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Returns Focus

CROSS-ASSET

Earning risk premia from interest rate volatility (part 2)

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Quantitative Strategies

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A unique source of value across currencies and curves

- Implied volatility tends to be higher than actual volatility measured in subsequent periods. We refer to such gaps as volatility risk premia (VRP), since option sellers seem to receive compensation for the risk of losses driven by volatility spikes, which are often linked to general market turmoil.
- In this report we extend our previous analysis of interest rate VRP. Moving beyond USD 1m10y swaptions, we investigate a range of liquid expiries, forward tenors, and currencies. We also consider intra-month seasonality, possible long/short strategies, and risk filtering techniques. Lastly, we note how horizon-dependent mean reversion and regulatory changes may have created better opportunities.
- A few results seem particularly noteworthy:
  - VRP strategies in USD, EUR, and JPY are particularly useful in rising rate environments, usually delivering solid returns while long-only bond positions underperform.
  - VRP exposure can perform well even when the absolute level of implied volatility is low.
  - Longer forward tenors and shorter expiries tend to outperform.
  - Risk premia seem higher leading up to major economic releases.
  - Interest rate VRP is not just a USD phenomenon. The evidence for interest rate VRP is just as strong if not stronger in EUR and JPY markets.
  - Since EUR and JPY interest rate markets have nothing close to the scale of MBS in USD, the old story that hedgers of MBS convexity drive interest rate VRP seems contradicted by the our analysis.
- Earning VRP by selling delta-hedged swaptions can be considered as part of the “carry” category of investment styles – strategies that tend to work well in a stable environment, but suffer in a risk-off market. We propose a simple carry stability filter to guide VRP exposure timing, which is designed to alleviate some of the drawdown caused by adverse market moves.

As an empirical matter, implied volatility tends to be higher than volatility realised in subsequent periods. This difference between implied volatility and subsequent realised volatility is regarded as volatility risk premium (VRP) which compensates option sellers for the risk of large losses due to volatility spikes, usually coinciding with market turmoil. Therefore, implied volatility is a “biased” expectation of future realised volatility. The existence of VRP is clear across different asset classes, as we have discussed in a number of previous reports. For example, please see Earning risk premia from interest rate volatility, Earning risk premia from equity volatility, and The role of equity volatility risk premium in asset portfolios.

In this report, we concentrate on interest rate VRP. Typically, interest rate volatility risk premium can be earned by systematically selling at-the-money-forward (ATMF) swaption straddles and hedging the delta exposure. In previous work, we discussed various characteristics of selling USD 1m10y volatility on a delta-hedged basis. We showed how it can be considered an alternative return source (or "alternative beta" as some call it) with a number of attractive features.

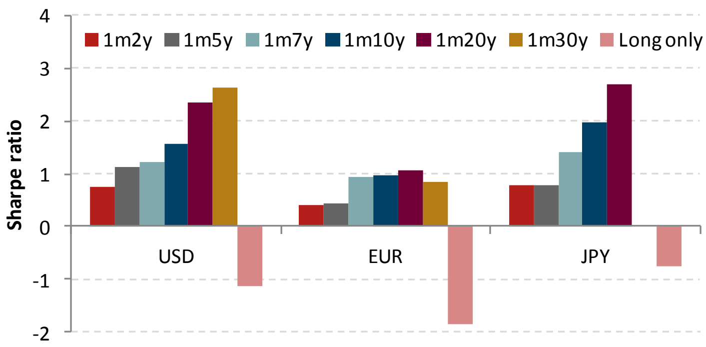
As we discussed in previous reports, VRP exposure is not risk free. Short positions in swaption straddles, even delta hedged, are likely to earn risk premia because they are exposed to systematic risk factors. Historical evidence shows that implied volatility tends to rise in times of market crisis.

Another way to think about VRP exposure is that it is like providing insurance and deserves compensation. One earns small, frequent rewards (option premia), while being exposed to large, infrequent losses. The catch is that these losses are likely to occur when other markets are also experiencing increased volatility. Hence, this kind of insurance has systematic risk, and deserves extra compensation. Other types of insurance, e.g., for flood damage or car accidents, are less likely to be associated with financial market turmoil. They are less likely to deserve systematic risk premia.

Interest rate VRP exposure outperforms in rising rate environments

It is particularly worthwhile to revisit interest rate VRP strategies at the current time. Expectations of recovery and rising rates are growing. The future does not look bright for long-only bond investors. But VRP exposure in interest rates seems to work particularly well in such environments, as shown below.

Fig. 1: Interest rate VRP strategies outperform long-only in rising rate environments



Source: Nomura Research. Rising rate environments are defined as periods when 10y USD swap rate, 10y EUR swap rate and 20y JPY swap rate respectively keep rising for more than one month. 1m30y JPY is excluded due to unavailability of quality volatility data. Long-only excess returns are calculated based on UST 10y, Bunds and JGB futures. The sample period is from Jan 2000 to Dec 2013. All returns are net of transaction costs.

Figure 1 shows the performance of selling 1m2y, 1m5y, 1m7y, 1m10y, 1m20y and 1m30y swaptions (delta-hedged on a daily basis) when rates are rising for three major markets – USD, EUR and JPY. We do not include JPY 1m30y swaptions due to limited data availability. The interest rate VRP strategies consistently outperform a government bond futures long-only strategy, which suggests that VRP exposure in interest rates can provide good returns even when rates are rising.

