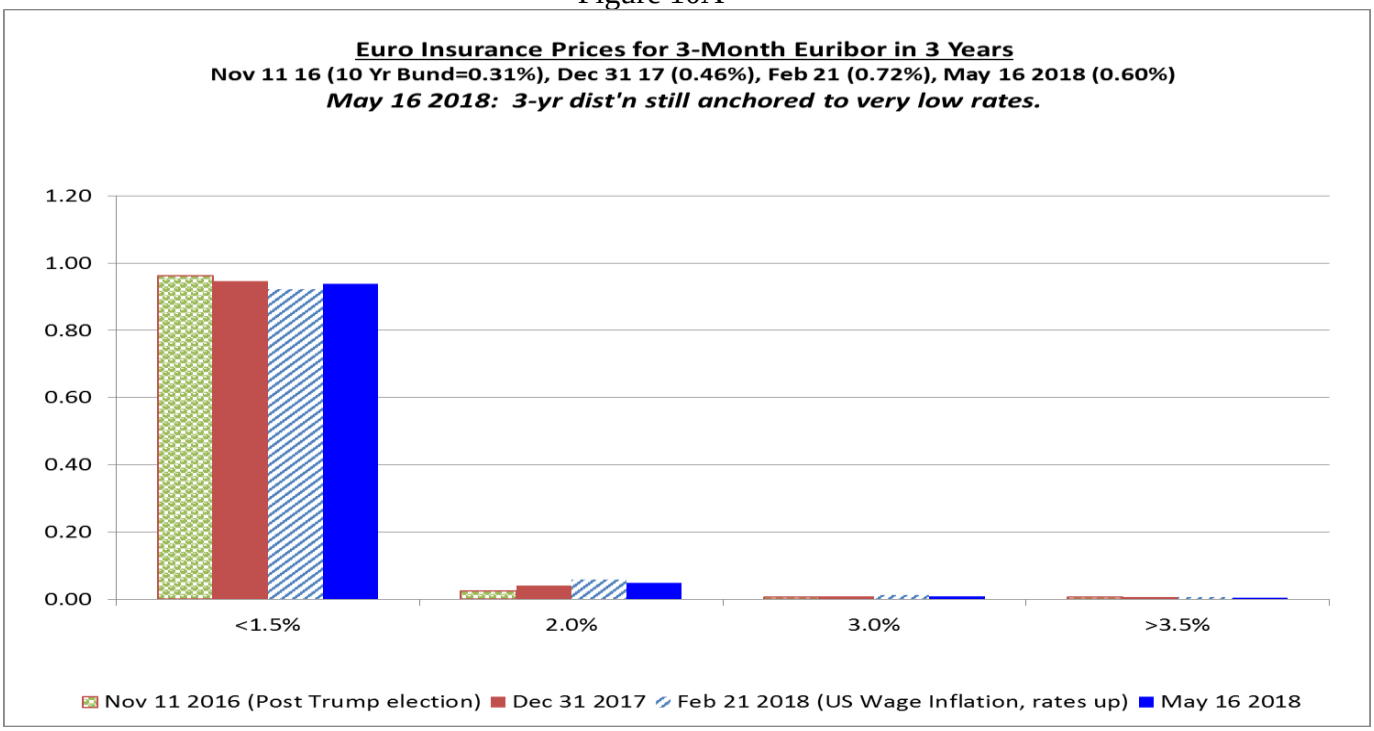


Figure 10B

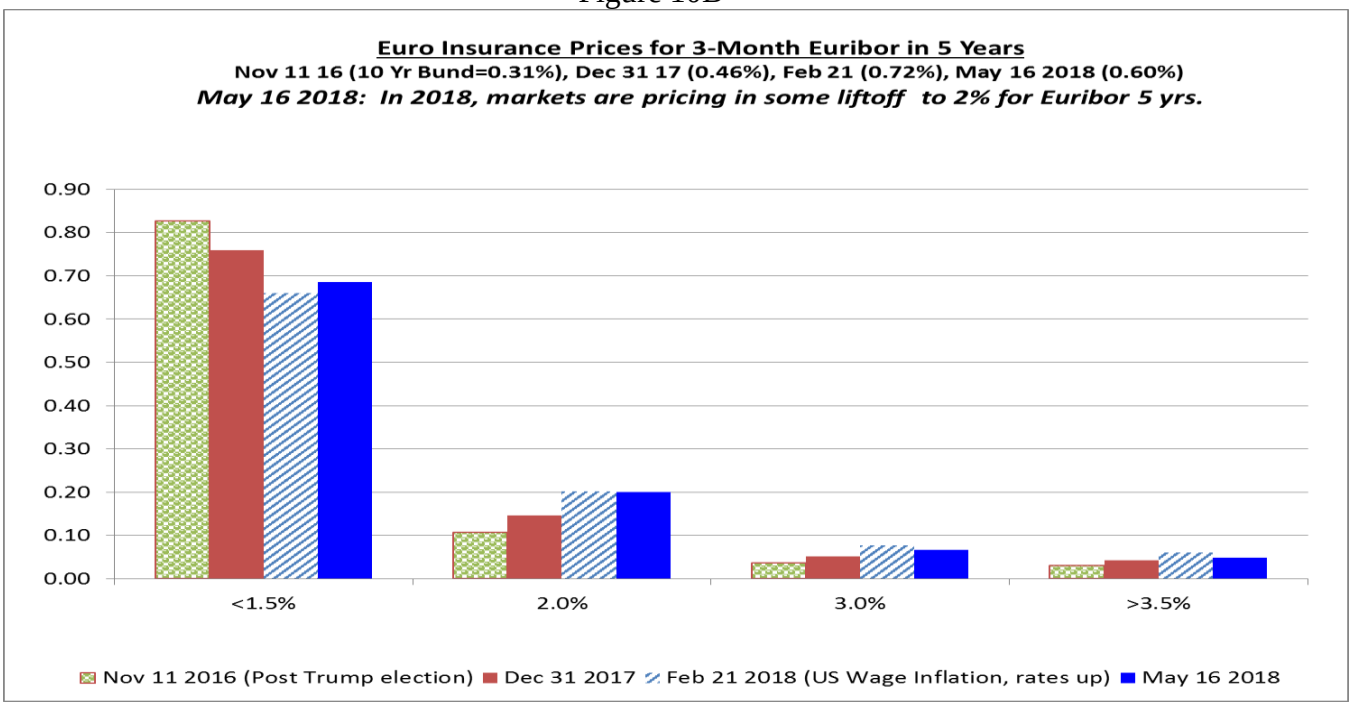
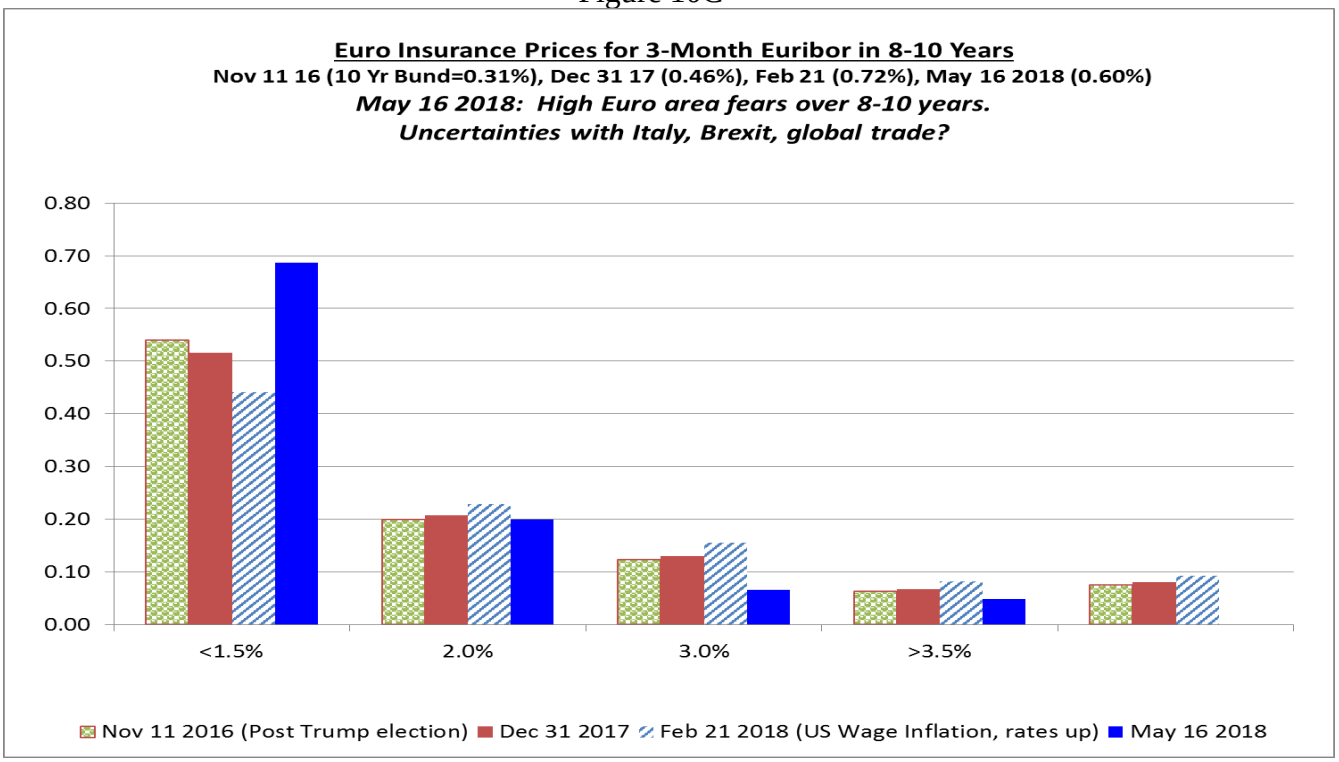


Figure 10C



V. U.K: Interest Rate Insurance Prices for Interbank Rates in 3, 5, and 8-10 Years

Appendix Figure A-3 shows that, while CPI inflation has been over 3% due to the weaker pound, growth in Britain has begun to lag that in the Euro Area by quite a bit. Significant progress has been made in Brexit discussions, led by Prime Minister Theresa May. However, there remains a lot of uncertainty about the eventual economic terms. The economy in Britain has weakened some, but remains generally strong. Unemployment is very low (Table 1) and stocks are at all-time highs (Table 2). Last November, the Bank of England finally lifted off in short rates, as shown in Figure 4A. However, long rates continue to remain very low, lagging increases in the USA (Fig. 4B), as the 10-year gilt is at 1.5% vs. the 10-year Treasury at 3.1%.

Figures 11A-11C give the insurance price distributions for the UK interbank interest rate 3, 5 and 8-10 years out. I am very pleased to see that the option-implied interest rate insurance price distributions for the UK interbank rate are showing substantial pricing in of normalization in rates in the next 3 years, as I expected they would. Despite Brexit, the UK economy is fundamentally strong, with very low unemployment and high wealth, and the government is very pro-business and is building more global trade links in an attempt to dampen the likely reduced trade growth with Europe. Note that in 2018 the price of the 2% rate bets in 3 years have increased by 75%, going from 0.20 to 0.35, while the fear scenario low rates have dropped from 0.72 to 0.53. Markets are showing less fear. Brexit negotiations appear to have slowed down the

implementation of major changes, which gives the UK and the Eurozone more time to adapt to the changes.

In 2018 so far, the 5-year distribution has also moved quite significantly towards higher prices for 2% and 3% rate scenarios, with a substantial drop in price for the fear scenario. However, do note that, while the 8-10 year prices have also moved towards pricing in normalization, the long-term distribution shows quite a bit of concern or risk aversion. Pricing of the low rate scenario is still pretty high, relative to the long tail for higher rates.

