Introducing the New Axioma Multi-Asset Class Risk Monitor

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Axioma's new Multi-Asset Class (MAC) Risk Monitor highlights recent trends in market and portfolio risk. The report is a collection of graphs and tables showing current multi-asset factor correlations and volatilities, treasury curves, yield, spread and FX histories, model portfolio risk analysis and stress tests. This paper will explain the methodology behind the graphs and how to use it in your analysis.

The report will be downloadable from the Insights section of the Axioma website. We will update it every Tuesday based on latest data available as of the previous Friday. We will also send out a Weekly Highlights email that individuals can subscribe to on Axioma.com.

The MAC Risk Monitor report has two main parts. The first contains market drivers and risk factors. It starts by looking at correlations between equity indices, government benchmark yields, corporate bond spreads (investment grade and high yield), currency exchange rates and commodity futures prices. It also has government yield curves over time as well as yield, spread and foreign exchange rate histories and risk time series.

The second part analyzes the impact of these drivers and factors on a global multi-asset class portfolio by looking at standalone volatilities and risk contributions by asset class over short and long-term time horizons. It highlights how the different asset classes and return drivers interact in a portfolio context and how correlations between them either increase or lower overall risk. We also shock some of these factors in a number of stress tests to examine how the portfolio reacts under a variety of market conditions.

We will walk through the different charts and tables and explain what they show and how they can be interpreted. The data in the examples is as of Nov. 18, 2016.

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1. Factor Correlations and Changes in Correlations

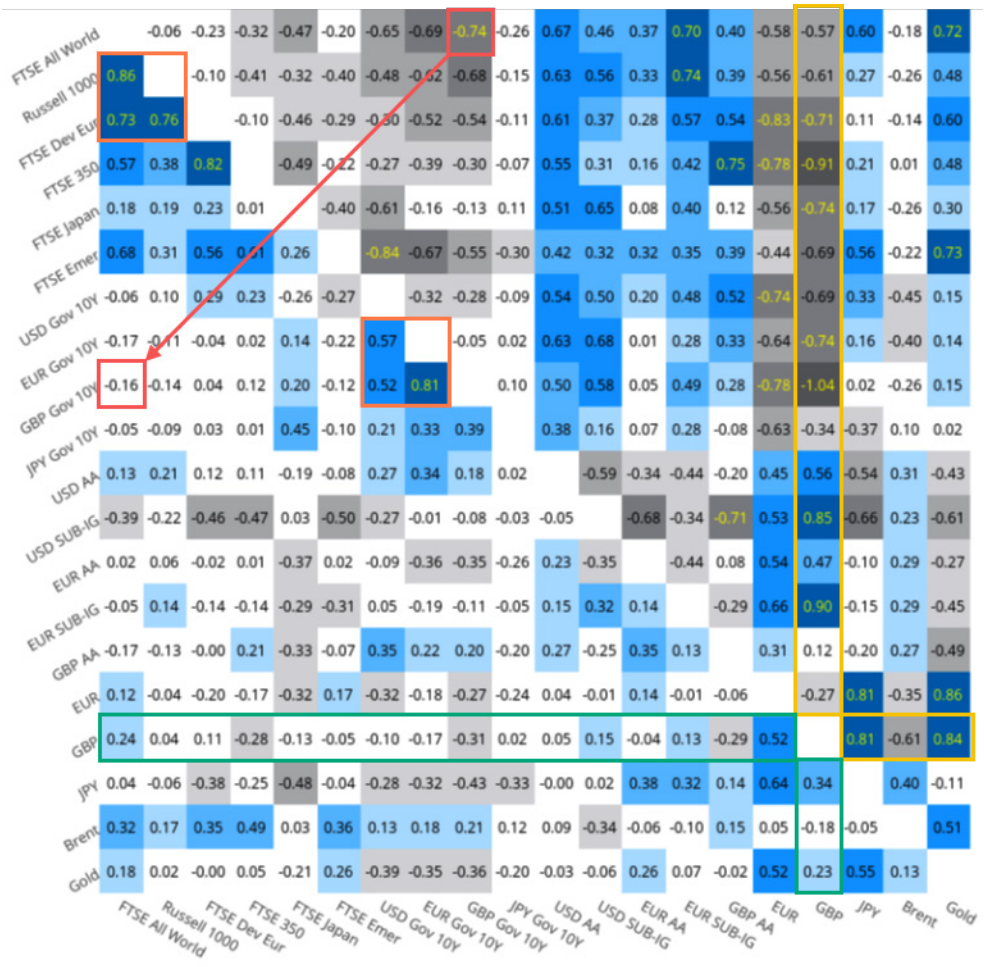
Figure 1, the Factor Correlations chart, shows correlations between major asset class factors and return drivers. The lower left triangle represents correlations of daily returns/ factor changes over the last sixty business days. The upper right shows changes in those correlations compared to the previous sixty-day period. Dark blue cells indicate significant positive correlations or large increases in correlations compared with the previous period, while dark grey means either a strong negative correlation or a significant decrease in correlation. Correlations or changes of more than 70% either way are further highlighted by a yellow font.