This result may appear somewhat counterintuitive. Investors might expect volatility to be particularly high in a rising rate environment. But the reality is that implied volatility rises to such an extent that systematically selling it provides good returns. In other words, while volatility may go up, the gap between implied and realised volatility goes up even more. And this implied/realised volatility gap is what really matters for VRP returns.

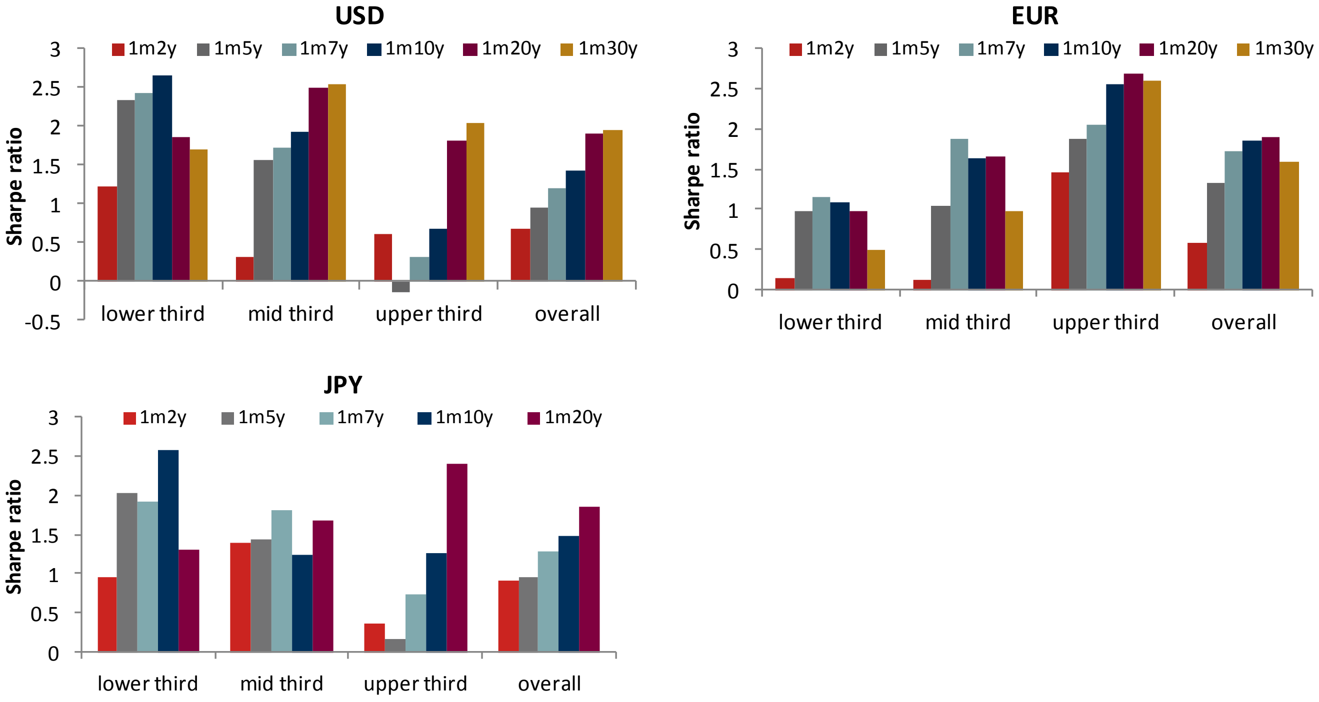
In the above chart, some readers may notice that longer underlying swap tenors tend to offer higher risk-adjusted returns. We will discuss the links between volatility risk premia and underlying swap tenors later in this report.

VRP exposure can perform well even when implied volatility is low

A common misconception is that VRP exposure can only work when the absolute level of implied volatility is high. Figure 2 demonstrates that volatility-selling performs well even when implied volatility is low. Again, this may seem counter-intuitive to many investors. But keep in mind that the performance of VRP exposure does not depend on the absolute level of volatility. Instead, VRP performance depends on the difference between implied volatility and realised volatility. And this difference is not tightly related to the level of implied volatility.

Fig. 2: VRP exposure performs well even when implied volatility is low.

For G3 rates, taking 1-month expiry as an illustration, VRP exposure performs well for swaptions of most tenors even in low volatility environments.



Source: Bloomberg, Nomura Research. We do not include JPY 1m30y volatility selling due to limited data availability. The sample period is from Jun 2002 to Dec 2013 for USD and EUR, from Nov 2001 to Dec 2013 for JPY.

In the remainder of this report, we extend this framework to various interest rate VRP strategies based on different selling frequencies, option expiries, and swap tenors for major swaption markets - USD, EUR and JPY, and then examine how these factors influence the level of VRP. We also investigate a carry stability filter to switch off VRP exposure during risk-off periods so as to mitigate some of the drawdown risk caused by adverse market moves.

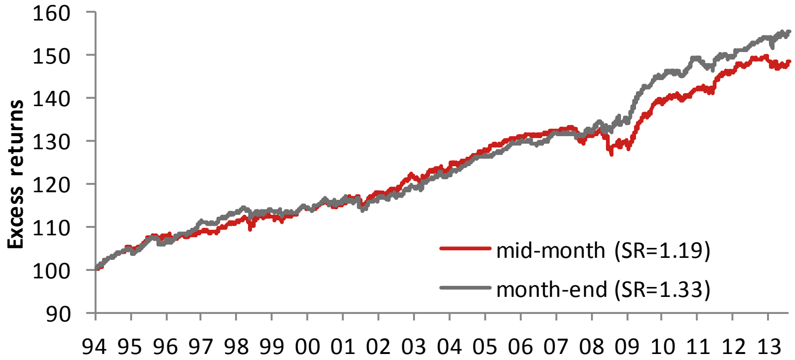
Selling swaptions daily to average swaption strike expsoure

In "Earning risk premia from interest rate volatility", our analysis was based on selling 1m10y USD swaptions on a weekly basis, delta-hedged daily. The reason for weekly swaption selling instead of monthly was to average exposure across swaption strike levels. Selling volatility at a daily frequency achieves this goal even better.