Figure 11A

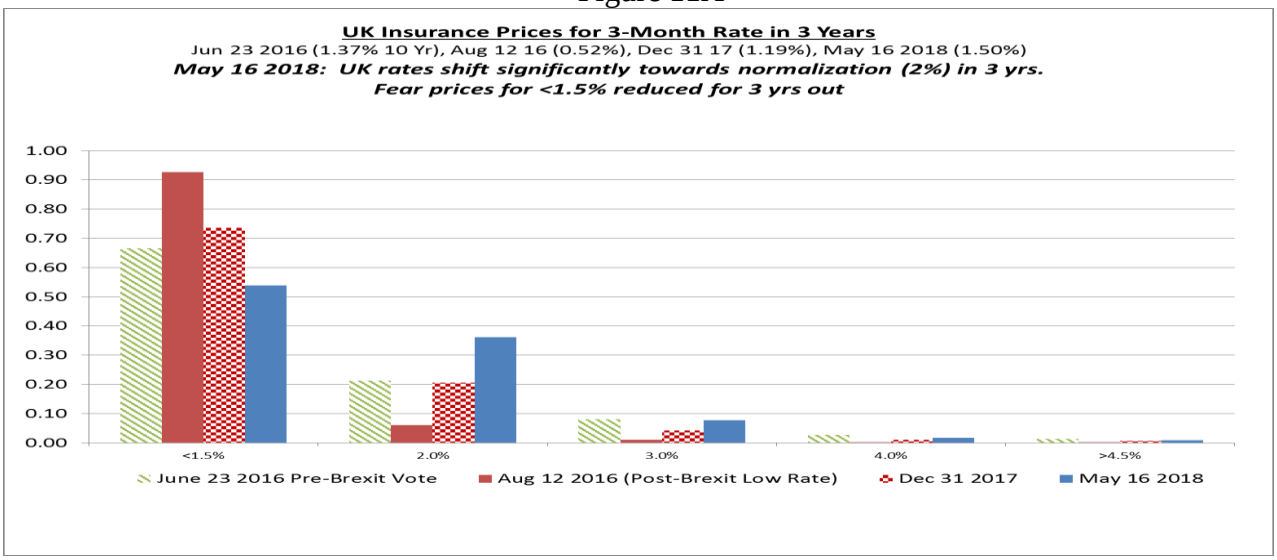


Figure 11B

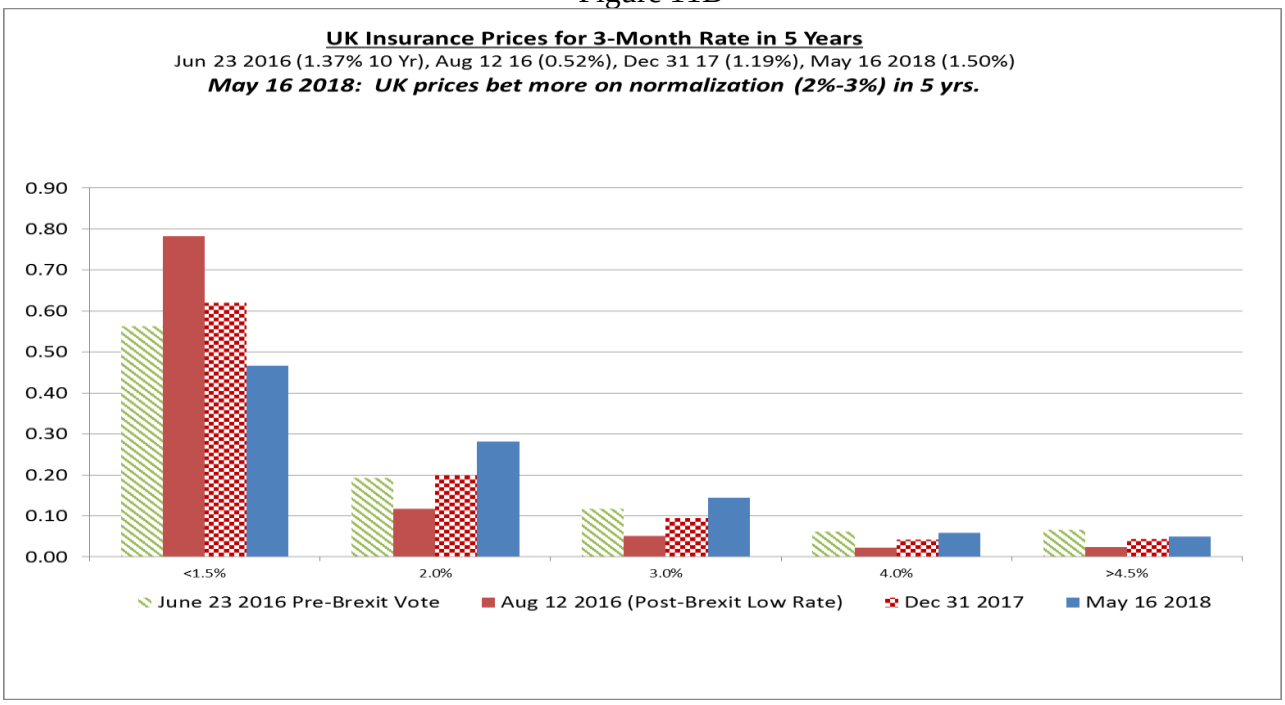
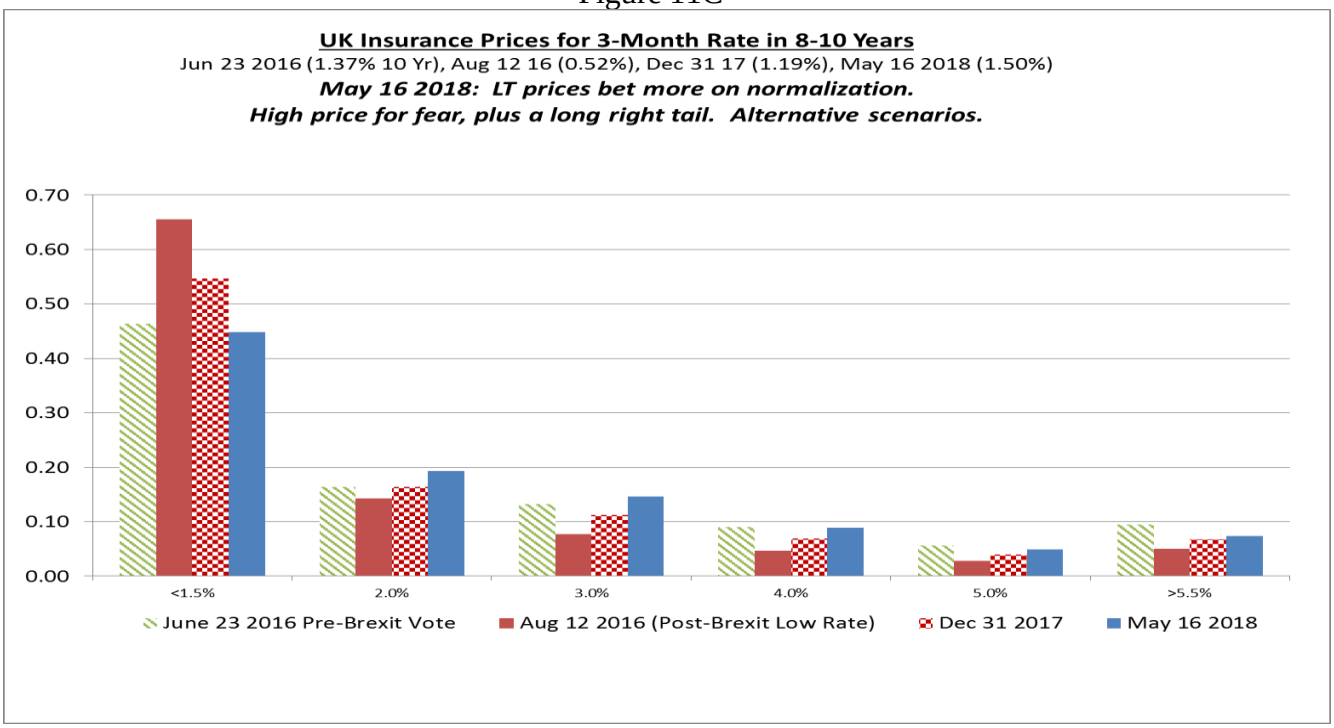