For the equity indices, we use market-timing adjusted returns based on the methodology in Axioma's equity risk models.

The country specific index returns are in the respective local currencies, while FTSE All World and FTSE Emerging Markets use the USD series. FTSE Developed Europe returns, on the other hand, are in euros. The currency returns at the bottom of the matrix are based on changes in the exchange rate versus the US dollar. For Gold and Oil, we use generic front month futures.

When looking at the lower left triangle of the matrix in figure 1, which shows daily correlations for the sixty business days between Aug. 29, 2016, and Nov. 18, 2016, we can immediately see two areas of high positive correlation: (1) the all-world, US and Developed European stock indices and (2) the USD, EUR and GBP 10-year government bond yields, all highlighted in orange.

Figure 1. Factor Correlations (60 days) and Changes in Correlations (versus previous 60 days)



Sources: FTSE, Russell, Axioma

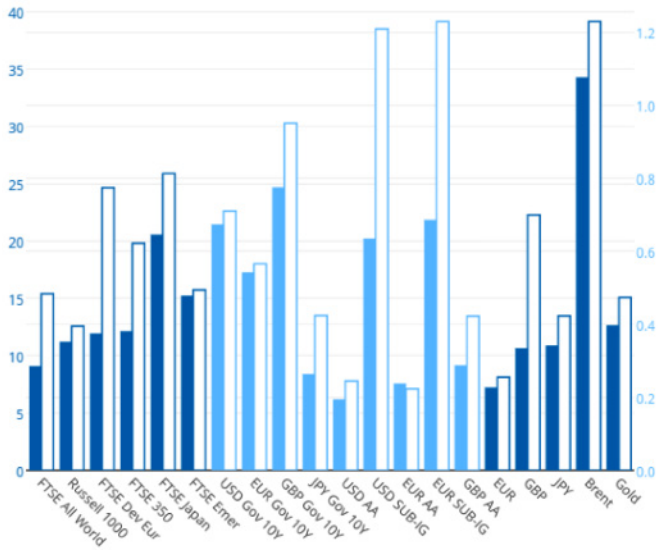
Another interesting thing to look for is big changes in correlation in the upper right triangle of the correlation matrix. For example, we can see a huge shift of -0.74 for the 10-year Gilt yield versus the FTSE All World (highlighted by a red square). The size of the change indicates that there was probably a positive correlation between those two in the previous 60-business day period (June 6, 2016, to Aug. 26, 2016). An easy way to find the corresponding current value is to move diagonally down to the left. In this case, we can follow the red arrow for four squares until we get to the diagonal and then another four until we arrive at the other field, highlighted in red, which has a value of -0.16. So we can conclude that in the preceding period, the correlation must have been +0.58 (-0.16 plus 0.74).

In some periods, we might find correlations changing across the board for one particular driver or asset class. For example, if we look at the fourth column from the right, we can see several dark grey and dark blue fields with yellow numbers. This indicates sharp changes in correlation for that particular time series, which happens to be the exchange rate of the British pound versus the US dollar. It is worth noting that once we get to the diagonal when coming from the top, we have to turn to the right in order to follow the changes (this is highlighted by a yellow border). The opposite needs to be done when we look at current correlations for the pound, i.e. we start from left to right and then turn downward at the diagonal, as indicated by the green outline.

2. Factor Volatilities

The volatility graph in figure 2 is based on the same data and same time periods (60 business days) as the correlation matrix. It uses percentage returns for equity indices, currencies and commodities and absolute changes for yields and spreads. Because of the different magnitudes of returns and rate changes, the government yields and corporate bond spreads in light blue are shown on a different scale (on the right-hand side) compared with the darker blue return volatilities. The white bars represent volatilities from the previous 60-business-day period.

Figure 2. Factor Volatilities (last 60 days versus previous 60 days)