In Figure 3, we show an example of how strike risks could make a difference. We test a VRP strategy on USD 1m10y on a monthly basis, but at two different trade schedules: one initiated at the mid-month and the other initiated at the month-end. In a normal market, the two schedules should generate similar returns. However, the real world is a messier place. Figure 3 shows a particular example of how the two schedules diverged during the Lehman collapse in 2008. A more recent example is the divergence of the two since the onset of Fed QE tapering concerns in May 2013.

Fig. 3: Performance of VRP exposure is subject to strike risks

Entering USD 1m10y VRP exposure at month-end outperforms entering at mid-month

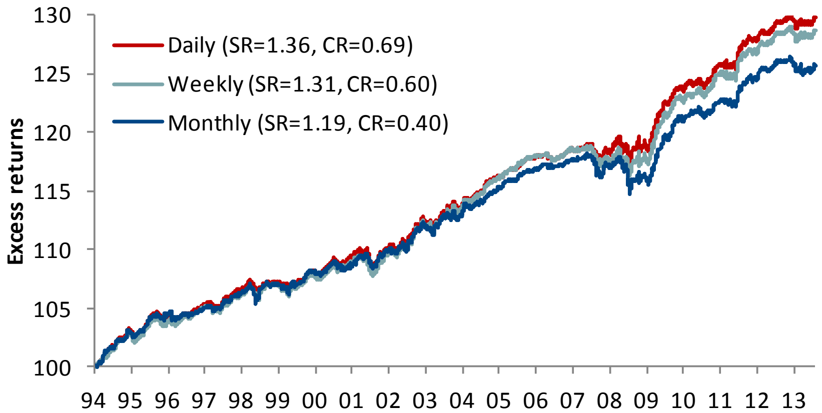


Source: Nomura Research. Excess returns are net of transaction costs.

Dividing strike exposures over a large number of days provides a relatively more stable gamma exposure. A strategy with a lower frequency selling schedule often suffers a significant drop in gamma when the market moves away from the initial strike. In Figure 4, we compare selling 1m10y USD swaptions on a daily, weekly, and monthly basis. All strategies are delta hedged to remain neutral to small movements in interest rates. We sell swaption straddles at the mid-week for weekly selling and at the mid-month for monthly selling. As expected, executing VRP exposure at a higher frequency reduces strike risks and drawdowns during risk-off periods, yielding a better risk-adjusted return. In our view, the daily frequency provides a cleaner picture for investors to understand VRP as a source of alternative beta, as it uses diversifies exposure to strike prices across all possible trading days.

Fig. 4: Daily swaption selling delivers more stable performance

Selling USD 1m10y at higher frequencies helps to diversity strike exposures.



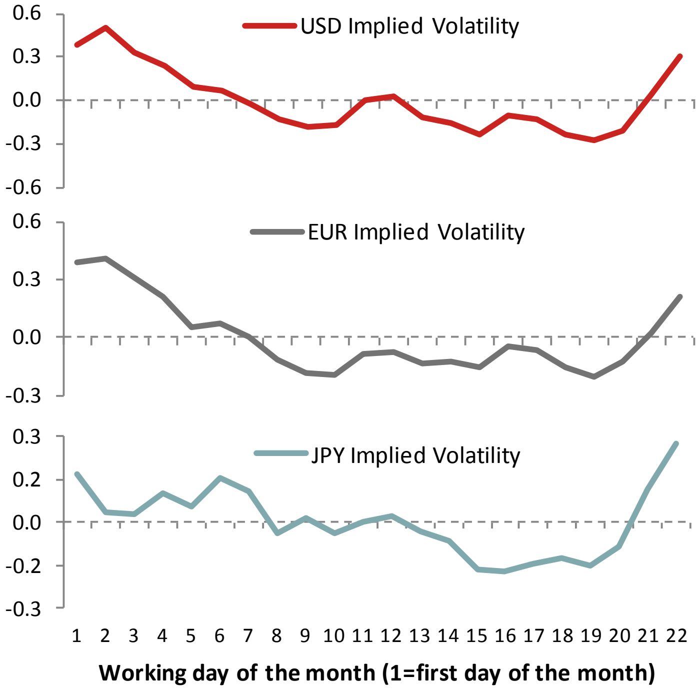
Source: Nomura Research. Excess returns are net of transaction costs and re-scaled to annualised volatility of 1.0%

Calendar effects: are certain times of the month better for initiating VRP?

Economic data releases can have a big impact on interest rate markets. Some important economic data are released at the same time each month, e.g., NFP is generally released on the first Friday of a month. Leading up to those announcements, markets seem to price in higher risk premia for macro uncertainties. As seen in Figure 3, VRP exposure initiated around the end of the month tends to generate higher returns than VRP exposure initiated at mid-month. Volatility premia may be higher because more investors demand protection and/or fewer investors are willing to supply protection before data releases.

