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When US rates rise, it may be time to consider adding emerging market bonds

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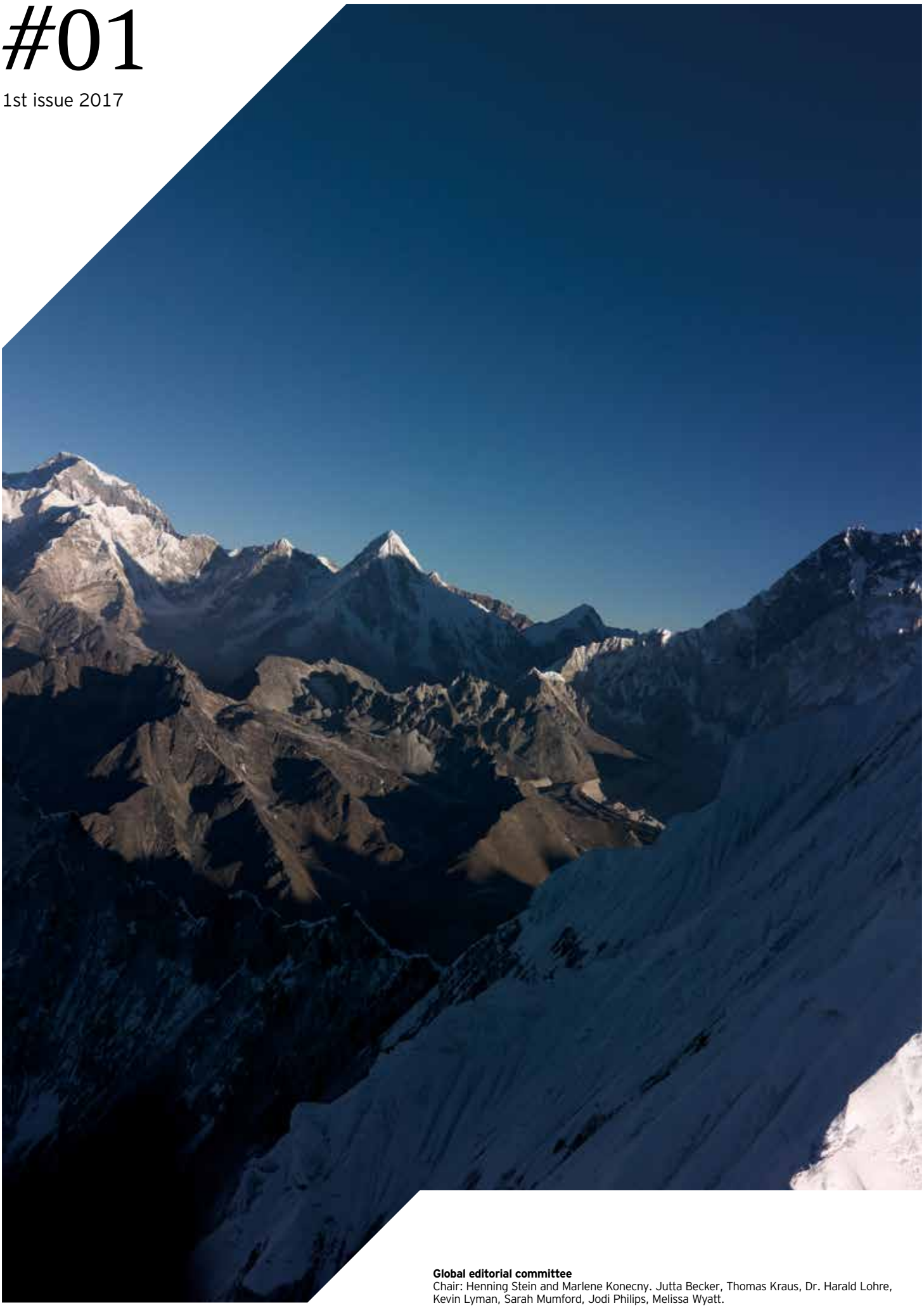

Once again, investors are concerned about rising interest rates. And with that concern, many are rethinking the outlook for their bond portfolios.