Figure 11C



VI. Prices for Insurance Against Falls in the Stock Market and Prices for Bets on the Upside for Stocks

Let us examine insurance prices that are implicit in the market prices of options on the S&P 500 stock price index, using the technique of Breeden and Litzenberger (1978, 2014). We use the Bloomberg Financial Markets data for "implied volatilities by moneyness." Using those and the Black-Scholes formula, we compute prices for options with a range of strike prices from 80% to 120% (in 5% increments) of the current S&P 500 index level, for maturities of 1, 3, 6, 12, 18 and 24 months. Table 3B gives the calculated prices (normalized to sum to $1.00) for bets that pay off $1.00 in the ranges given in Table 3A for the S&P 500 in 1 year, as a percentage change from its current value.

Table 3A

Left tail spread receives $1.00 if the S&P 500 is	-12.5% or more	from current level
90 Butterfly receives $1.00 if the S&P 500 moves:	-12.5% to -7.5%	from current level
95 Butterfly receives $1.00 if the S&P 500 moves:	- 7.5% to -2.5%	from current level
100 Butterfly receives $1.00 if the S&P 500 moves:	-2.5% to +2.5%	from current level
105 Butterfly receives $1.00 if the S&P 500 moves:	+2.5% to +7.5%	from current level
110 Butterfly receives $1.00 if the S&P 500 moves:	+7.5% to +12.5%	from current level
Right tail spread receives $1.00 if the S&P 500 is	+12.5% or more	from current level

A number of points are very interesting in the market's prices of bets that are implicit in option prices, as shown in Table 3B. First, note that in the bubbly times of 2005-2006, right

before the Great Recession that started in late 2007, investors paid considerably more for the right tail (upside for stock bets) than they paid for the left tail (downside for stocks bets). On January 3, 2005, the prices were $0.26 for the upside of an S&P500 gain of 12.5% or more in 1 year, and only $0.14 for the downside of a loss of 12.5% or more in 1 year, a spread of $0.12, or 12.0% of $1.00 one would get for sure if one bought all of these spreads.

This changed quite dramatically as the Great Recession unfolded, and the markets fell off a cliff. From Table 3B, on November 30, 2008, at a time of financial terror, investors paid 56.3% for the downside protection and only 21.7% for the upside, a difference of 34.6%. This spread between the price of the downside protection versus the price of the upside gainer presumably measures risk and risk aversion. We call this price spread a measure of "Risk Aversion" evidenced in the option markets. Continuing to look down the right-hand column of Table 3B, we can see the reduction in risk aversion as the economy recovered from the Great Recession. By the end of 2009, the left tail vs. right tail price spread was down from the 34.6% peak to 20.5%, and at the end of 2013 was down to only 10.2%.

In 2018, as global economies around the world were strong and unemployment low, it has been a roller-coaster for stock prices and volatility, as described in earlier sections, given the inflation fears in February and the trade war talk in March and April. The distributions that we extract from option prices for S&P 500 options show these ups and downs quite dramatically. On February 5th, after the worries about wage inflation tanked markets and caused volatility to surge from 11% to 37% on the VIX, prices of the left-tail put hedges went from 14.1% on December 31, 2017 to 32.8% on February 5, 2018. In the subsequent calm, this dropped back to 22.8% on February 28th. However, with the US-China trade war actions, it surged again to 28.5%. Our "risk aversion" measure of left tail price minus right tail price moved similarly from 2.6% up to 17.5%, back to 9.8%, then up to 13.7%, before calming to 5.6% at present. It has been a roller-coaster of price moves and risk aversion in the first five months of 2018!