Fig. 5: Average z-score of implied volatility during a month

Higher implied volatility on average is found at both the beginning and the end of month.



Source: Bloomberg. The sample period is from 2003 to 2013 (for JPY 1m30y, the sample is from Sep 2009 to Dec 2013 due to the availability and the quality of data).

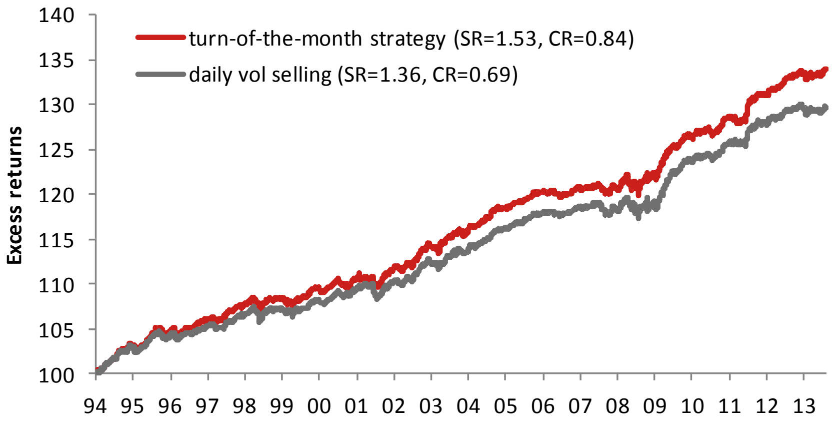
In Figure 5, we show the average z-score[1] of ATMF implied volatility on 1m2y, 1m5y, 1m7y, 1m10y, 1m20y and 1m30y for USD, EUR and JPY across the month. The curve is generally tilted on both ends, which indicates that volatility risk premium at both the beginning and the end of month is systematically richer.

This “anomaly” allows us to systematically harvest VRP’s richness around the turn of the month. A simple way to achieve this is to only initiate VRP exposure on a daily basis for a one-week period starting from the last business day of the month. Figure 6 compares this simple turn-of-the-month strategy with the regular daily strategy from before. As shown in Figure 4, the daily strategy materially outperforms monthly and weekly. But the turn-of-the-month strategy seems to outperform daily. It outperforms in terms of both Sharpe ratio and Calmar ratio.

1 The z-score is calculated as the actual implied vol level less the average of implied vol over the same month, and then divided by the standard deviation of implied vol over the same month.

Fig. 6: Calendar effect allows for a better timing to enter VRP exposure

An example of initiating VRP exposure daily for a 1-week period starting around month-end

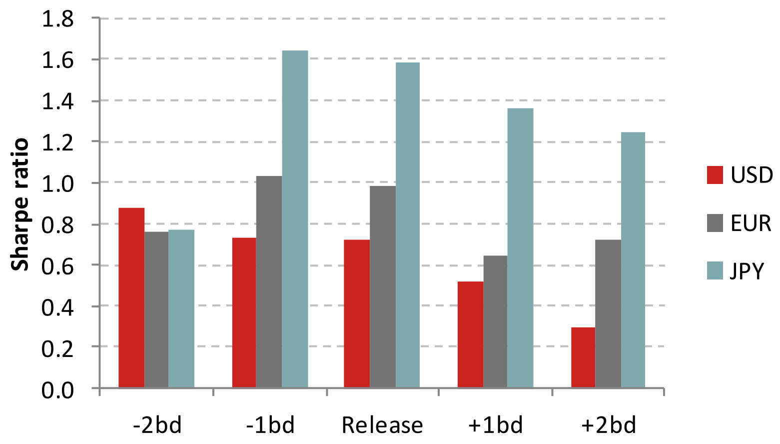


Source: Nomura Research. Excess returns are net of trading costs and re-scaled to annualised volatility of1.0%

Why does this works as well as it does? The answer probably has to do with the release dates of nonfarm payrolls (NFP), which is generally considered one of the most important macroeconomic indicators. The release of the NFP numbers generally drives considerable market volatility. It is easy to imagine that the market prices in higher risk premia ahead of this release. We design a test for this intuition. We construct five monthly interest rate VRP strategies across G3 rates: selling 1m10y straddles two business days before the release date, one business day before, on the release date, one business day after and two business days after the release date.

Fig. 7: Volatility risk premia vary significantly before and after the release of NFP

Volatility risk premia drop after the release of nonfarm payrolls.



Source: Nomura Research. The returns are calculated over the period 2001 to 2013 and net of transaction costs.

Figure 7 depicts the risk-adjusted returns of these strategies. For USD, the results are in the red bars on the left. We can see a clear trend lower as the release date is passed. In EUR and JPY risk premia also seem to peak just before the release date. In general, VRP tends to be higher one business day before and on the NFP release date, and then decreases after one business day. This pattern may provide another timing factor for "smart" VRP exposure.

In some ways this is like classic insurance premia behaviour. Customers are willing to pay more for insurance when uncertainty and/or fear is greatest, and less when it declines.