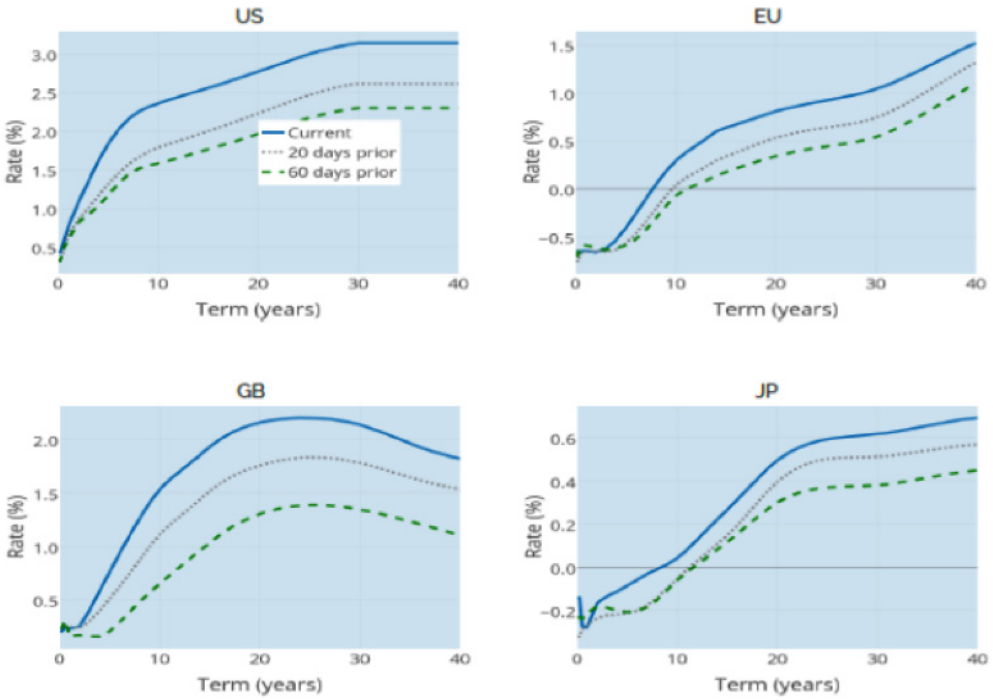
Source: Axioma

When looking at the white bars compared with the solid bars, it is apparent that volatilities have come down significantly for a number of asset classes. The time series with the smallest change and the only one showing a marginal increase in volatility was EUR 'AA' spreads.

3. Government Zero Coupon Yield Curves

The curves shown in figure 3 are zero-coupon yield curves, constructed from vanilla bonds issued by the respective sovereign for each currency. The Eurozone curve represents minimal cost of funding and is primarily built from German, Dutch and Austrian debt, though the exact composition can change depending on the current funding costs across participating sovereigns in the Euro system. The solid blue line is the current curve, while the dotted grey and dashed green lines are from 20 and 60 business days ago, respectively.

Figure 3. Government Yield Curves



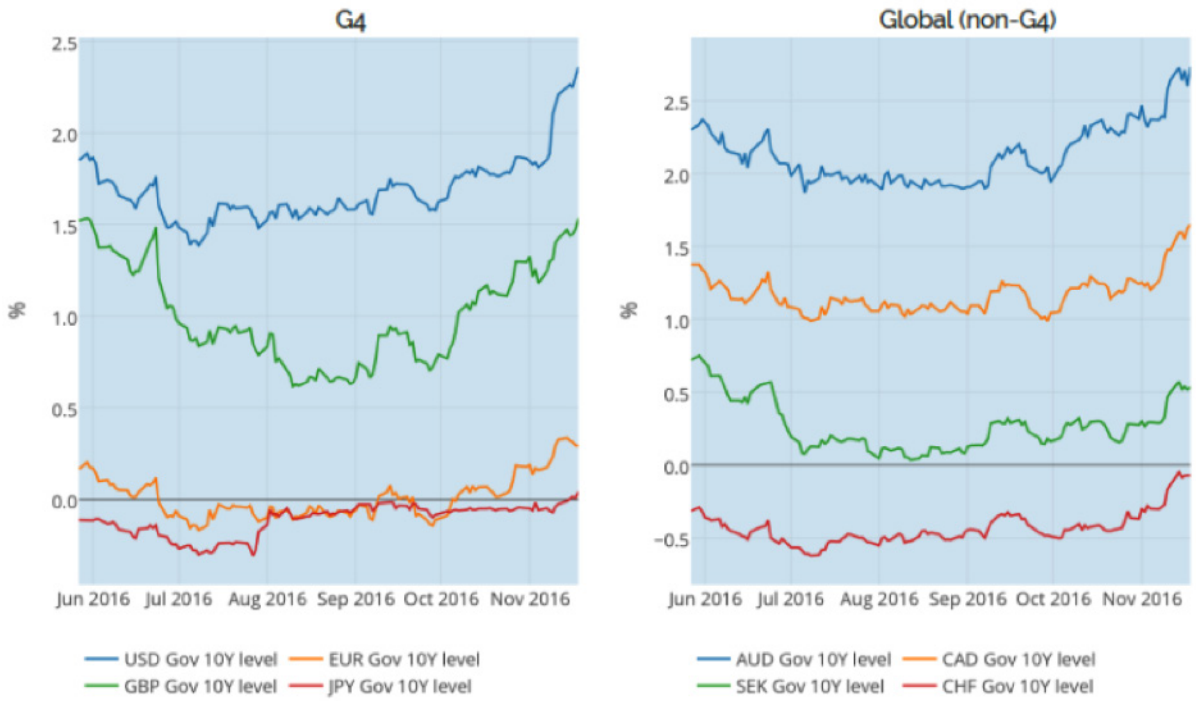
Source: Axioma

The examples above show that government bond yields have risen substantially across the board over the past three months (60 business days), in particular in the United States and Britain. Both were driven by concerns about increased government spending following Donald Trump's victory in the US presidential election and Britain's decision to leave the EU.

4. 10Y Government Zero Coupon Yields

The next two charts show the development of benchmark government yields over the most recent half-year (120 business day) period. The first graph has the 10-year points of the G4 curves we saw in the previous section, while the plot on the right shows those same points for the most actively traded non-G4 currencies.