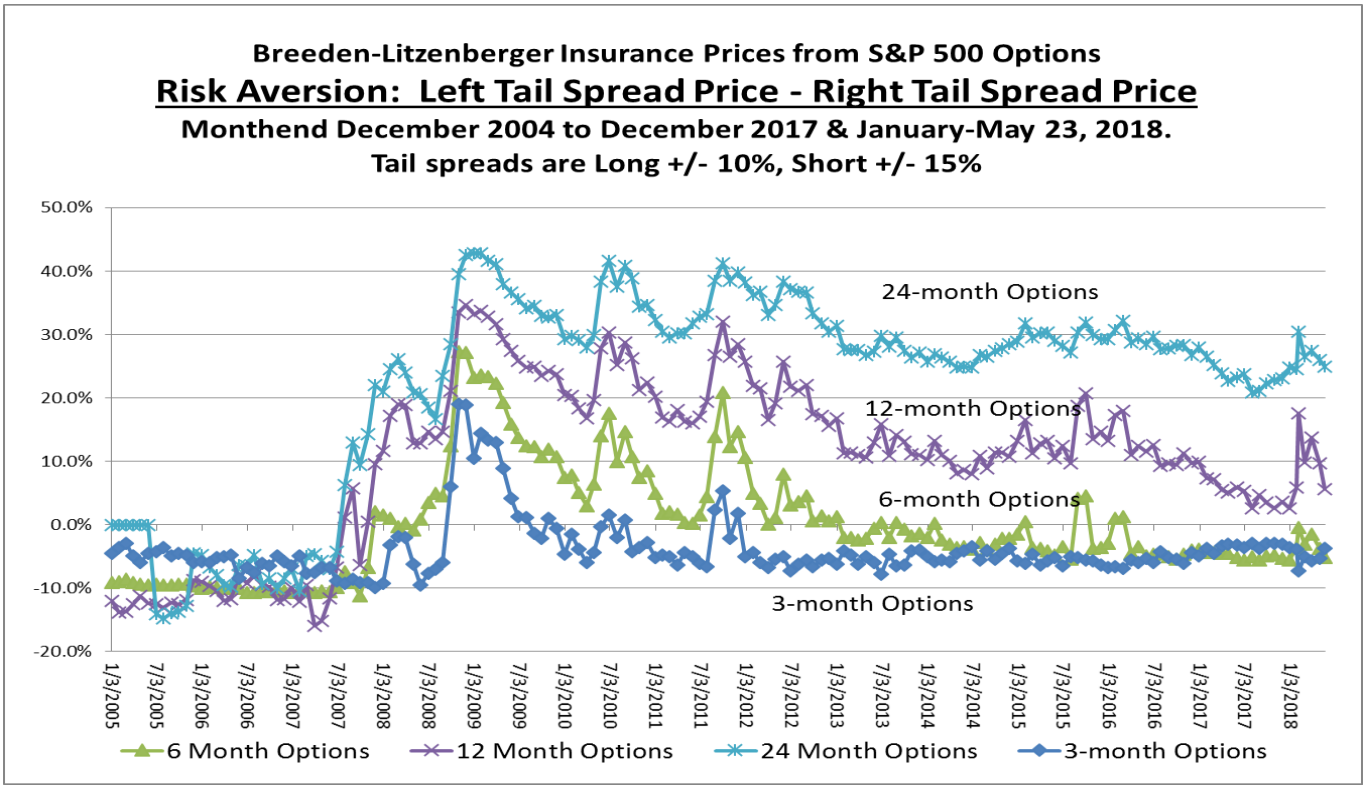
Risk aversion changes over time that are estimated with this Breeden-Litzenberger technique are graphed in Figure 6 for 3, 6, 12 and 24 month options. I find it interesting that risk aversion seems much larger in the longer term options, leading me to conjecture that they are used more by hedgers. Shorter term options may be more likely to be used by shorter-term speculators and do not show much evidence of risk aversion, as we define it.

Note that in 2018, risk aversion implicit in prices of tails for 12 and 24-month options increased dramatically in February, and a bit less so in late March/early April. After each of those episodes, the spread of tail prices subsequently fell back, reflecting lower concerns by investors for downide risk vis-à-vis upside opportunity. However, given this awakening to the realities of stock market and global economic risk, our risk aversion estimate does remain well above its extraordinarily low levels in late 2017, which were such a concern to the Federal Reserve and to central banks around the world.