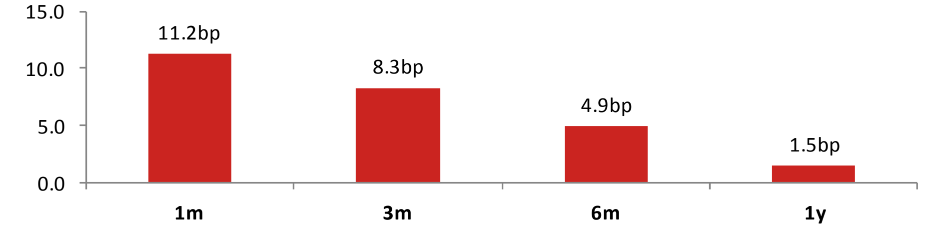
Option expiry effect: a downward sloping term structure in volatility risk premia

Some empirical studies, such as Duyvesteyn et al. (2013, please see References on page 13), document that volatility risk premia have a downward sloping term structure in option maturities, i.e., VRP in short-dated options is generally more pronounced than long-dated ones. This can be well explained by short-dated expiration's higher gamma which leads option sellers to require higher volatility risk premia to bear the jump risks.

To illustrate, we approximate this term structure by comparing the average of volatility risk premia across 1m, 3m, 6m and 1y expiries of USD 10y swaptions. The risk premium is calculated as the difference between implied volatility and actual volatility, and then averaged out for the past 10 years. Figure 8 shows that volatility risk premia are highest for options in one-month expiry (11.2bp), and then decline quickly as option expiry approaches 1-year.

Fig. 8: Volatility risk premia decline as expiries increase for USD 10y swaptions

There is a downward sloping term structure in volatility risk premia along option expiry (measured by the gap between implied vol and realised vol).

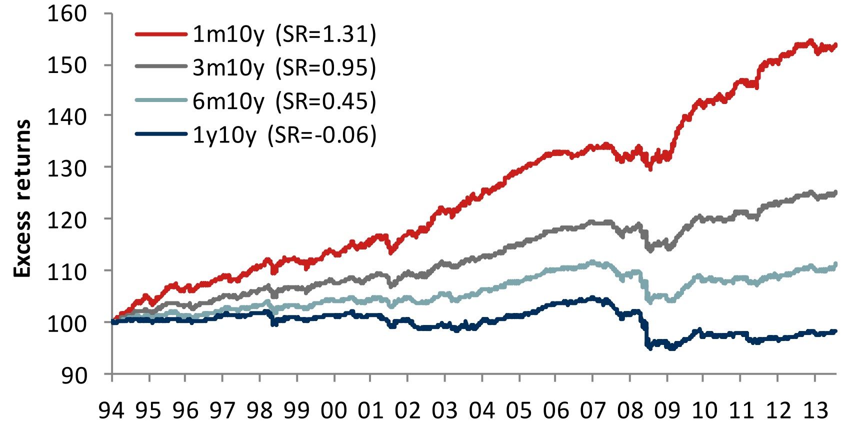


Source: Nomura Research, Bloomberg. The average VRP are calculated over the period 2003 – 2013.

In Figure 9, we compare interest rate VRP strategies by that use different expiries from 1m to 1y on the same underlying swap tenor (10y). All swaptions are sold on a weekly basis (delta-hedged daily) and the excess return is net of transaction costs. In line with Figure 8, VRP exposure on shorter expiries tends to perform better.

Fig. 9: Volatility risk premia seem richer at shorter expiries

VRP exposure using swaptions with shorter expiries outperforms.



Source: Nomura Research. Excess returns are net of transaction costs.

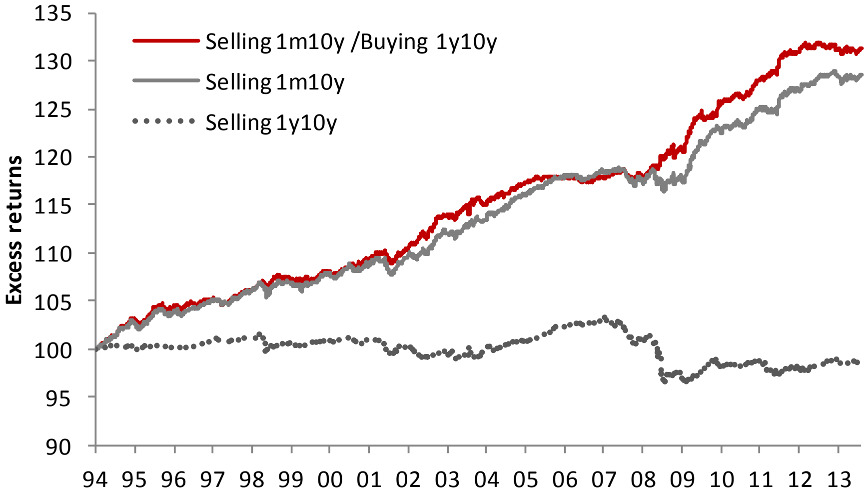
The difference in VRP across option expiries may entail a relative value opportunity. By going long/short VRP exposure at different expiries, we are able to construct a long/short portfolio to reap the difference in VRP. For example, we can sell USD 1m10y swaption straddles and buy USD 1y10y swaption straddles (delta-hedged daily). Apart from the aforementioned, this long/short combination also helps mitigate several risks:

- The jump risk due to discrete delta hedging as the long/short legs of the underlying forward swaps largely offset each other
- The systemic risk in terms of market volatility as the vega exposure of the two legs largely offset

Figure 10 exhibits a chart of cumulative excess returns as well as a table of return statistics for the strategy of going short a 1m10y swaption and long a 1y10y swaption. We weigh these two legs such that the long/short package is gamma neutral.

Fig. 10: Short USD 1m10y vs long USD 1y10y delivers higher risk-adjusted returns than the individual VRP strategies

VRP on the same tail but between different expiries leads to relative value opportunities.