Figure 4. 10Y Government Zero Coupon Yields



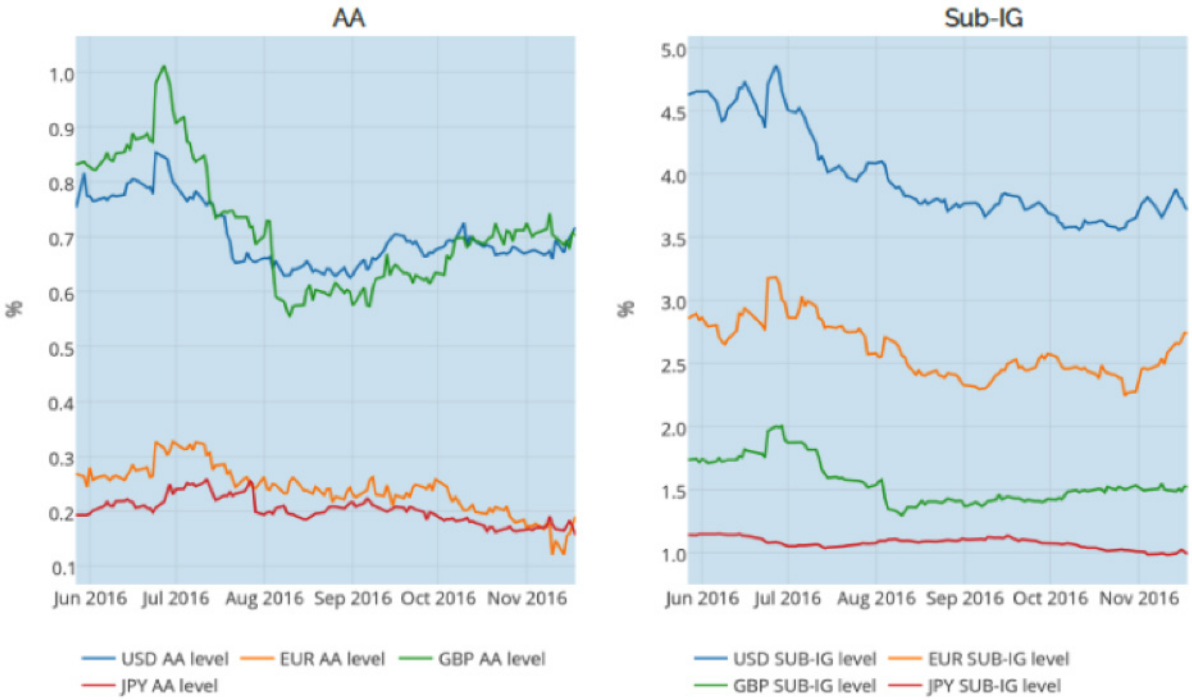
Source: Axioma

The G4 graph on the left confirms what we already saw in the curve charts, namely that benchmark rates in the US (blue line) have risen sharply since the presidential election at the beginning of November while Gilt yields (green line) have been climbing up more gradually from their post-referendum lows. It is also worth noting that the 10-year JGB yield (red line, left) has gone above zero for the first time since February, while CHF rates (red line in the right-hand chart) also seem to approach positive territory.

5. Corporate Bond Spreads

The levels shown in the corporate bond spread graphs are average spreads over the swap curve in the respective currencies, weighted by amount outstanding. The rating groups ('AA' and sub-investment grade) are blended composites derived from available rating sources.

Figure 5. G4 Corporate Bond Spreads



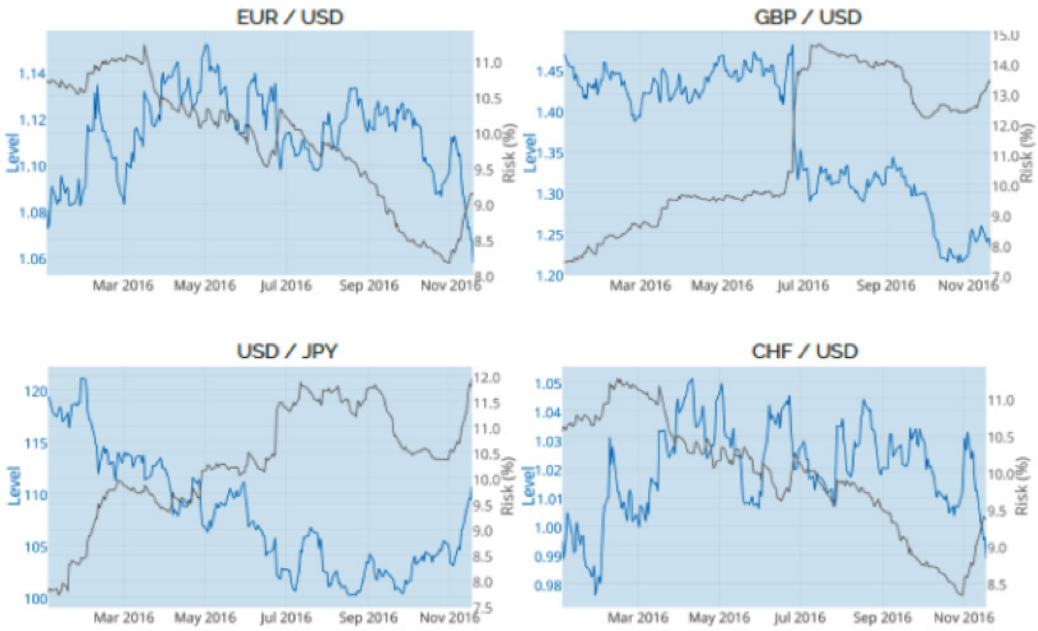
Source: Axioma

We can see that 'AA' spreads in GBP (green line in the left-hand side graph) and USD (blue) have declined significantly from their highs immediately after the Brexit vote at the end of June. Euro corporate bond spreads (orange line), on the other hand, have been fairly stable over the past six months, as we already noted in the volatility graph in figure 2.