Table 3B

	S&P 500 Insurance Prices (Risk-neutral density) 2005-2013								**12 Months**	
	Monthend Data from December 2004. Uses Breeden-Litzenberger (2014) technique								5/24/18 12:23 PM	
			$90%-$85 Puts			ATM		$110-$115 Calls		
	ATM	S&P 500	**Left Tail**	90	95	100	105	110	**Right Tail**	**Left Tail**
Date	Implied σ	Spot Index	**Spread**	Butterfly	Butterfly	Butterfly	Butterfly	Butterfly	**Spread**	**-Right Tail**
1/3/2005	14.8	1202.1	**14.0%**	11.8%	13.7%	13.8%	12.3%	8.4%	**26.0%**	**-12.0%**
12/30/2005	14.3	1248.3	**11.3%**	15.4%	17.7%	15.5%	12.0%	7.8%	**20.3%**	**-9.0%**
6/30/2006	14.5	1270.2	**11.5%**	16.1%	18.1%	14.5%	11.8%	7.2%	**20.8%**	**-9.3%**
12/29/2006	14.0	1418.3	**10.1%**	15.9%	18.6%	15.6%	12.2%	7.7%	**19.9%**	**-9.9%**
6/29/2007	15.8	1503.4	**14.9%**	15.8%	16.6%	13.2%	11.0%	6.9%	**21.7%**	**-6.8%**
12/31/2007	22.2	1468.4	**32.7%**	13.1%	11.9%	8.5%	7.7%	5.0%	**21.1%**	**11.6%**
3/31/2008	23.8	1322.7	**39.0%**	11.9%	10.6%	7.4%	6.9%	4.2%	**20.1%**	**18.9%**
6/30/2008	22.3	1280.0	**34.6%**	13.1%	11.6%	8.5%	7.4%	4.8%	**20.0%**	**14.6%**
9/30/2008	27.0	1166.4	**42.7%**	10.1%	9.1%	6.4%	6.3%	4.0%	**21.5%**	**21.2%**
10/31/2008	39.4	968.8	**55.0%**	6.5%	6.1%	3.8%	4.5%	2.5%	**21.5%**	**33.5%**
11/28/2008	41.6	896.2	**56.3%**	6.0%	5.7%	3.7%	4.2%	2.5%	**21.7%**	**34.6%**
12/31/2008	36.3	903.3	**53.9%**	7.0%	6.5%	4.3%	4.7%	2.9%	**20.7%**	**33.2%**
1/30/2009	37.1	825.9	**54.2%**	7.2%	6.4%	4.3%	4.6%	2.8%	**20.5%**	**33.7%**
2/27/2009	36.9	735.1	**53.6%**	7.1%	6.4%	4.5%	4.6%	3.0%	**20.8%**	**32.8%**
3/31/2009	36.9	797.9	**53.1%**	6.9%	6.3%	4.6%	4.6%	3.0%	**21.5%**	**31.6%**
6/30/2009	26.8	919.3	**44.8%**	10.7%	9.2%	6.6%	6.0%	3.9%	**18.9%**	**25.9%**
12/31/2009	22.8	1115.1	**38.6%**	13.0%	11.1%	8.1%	6.8%	4.3%	**18.1%**	**20.5%**
6/30/2010	28.9	1030.7	**48.0%**	10.7%	9.0%	5.9%	5.6%	3.2%	**17.7%**	**30.3%**
12/31/2010	21.4	1257.6	**36.9%**	14.6%	12.2%	8.4%	7.1%	4.2%	**16.7%**	**20.2%**
6/30/2011	19.4	1320.6	**32.5%**	16.8%	13.7%	9.9%	7.4%	4.3%	**15.4%**	**17.0%**
7/29/2011	20.7	1292.3	**35.7%**	15.4%	12.7%	8.7%	7.2%	4.1%	**16.3%**	**19.5%**
8/31/2011	25.3	1218.9	**43.4%**	12.6%	10.2%	7.2%	6.1%	3.6%	**16.7%**	**26.7%**
9/30/2011	30.8	1131.4	**50.4%**	9.4%	8.1%	5.3%	5.3%	3.0%	**18.4%**	**32.0%**
12/30/2011	24.1	1257.6	**42.4%**	13.2%	10.8%	7.1%	6.3%	3.6%	**16.7%**	**25.8%**
6/29/2012	21.0	1362.2	**36.8%**	16.1%	12.8%	8.6%	6.9%	3.7%	**15.1%**	**21.7%**
12/31/2012	18.7	1426.2	**31.9%**	17.1%	14.0%	10.0%	7.6%	4.2%	**15.2%**	**16.7%**
6/28/2013	17.7	1606.3	**30.4%**	17.7%	14.8%	10.3%	7.8%	4.6%	**14.5%**	**15.9%**
12/31/2013	15.2	1848.4	**23.3%**	19.8%	17.3%	12.8%	8.7%	5.0%	**13.1%**	**10.2%**
6/30/2014	14.3	1960.2	**20.2%**	21.7%	19.2%	13.1%	8.9%	4.7%	**12.2%**	**7.9%**
12/31/2014	17.3	2058.9	**27.0%**	21.0%	16.7%	9.8%	7.8%	3.9%	**13.8%**	**13.2%**
6/30/2015	16.6	2063.1	**25.9%**	21.8%	17.4%	9.7%	7.9%	3.8%	**13.5%**	**12.5%**
7/31/2015	15.3	2103.8	**22.5%**	22.9%	18.9%	10.9%	8.3%	3.8%	**12.8%**	**9.7%**
8/31/2015	19.8	1972.2	**34.0%**	18.1%	14.2%	7.9%	7.2%	3.3%	**15.3%**	**18.7%**
9/30/2015	20.2	1920.0	**36.4%**	16.0%	13.1%	7.7%	7.2%	4.0%	**15.7%**	**20.8%**
12/31/2015	17.5	2043.9	**27.5%**	21.1%	16.7%	8.9%	7.9%	3.6%	**14.3%**	**13.2%**
6/30/2016	17.0	2098.9	**26.1%**	22.3%	17.5%	9.1%	7.9%	3.5%	**13.6%**	**12.5%**
10/31/2016	16.8	2126.2	**25.2%**	22.6%	17.8%	9.1%	8.0%	3.5%	**13.9%**	**11.3%**
11/30/2016	16.3	2198.8	**23.4%**	22.5%	18.2%	10.3%	8.1%	3.7%	**13.7%**	**9.7%**
12/30/2016	16.4	2238.8	**23.5%**	22.4%	18.1%	10.6%	8.1%	3.6%	**13.6%**	**9.9%**
1/31/2017	14.9	2278.9	**19.9%**	23.4%	19.8%	12.1%	8.5%	3.8%	**12.6%**	**7.3%**
2/28/2017	14.8	2363.6	**19.8%**	23.2%	19.8%	12.2%	8.6%	3.8%	**12.7%**	**7.1%**
3/31/2017	13.9	2362.7	**17.5%**	23.7%	20.9%	13.0%	8.8%	4.0%	**12.0%**	**5.5%**
6/30/2017	14.1	2423.4	**17.4%**	24.3%	21.3%	12.4%	8.7%	3.9%	**12.0%**	**5.3%**
7/31/2017	12.8	2470.3	**13.6%**	24.7%	23.2%	14.5%	9.1%	3.9%	**11.0%**	**2.6%**
8/31/2017	13.9	2471.7	**16.4%**	24.6%	21.7%	13.0%	8.7%	3.7%	**11.8%**	**4.7%**
9/29/2017	13.5	2519.4	**14.8%**	25.3%	22.7%	13.3%	8.8%	3.7%	**11.3%**	**3.5%**
10/31/2017	12.9	2575.3	**13.3%**	25.6%	23.9%	14.2%	8.9%	3.5%	**10.7%**	**2.6%**
11/30/2017	13.7	2647.6	**14.9%**	26.0%	23.0%	12.9%	8.6%	3.3%	**11.3%**	**3.6%**
12/29/2017	13.6	2673.6	**14.1%**	26.8%	23.8%	12.3%	8.6%	3.0%	**11.4%**	**2.6%**
1/29/2018	14.3	2853.5	**18.0%**	23.8%	20.7%	13.0%	8.6%	3.8%	**12.1%**	**5.9%**
2/5/2018	20.0	2648.9	**32.8%**	21.1%	15.4%	5.1%	7.2%	3.2%	**15.3%**	**17.5%**
2/28/2018	16.3	2713.8	**22.8%**	23.5%	18.7%	10.2%	8.0%	3.9%	**13.0%**	**9.8%**
3/29/2018	17.9	2640.9	**28.5%**	20.8%	16.3%	8.6%	7.7%	3.5%	**14.8%**	**13.7%**
4/30/2018	16.1	2648.1	**23.1%**	22.9%	18.5%	10.2%	8.2%	3.6%	**13.5%**	**9.6%**
5/23/2018	14.5	2733.3	**17.6%**	25.3%	21.5%	11.7%	8.5%	3.4%	**12.0%**	**5.6%**