	Average return	Ann. Vol	Max drawdown	Sharpe ratio	Calmar ratio
1m10y/1y10y	2.0%	1.4%	1.88%	**1.42**	**1.07**
1m10y	2.3%	1.7%	3.75%	**1.31**	**0.60**
1y10y	-0.1%	1.5%	9.61%	**-0.06**	**-0.01**

Source: Nomura Research. All stats are net of trading costs, and the cumulative returns in the chart are re-scaled to 1.0% annualised vol.

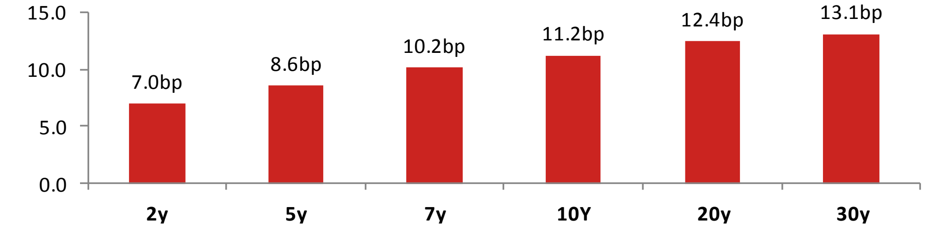
This long/short strategy delivers a high Sharpe ratio (1.42) and, more importantly, a high Calmar ratio (1.07) relative to those of each individual leg.

Swap tenor effect: an upward sloping term structure in volatility risk premium

Apart from expiries, we found that VRP is also affected by its underlying swap tenor. Swaptions on longer-tenor swap tend to have higher VRP. Figure 11 depicts the average VRP for one-month expiry on USD 2y, 5y, 7y, 10y, 20y and 30y swaptions in the past 10 years. The VRP is calculated in the same way as that in Figure 8. This chart shows that on average there is an upward sloping term structure in VRP in swap tenors.

Fig. 11: Average VRP for 1-month USD swaption on different swap tenors

There is an upward sloping term structure in volatility risk premia along underlying swap tenor (measured by the gap between implied volatility and realised volatility).



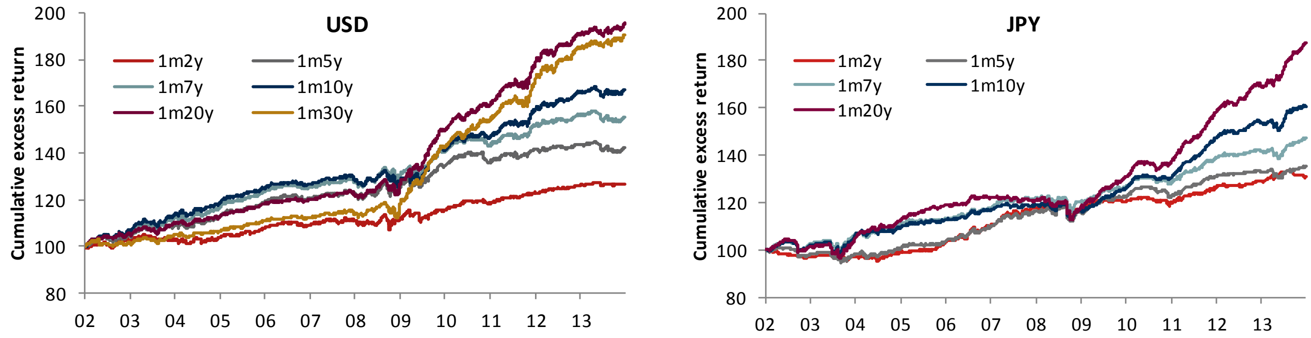
Source: Nomura Research, Bloomberg. The average VRP are calculated over the period 2003 – 2013.

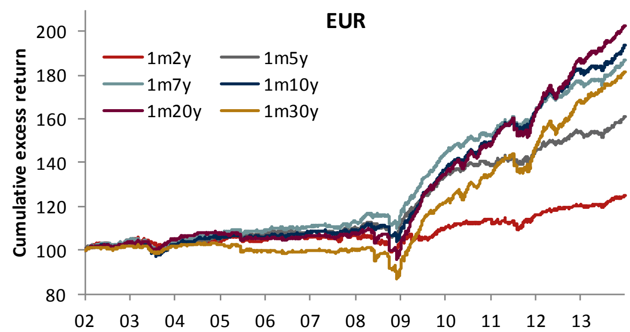
Figure 12 exhibits the performance of VRP exposure across tenors and the three major swaption markets. The volatilities of these return series are all scaled to 3% for comparison. The cumulative excess return series show that a longer underlying swap tenor implies a better performance, thereby a higher volatility risk premium.

The 30y tenor in USD and EUR may be an exception, apparently offering slightly less premia than 20y. However, these differences are slight and may derive from outlier effects.

Fig. 12: Volatility risk premia vary across different underlying swap tenors

VRP exposure on longer swap tenors tends to yield higher returns





Sharpe ratio

	USD	EUR	JPY
1m2y	0.66	0.62	0.90
1m5y	1.00	1.32	0.94
1m7y	1.26	1.72	1.22
1m10y	1.46	1.81	1.50
1m20y	1.91	1.87	1.80
1m30y	1.84	1.55	

Source: Nomura Research. All results are calculated over the period 2002 - 2013 and net of transaction costs. We exclude JPY1m30y straddle selling here due to the limited data availability.