6. Exchange Rates and Predicted Risk

These graphs show exchange rates versus the US dollar. We use Axioma's short-horizon model to predict the risk.

Figure 6. Exchange Rates and Predicted Risk



Source: Axioma

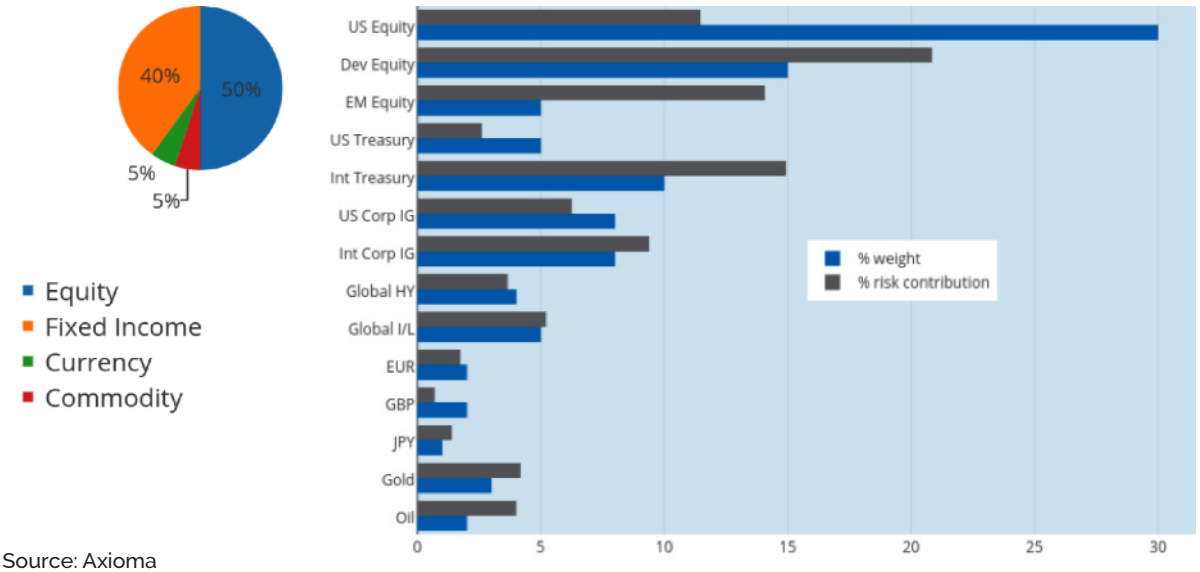
In the charts above, we can see that predicted risk has increased between one and 1.5 percentage points for all four depicted currencies since the beginning of the month. When comparing the actual exchange rate moves for EUR, JPY and CHF, it seems likely that this was driven by the recent strengthening of the dollar rather than anything specific for those individual currencies.

7. Model Portfolio Asset Class Weights versus Risk Contributions

The analysis from this point forward is based on a multi-asset class portfolio, consisting of 50% equities (30% US, 15% developed global, 5% emerging markets), 40% bonds (US, global and inflation-linked Treasuries, investment grade and high-yield corporate bonds), 5% foreign-currency cash (EUR, GBP and JPY) and 5% commodities (gold and oil futures plus cash). The portfolio is denominated in USD.

The detailed asset class weights can be seen in the figure below. The bar chart also shows the percent contribution of each category to overall portfolio risk, which in this case is based on daily, unweighted returns over the last 60 business days. It can be seen that some asset classes add more to total risk than would be implied by their percentage, while others contribute less. It is even possible for some categories to lower risk, which would then be indicated by a negative grey bar.

Figure 7. Model Portfolio Asset Class Weights vs Percent of 60-day Risk Contribution



Source: Axioma

When looking at figure 7, it may seem a bit surprising at first glance that the risk contribution of US equities is so much less than what is implied by their weight (11.5% versus 30%, respectively), given that stocks are among the riskier asset classes in the portfolio. However, almost half of the securities in the portfolio are denominated in currencies other than the USD, which appreciated sharply over the last three weeks, gaining, for example, 4% versus the euro or 6% relative to the yen. This means that assets from those markets appear to have lost value, or at least gained less than their American counterparts, when measured in the portfolio's base currency, which is the US dollar. That in turn results in negative correlations of US versus non-US assets, which materialize as the diversification effects we can now observe for US stocks, treasuries and corporate bonds.