Figure 12



An additional comparison that is informative is comparing the prices for payoffs in different S&P 500 return ranges with their historical frequencies of occurrence. Of course, insurance prices are looking forward, whereas historic frequencies represent past data, so these may be disconnected. But, nonetheless, we might learn something from past frequencies of +/-5%, +/-10%, and +/-20% moves and how prices of payoffs compare with those frequencies. To examine the historic frequencies, we first looked at the entire Ibbotson sample, which starts with 1926 data, giving 1-year returns from 1927. With data ending in 2015, we have 88 years of rolling monthly data from which to compute frequencies of moves of various sizes. And then, to check to see if "this time is different," we examined only the last 20 years of data, 1996-2015, which would much more greatly reflect the Great Recession. These historic frequencies are presented in the hatched bars in Figures 13A and 13B for 12-month returns and 3-month returns, respectively. As you can see, the right tail is largest, as mean returns were about 10% per year, so a 12.5%+ return is not a large positive deviation.

Figures 13A and 13B show the comparison of the option markets' implied insurance prices for various moves versus their historic frequencies. In Figure 13A (1-year moves), the graph dramatically shows a great deal of risk aversion in 2015-2016 data, as prices for left tail coverage were way higher than their frequencies and prices for right tail upside were way less than their historic frequency. Furthermore, this was also true with +/-10% and +/-5% move comparisons. However, it is interesting to see that in 2017 and at present, the price of large left tail (downside) coverage has declined considerably and is nearing historic frequencies. Thus,

there is a smaller amount of risk aversion for the "large downside moves." But note the prices of 90 and 95 strikes vs. the 110 and 105 strikes, as they show a substantial amount of risk aversion "in the small," i.e., for smaller moves. Interesting. It remains the case that prices of upside, bullish bets seem priced seriously low, which would be evidence of a great reward now for very high beta bets. Figure 13B shows that "risk aversion in the small" is also prevalent in the 3-month option prices.

Figure 13A

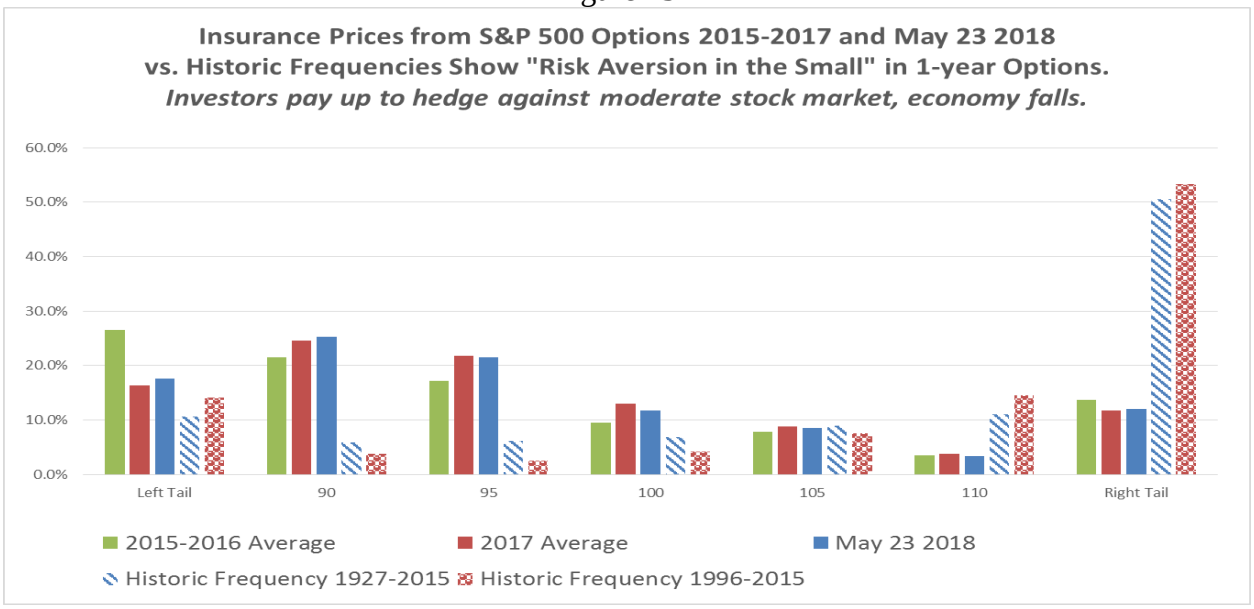
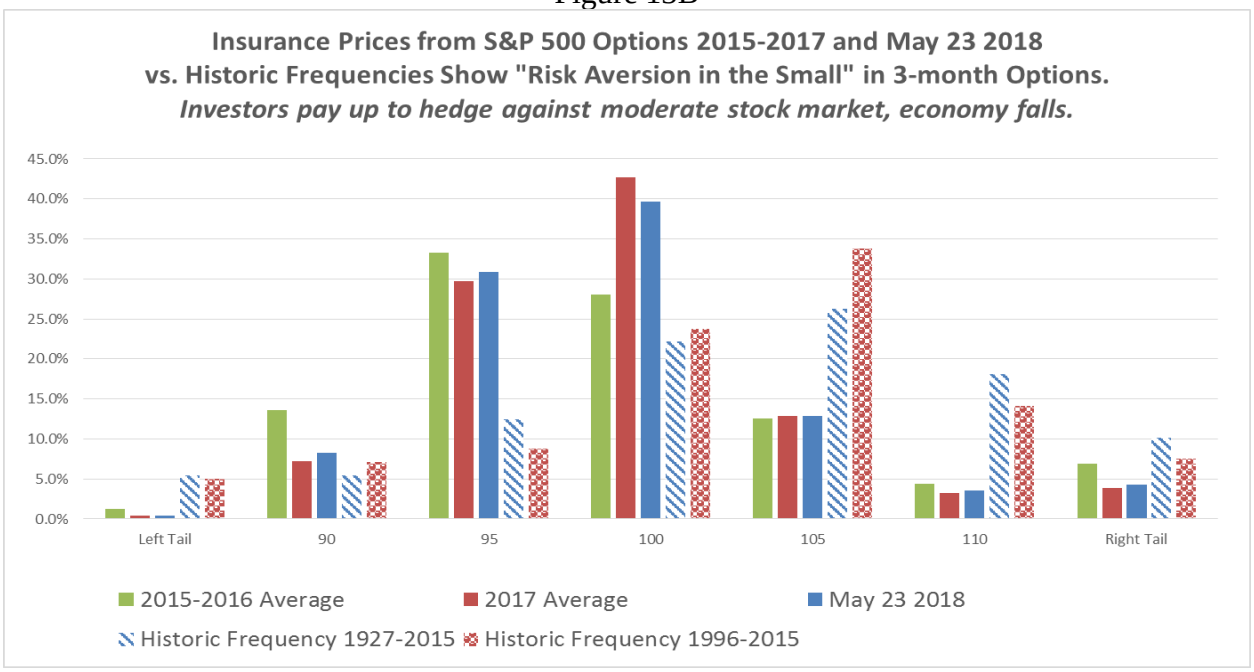