To further investigate the relationship between VRP and underlying swap tenor, we measure the mean-reversion strength of swap rates of different tenors. For a mean-reverting process, the higher the mean-reversion strength, the faster the volatility decays with expiries, which might indicate a larger gap between implied volatility and realised volatility. At a more prosaic level, selling volatility on a swap that is more likely to mean revert is less risky than selling volatility on a swap that is likely to explode either up or down.

At a less technical level, this is similar to saying that for the same insurance premium, it is a better opportunity to sell fire insurance in a region with stone houses, high rains and low sunlight than in a region with wooden houses, hot temperatures, zero cloud cover, and no rain.

We calculate Hurst exponents to gauge the mean-reversion strength. If the Hurst exponent is lower than 0.5, then the series is less persistent (i.e., mean-reverting); if it is higher than 0.5, then the series is more persistent (i.e., trending); if the series is a Brownian motion (neither trending nor mean reverting), then the Hurst exponent is 0.5. Figure 13 shows Hurst exponents for USD swap rates across different tenors. Apart from the 30y swap, the mean-reversion strength increases with tenor. This is consistent with the previous observation that there are richer volatility risk premia for longer tenors.

Fig. 13: Mean-reversion strength of USD swaps with different tenors

Stronger mean-reversion behaviour is generally observed for longer tenors

	Hurst
2y Swap	0.506
5y Swap	0.490
7y Swap	0.488
10y Swap	0.482
20y Swap	0.468
30y Swap	0.474

Source: Bloomberg, Nomura Research. Lower Hurst exponent implies stronger mean reversion. The sample period is from Jan 2000 to Dec 2013.

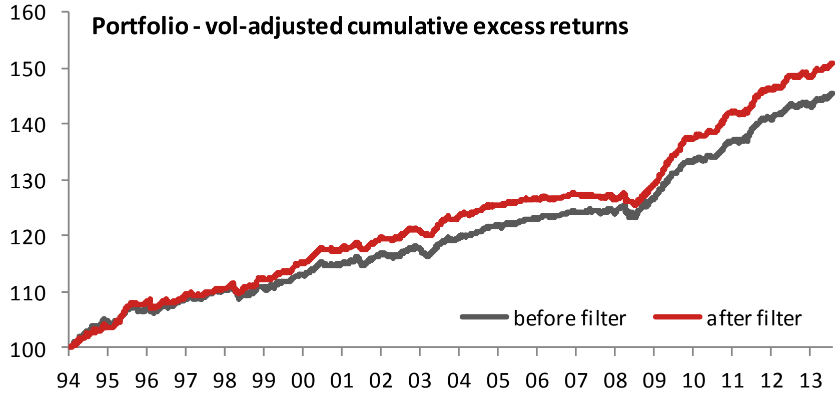
Using a stability filter to mitigate drawdown risks

After examining different factors that affect volatility risk premia, we now move to construct a stability filter to mitigate drawdown risks. The general ideas are 1) to avoid entering VRP exposure when volatility is expected to rise, and 2) to avoid VRP exposure when expected VRP is low or negative.

In our test, we deploy a simple stability filter which checks the trends of implied volatility and volatility risk premia. Volatility risk premia are approximated by the difference between implied volatility and realised volatility. We sell swaption straddles only when either implied volatility is declining or implied volatility is modestly increasing accompanied by a rising risk premium. In Figure 14, we show how using this filter leads to an improvement in the performance in risk-adjusted terms.

Fig. 14: A carry stability filter can mitigate drawdown risks

The portfolio represents an equal-weighted portfolio of short positions in delta-hedged 1m10Y swaption straddles, sold daily, in USD, EUR and JPY.



	USD	EUR	JPY	Portolio
Sharpe Ratio				
Before	1.36	1.80	1.38	**1.96**
After	1.52	2.06	1.40	**2.16**
Calmar Ratio				
Before	0.69	0.91	0.58	**0.88**
After	0.88	1.39	0.53	**1.29**

Source: Nomura research. To make performance comparable, the excess returns in the chart are re-scaled to 1.0% annualised volatility. Results are net of trading cost.

This stability filter, together with daily trading frequency, offers economic benefits in most cases, though the JPY 1m10y Calmar ratio is slightly worse. It avoids the high costs of unwinding deep OTM swaptions in a stressed market that would be triggered by simple stop loss rules. By spreading out the VRP exposures across daily frequency and selectively entering VRP exposure, downside risks can be alleviated in a more practical way.

Structural change of volatility risk premia after subprime crisis?

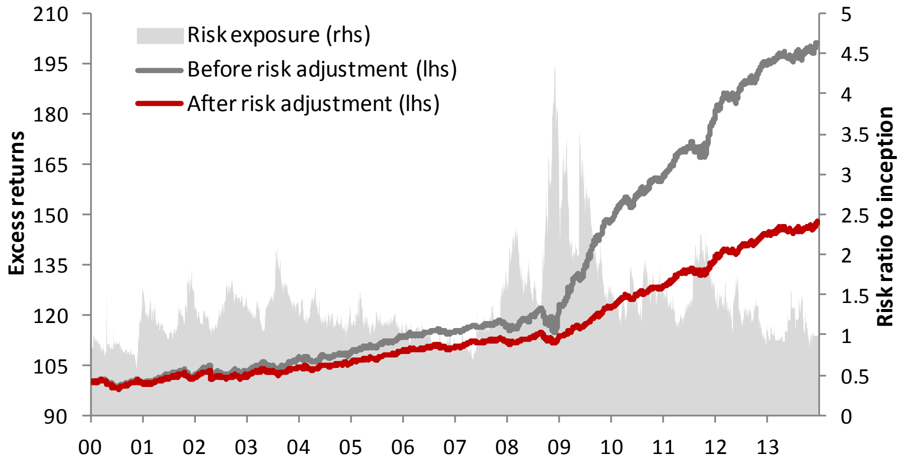
In some of the charts shown in previous sections, one can notice that the performance of VRP changes after the subprime crisis. Rennison et al. (2012, please see the References on Page 13) also found similar results in their study. Specifically, the post-crisis average return appears to be larger than the pre-crisis return.