8. Asset Class Standalone Volatilities and Volatility Contributions

Figure 8 shows risk numbers broken down by asset class. The first number column contains the percentage weight of each category, followed by three columns of short-term volatilities and contributions based on daily, unweighted returns over 60 business days. The long-term risk numbers in the last three columns on the right use weekly returns over a five-year period with a half-life of one year. The standalone standard deviation column is the volatility of each bucket independent of the rest of the portfolio. Standard deviation contribution (uncorrelated) is the bucket volatility multiplied by its weight. The sum of these individual contributions is not equal to the total portfolio risk, as it does not take diversification effects from other asset classes into account. The correlated standard deviation contributions, on the other hand, do add up to the overall portfolio volatility.

Figure 8. Asset Class Standalone Volatilities and Volatility Contributions

	% Weight	60d Std Dev (Standalone)	60d Std Dev Contribution (Uncorrelated)	60d Std Dev Contribution (Correlated)	5y Std Dev (Standalone)	5y Std Dev Contribution (Uncorrelated)	5y Std Dev Contribution (Correlated)
Total	**100**	**5.76**	**5.76**	**5.76**	**8.30**	**8.30**	**8.30**
Equity	**50**	**9.71**	**4.85**	**2.66**	**14.69**	**7.35**	**6.84**
US Equity	30	15.55	4.66	0.66	15.47	4.64	3.87
Dev Equity	15	9.19	1.38	1.20	16.37	2.46	2.26
EM Equity	5	19.40	0.97	0.81	17.71	0.89	0.72
Fixed Income	**40**	**10.58**	**4.23**	**2.41**	**5.89**	**2.36**	**0.86**
US Treasury	5	6.69	0.33	0.15	3.85	0.19	-0.02
Int Treasury	10	14.97	1.50	0.86	8.91	0.89	0.29
US Corp IG	8	9.40	0.75	0.36	5.30	0.42	0.01
Int Corp IG	8	13.05	1.04	0.54	9.18	0.73	0.28
Global HY	4	7.21	0.29	0.21	5.00	0.20	0.15
Global I/L	5	9.95	0.50	0.30	7.38	0.37	0.15
Currency	**5**	**9.77**	**0.49**	**0.22**	**8.30**	**0.42**	**0.17**
EUR	2	11.30	0.23	0.10	9.37	0.19	0.06
GBP	2	10.48	0.21	0.04	12.38	0.25	0.12
JPY	1	16.05	0.16	0.08	11.16	0.11	-0.01
Commodity	**5**	**13.93**	**0.70**	**0.47**	**17.73**	**0.89**	**0.44**
Gold	3	19.26	0.58	0.24	15.65	0.47	0.06
Oil	2	30.05	0.60	0.23	37.99	0.76	0.38

Source: Axioma

For example, when looking at long-term risk for US Treasuries (indicated by an orange border), we can see a standalone volatility of 3.85%. Multiplying this number by the bucket weight of 5% gives a "contribution" of 0.19%. However, the slight negative contribution of -0.02% in the next column indicates that treasuries must have been negatively correlated with at least some of the other asset classes over the last five years (mostly equities, high yield bonds and oil in this case), thus providing diversification and lowering total portfolio volatility.

It is also interesting to notice that the contribution from US Treasuries is slightly positive (0.15%) when looking at the last 60 business days, though still a lot smaller than the contributions of other asset classes with a similar weight, like, for example,

emerging market stocks, which add 0.81% to total risk (both highlighted in yellow). In fact, all asset classes seem to increase risk when looking at the shorter horizon. Yet, this does not necessarily indicate a positive correlation between all asset class returns, but the fact that equity and treasury returns recently seemed to have gone in the same direction has lessened potential diversification benefits that may have been there in the past.

9. Volatilities and Contributions by Risk Type

The numbers in figure 9 are based on the same risk model settings as in the previous section, namely 60 business days of daily returns for short-term risk and weekly returns over five years with a half-life of one year for the long term.
Note that this table does not have a percentage weight column. This is because some of the risk types will affect several of the asset class, while returns of some assets can be driven by several risk factors. For example, all assets not denominated in the base currency of the portfolio (in this case USD) will have FX risk, and all fixed income assets are likely to be affected by what happens to risk-free interest rates in their currency market. On the other hand, the risk of a callable bond will most likely be driven by interest rates, credit risk, optionality (vega), and maybe FX.

Figure 9. Volatilities and Contributions by Risk Type

	60d Std Dev (Standalone)	60d Std Dev Contribution (Uncorrelated)	60d Std Dev Contribution (Correlated)	5y Std Dev (Standalone)	5y Std Dev Contribution (Uncorrelated)	5y Std Dev Contribution (Correlated)
Total	**5.78**	**5.78**	**5.78**	**8.30**	**8.30**	**8.30**
FX	9.41	4.37	2.32	7.20	3.35	1.47
Equity	11.21	5.61	1.61	14.30	7.15	6.19
Inflation	5.37	0.27	-0.08	4.14	0.21	0.07
Interest Rate	6.00	2.40	1.32	4.09	1.63	-0.17
Issuer Credit	1.21	0.32	0.14	2.00	0.52	0.30
Vega	0.43	0.03	-0.01	0.59	0.04	0.01
Commodity	13.93	0.70	0.47	17.73	0.89	0.44