Figure 13B



Appendix

Figure A-1

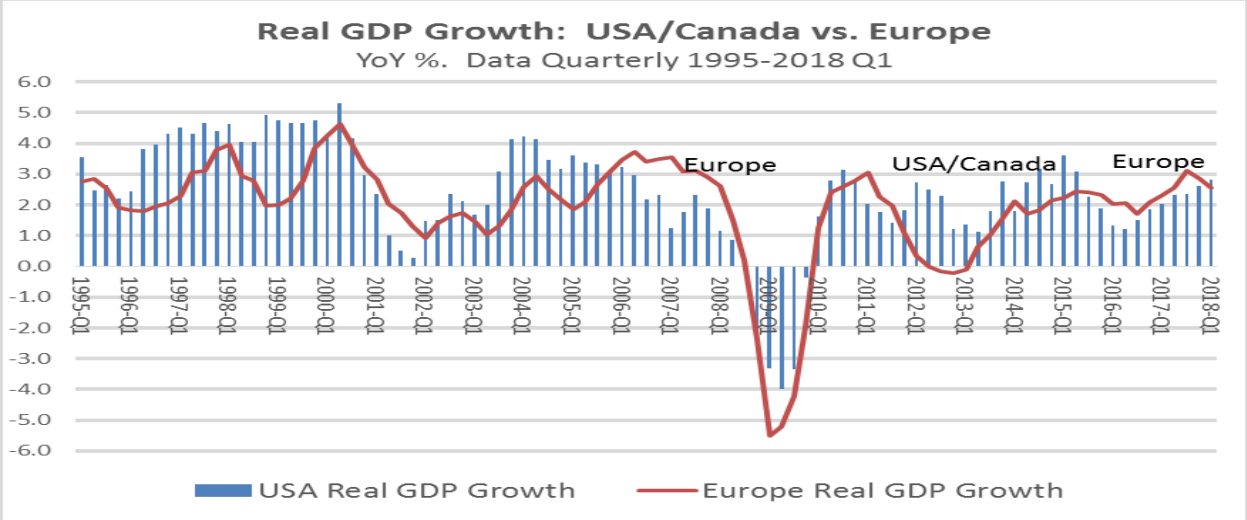


Figure A-2

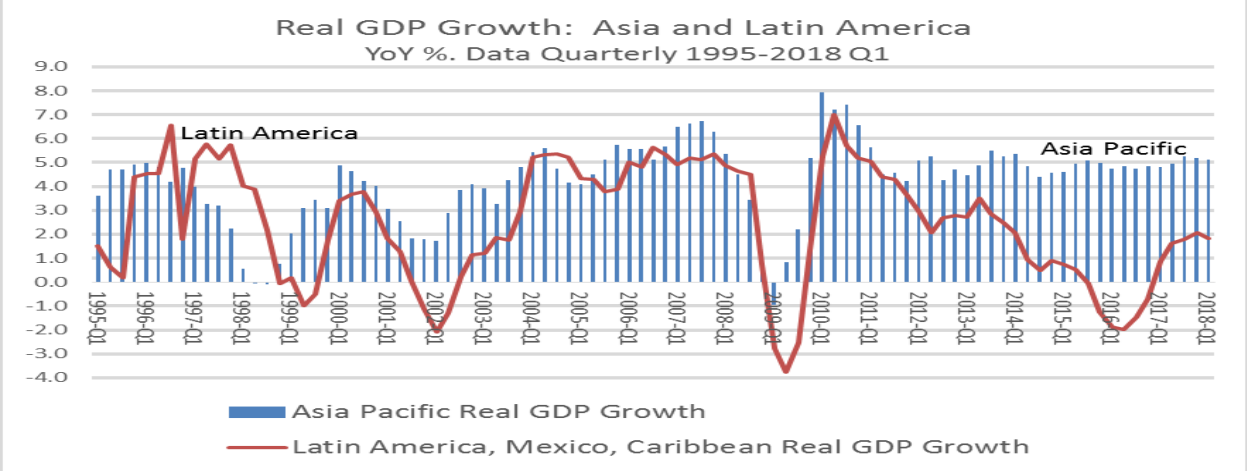


Figure A-3