There is some truth to this but it is also important to consider risk adjustments. Since the structural change appears to be much more pronounced for long-tenor swaptions, we concentrate on USD 1m30y VRP strategy here as an example. As our strategy involves selling a fixed notional of swaptions every period, we have not adjusted for the effective risk of the strategy, which depends on the levels of implied volatility and gamma.

In Figure 15, we see that if we hold our approximation to the risk of the strategy constant[2], we eliminate some portion of this change.

Fig. 15: Post-crisis VRP returns may look better than they really are

After risk exposure adjustment, the performance is more similar to pre-crisis period



Source: Nomura Research. Excess returns are net of transaction costs

However, we notice that even after risk adjustment, there is still a structural shift in terms of the effectiveness of the interest rate VRP strategy after subprime crisis. VRP exposure seems to generate higher returns after the crisis.

One explanation may be that investors are generally more cautious about interest rate risk after the crisis. There is in general a greater reluctance of investors to sell optionality to earn carry than there was before. Anecdotally, we notice in our conversations with sophisticated fund managers that there seems to be more interest in buying optionality than in selling it since the crisis.

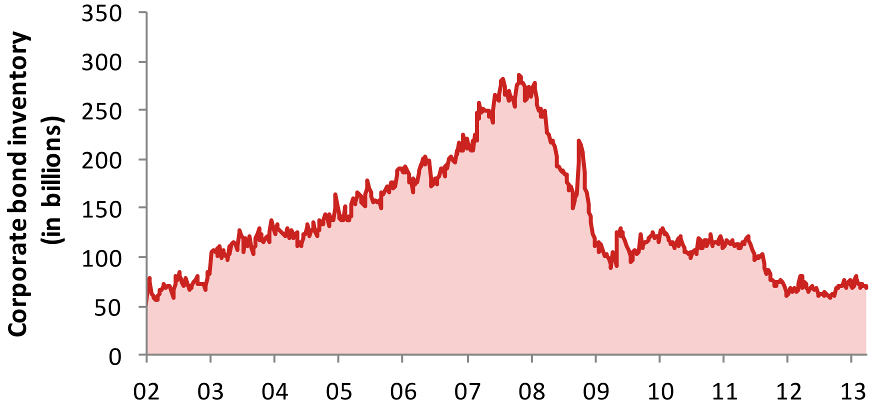
One could think of those investors betting on a meltdown in Japanese solvency using long JPY swaption payers as an example of this crowd. Their purchases are another factor driving interest rate implied volatility higher.

But beyond changing tastes and preferences, it is almost certain that regulatory changes have played a key role. In particular, the Basel capital rules and related changes have made it more expensive for banks to take certain types of risk, including credit and volatility exposure.

One illustration of this change is visible in Figure 16, which shows corporate bond inventories of US primary dealers. The plunge in credit inventories does not reflect an aversion to credit risk per se. Rather it reflects higher capital charges associated with holding credit exposure.

[2] We approximate the VaR of the portfolio as the Gamma*ImpliedVolatility^2, where Gamma is measured in $\Delta price^2/\Delta bp^2$ and Impliedvolatility in bp.

Fig. 16: Dealer credit inventories have declined after the crisis.
Higher capital charges have driven down primary dealers' corporate bond holdings since the credit crunch.



Source: Fed Reserve Bank of New York

In a similar fashion, dealers running short gamma positions are now charged more capital, because it increases VaR and Stress VaR. So for a given ROE (return on equity) target, dealers require a bigger expected profit (or equivalently higher levels of VRP) to compensate for the higher capital charges. This tends to widen the gap between implied volatility and realised volatility. High capital charges make dealers less willing to take risk, and the declining supply of volatility sellers drives up volatility risk premia.

Some believe dealers' reluctance to take large exposures has led to choppier markets after the crisis, or at least to the perception that markets are choppier. Risk managers with this view are likely to exacerbate this cycle by reducing risk limits, causing investors to hold smaller notional exposure than they did during the run-up to the crisis.

A time to consider VRP in interest rates

Mention the word "derivative" or "volatility" and many investors instinctively recoil. But when a product is so unloved, it may represent good value. In this report we have tried to focus on facts rather than feelings. And the data tells a consistent story across currencies, swap tenors and expiry points. Volatility risk premia (VRP) exist. It is not a phenomenon confined to USD markets. If anything, VRP seem stronger in EUR and JPY than in USD. Hence, the old belief that VRP in interest rates is just an artefact of MBS convexity hedging seems increasingly at odds with reality.

Given recent regulatory changes, the attractiveness of VRP exposure seems even greater. There are fewer sellers of optionality and more buyers. When there are fewer sellers of insurance in a market place, it usually pays to be one of them. Given the real prospect of higher interest rates in the years to come, it is especially important that interest rate investors consider other ways to make returns. Just being long bonds may not be good enough anymore. VRP exposure may be one of the most scalable ways to earn good returns going forward.

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Appendix A-1

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