Source: Axioma

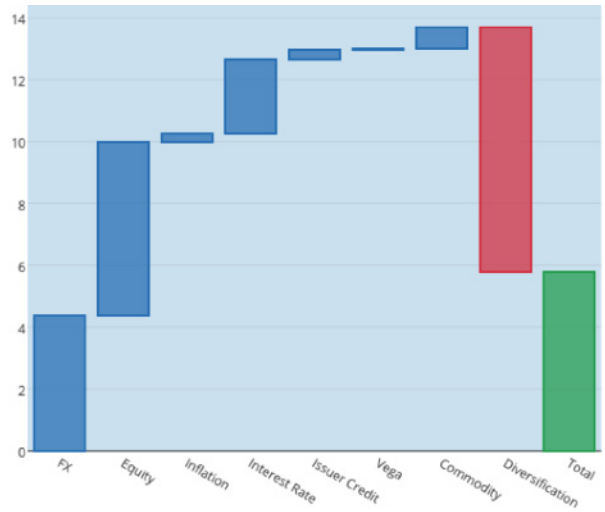
Figure 9 shows that risk estimated from the last three months is substantially lower than for the five-year period (5.78% versus 8.30%, respectively). The biggest reduction can be observed for equity risk where the contribution declined from 6.19% to 1.61% (a drop of almost 75%) even though equity standalone volatility only decreased by about a fifth from 14.30% to 11.21%. The reason for this disproportionate decline in contribution is the recent movements of interest rates and FX. In section 4, we saw that government yields have risen sharply over the last three weeks, which means that prices of fixed income securities have declined. At the same time, the graphs in figure 6 showed a strong depreciation of foreign currencies versus the US dollar.

This downturn in fixed income and foreign exchange markets combined with an upswing in equities has led to the significant reduction in overall portfolio risk we can now observe. It was partly offset, however, by the increases in exchange rate and interest rate standalone volatility, which translated into a higher contribution for FX and turned a -0.17 risk reduction from interest rates into an addition of 1.32%.

10. Volatility Contributions by Risk Type (Uncorrelated)

The waterfall chart in figure 10 shows contributions by risk type for the most recent 60-day period. The fact that the contributions are uncorrelated means that the total of the blue stacked bars is higher than the overall risk (green bar), so that we can clearly see the impact of diversification, which is represented by the red bar.

Figure 10. Volatility Contributions by Risk Type (Uncorrelated)



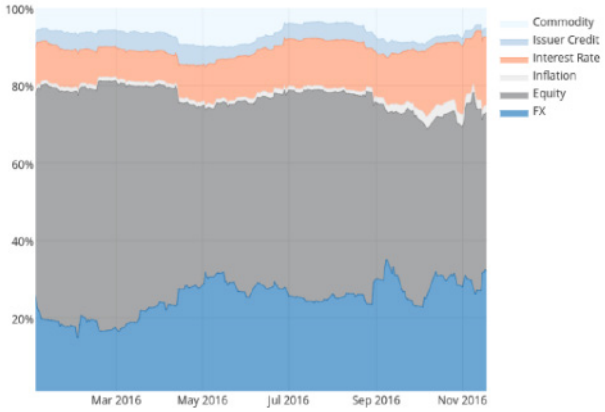
Source: Axioma

A waterfall chart is a different way of visualising what we discussed in section 8. Standalone volatilities for foreign exchange and interest rates are significantly higher than their longer-term averages. Therefore, simply adding the uncorrelated contributions gives a total of almost 14%, while overall portfolio volatility is only 5.76%, thus implying a diversification effect from correlation of around 8%.

11. Percent Volatility Contributions over Time

The stacked chart in figure 11 shows the uncorrelated contributions (excluding diversification) from the waterfall chart in figure 10 as percentage contributions to overall risk over time for the past half year.

Figure 11. Percent Volatility Contributions over Time



Source: Axioma

The time series chart above shows how FX and interest rate risk have increased in terms of contribution to total portfolio volatility, while the equity portion has gone down.

12. Model Portfolio Sample Stress Tests

The final table in the report shows a collection of stress tests and how they would affect our multi-asset class portfolio. Most of the stress tests are transitive, which means we shock one time series and all other risk factors move in line with correlation structure over a certain time period. But there are also two historical scenarios in which we simulate the actual movements of pricing factors during the specified timeframe. The numbers in the table are contributions to portfolio return in percent.

The first two columns after the weight column represent transitive tests, in which we let the S&P 500 Index (SPX) drop by 10%. In the first scenario (SPX -10%), we use a dynamic lookback period of one year from the current valuation date for the covariance calibration. The second one (SPX -10% 2008) uses the same shock for the SPX, but the calibration period from Jan. 1 to Dec. 31, 2008, is now kept static. The third stress test also covers a period in which the US stock market declined by roughly 10% (Aug. 17-25, 2015), but this time we repeat the exact market driver movements during that week.

The next scenario, covering the aftermath of the Lehman Brothers default from Sept. 15 to Oct. 27, 2008, is also driven by actual market movements. The two stress tests, in which we shock US Treasury 5-year and 10-year key rates up by 100 and 200 basis points, respectively, are again transitive with a one-year lookback. In the final, "macro" shock, we increase oil prices by 20% and once more the other asset classes move in line with correlations from the previous 12-month period.

Figure 12. Model Portfolio Sample Stress Tests

	% Weight	SPX -10%	SPX -10% (2008)	Mkt. Selloff Aug 2015	Lehman Default	US 5Y rate +100bps	US 10Y rate +200bps	Oil +20%
Total	**100**	**-4.37**	**-3.96**	**-4.61**	**-22.34**	**2.25**	**6.26**	**1.80**
Equity	**50**	**-4.36**	**-3.98**	**-4.90**	**-15.61**	**3.83**	**8.62**	**1.42**
US Equity	30	-3.06	-3.06	-3.36	-8.62	2.56	5.76	0.85
Dev Equity	15	-0.97	-0.67	-1.06	-5.14	1.03	2.35	0.43
EM Equity	5	-0.32	-0.25	-0.48	-1.85	0.23	0.51	0.14
Fixed Income	**40**	**0.19**	**0.12**	**0.27**	**-5.52**	**-1.72**	**-3.09**	**-0.03**
US Treasury	5	0.06	0.05	0.01	-0.04	-0.25	-0.48	-0.03
Int Treasury	10	0.08	0.03	0.19	-0.65	-0.49	-0.84	-0.00
Global I/L	5	-0.00	0.01	-0.01	-0.60	-0.25	-0.45	0.01
US Corp IG	8	0.10	0.05	-0.04	-1.51	-0.52	-1.02	-0.05
Int Corp IG	8	0.02	-0.00	0.16	-1.55	-0.22	-0.35	0.01
Global HY	4	-0.05	-0.02	-0.03	-1.17	0.01	0.04	0.03
Currency	**5**	**-0.02**	**-0.01**	**0.11**	**-0.38**	**-0.01**	**0.06**	**0.03**
EUR	2	0.01	-0.01	0.06	-0.25	-0.02	-0.02	0.00
GBP	2	-0.06	-0.02	0.01	-0.27	0.08	0.21	0.03
JPY	1	0.03	0.02	0.04	0.14	-0.07	-0.13	-0.01
Commodity	**5**	**-0.18**	**-0.08**	**-0.09**	**-0.83**	**0.16**	**0.67**	**0.38**
Gold	3	0.10	0.01	0.07	-0.14	-0.27	-0.50	-0.01
Oil	2	-0.28	-0.09	-0.16	-0.68	0.43	1.17	0.40

Source: Axioma

If we take a look at the three equity shocks first, we notice that the US Equity category loses around 3% in each scenario. This is not surprising given that we let the American stock market crash by 10% and that US shares carry a weight of 30% in our portfolio. However, overall portfolio returns are quite different between the three calibration periods, ranging from -3.96 in 2008 to -4.61 for August 2015. The differences are almost entirely due to what happened to share prices in other developed markets outside the US. As it is the American market we are shocking here, this means the variations are mainly due to how correlated equity markets around the globe were with US stocks and to the volatility of other markets, as well. For example, developed markets were a lot more correlated with the US in the last twelve months than they were in 2008. Another factor that influences by how much other markets move is what exchange rates do during the analysis period as we discovered when looking at asset class risk contributions in section 7.

In the Lehman Brothers historical scenario, the US stock market lost slightly more than 30% from the day before the default to the trough on Oct. 27, 2008. With a weight of 30% for US stocks, this translated into a return contribution of almost 9%. The other stock categories, both developed and emerging markets, show comparable return contributions given their respective weights. What is different this time, however, is the performance of fixed income assets. While bond prices went up on average in the previous three examples, they now account for about a quarter of the portfolio's losses. This mainly comes from corporate bonds, which lost almost 20% on average in investment grade and nearly 30% in high yield.

The increases in US Treasury key rates in the following two stress tests, though negative for most fixed income assets, seem to be beneficial for the portfolio performance overall, as strong equity returns lead to a total return of 2.25% for the 100-basis point increase in the 5-year rate and 6.26% when the 10-year yield rises by 200 basis points. In the first scenario US Treasuries lose about 5%, resulting in a loss contribution of 0.25%. For the 200-basis point shift, we get twice that amount as one would expect. US investment grade bonds experience a bigger loss, even when adjusting for their slightly higher weight. High yield bonds, on the other hand, seemed to be largely unaffected and even showed a slight positive return. This behavior becomes clearer when we go back to the correlation matrix in figure 1 and see that 'AA' spreads were positively correlated with rates, thus aggravating losses, while sub-investment grade showed almost no correlation, which is why they seem to have been largely unaffected by the rises in treasury yields.

A rise in the oil price also seems to result in a positive portfolio performance of 1.80%. This is mainly driven by a contribution of 0.40% in our oil future (20% price increase multiplied by a 2% weight), while equities roughly add the remaining 1.40%. We have seen a couple of times before in this report that share prices and oil appear to have been positively correlated recently. It might be worth emphasizing at this point, though, that correlation does not imply causation. In other words: rising oil prices do not necessarily cause stock prices to go up or the other way around. They just tended to move into the same direction over the last 12 months.