What should investors consider doing? In this edition of Risk & Reward, my colleagues from the Emerging Market Team within Invesco Fixed Income argue for diversification. In other words, they advocate what has always been at the heart of professional investment management.

Specifically, they suggest looking beyond traditional developed market asset classes to rediscover emerging market bonds. Our research shows that, since the introduction of the Fed's unconventional monetary policy after the global financial crisis, such a strategy has the potential to be more beneficial than ever, given that some of the old correlations are no longer as stable as they used to be.

Diversification can be a good strategy when interest rates are falling, and perhaps even more so when they are on the rise. But diversification alone may not be sufficient. Because of the large diversity of return drivers, we believe active management is paramount. Investors should consider the entire fixed income opportunity set, and select an investment manager equipped and prepared to actively navigate the environment.

Needless to say: such an investment manager must have experience, and should focus on research and analysis. This is particularly important when it comes to emerging market investment, since the emerging markets as a group are not very homogenous. It can pay to choose the right countries, sectors and individual securities – perhaps more so than in the more efficient developed markets.

To demonstrate that we take our commitment to research on emerging market bonds seriously, we've devoted this edition's feature topic to this asset class. We show you the results of an empirical study based on 25 years of interest rate data, spanning a period of considerable change.

As 2017 progresses, global growth will be one of the key things to watch. My colleagues at Invesco Fixed Income believe that growth expectations may have gone too far, and are thus subject to disappointment in the near term. But, overall, both they and I believe that the world economy is more stable now after years of unconventional monetary policy. At Invesco, our optimistic perspective is for relatively stable, if subdued, global growth, firming commodity prices and moderate inflation – a backdrop that is likely to be favourable for emerging market bonds.

Regards,

Marty Flanagan
President and CEO of Invesco Ltd.

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In focus

When US rates rise, it may be time to consider adding emerging market bonds

By Invesco Fixed Income Emerging Markets Team represented by Julie Salsbery

In brief

According to conventional wisdom, when US interest rates rise, US dollar-based investors should sell US Treasuries and move to equities and perhaps some non-US developed market bonds. But, our analysis shows this to be too simple – particularly since the US Federal Reserve (Fed) adopted unconventional monetary policies during the financial crisis of 2008-2009. We believe investors should consider the entire fixed income opportunity set, and select an investment manager equipped and prepared to actively navigate the environment. Given the growing disparities in outcomes for growth, inflation, and policies across the globe, we believe exposure to emerging markets fixed income can enhance yield and improve diversification – both of which may be beneficial as interest rates rise.

Once again, investor concern about higher interest rates is on the rise. And with that concern, many investors are rethinking the outlook for their bond portfolios. What should they consider? Diversification. And, since the introduction of unconventional monetary policy by the Fed in 2009, we believe this should not be limited to fixed income in developed markets, but should also include emerging markets.

For this exercise, we've chosen to consider the US 10-year Treasury rate, as opposed to the federal funds rate, as we believe that market interest rates can anticipate or lag actions of the Fed and are therefore more pertinent when examining the effects of rising interest rates on other financial assets. This has been especially true recently, as the market has frequently anticipated Fed moves – and pushed US Treasury rates significantly higher – even when the Fed did nothing. Moreover, US 10-year Treasury rates are more-representative of the underlying cost of funding for issuers in the US dollar bond market.

Over the past 25 years, nine periods can be identified in which US interest rates were rising (table1)[1].

We define a period of rising rates as one in which the rate on the US 10-year US Treasury rose by 100 basis points or more, although we also include the first half of 2015 when rates rose by only 84 basis points.

As seen in table 1, over the past 25 years, fixed income assets performed relatively poorly during periods of rising rates, while equities performed well. Indeed, in every period of rising rates, US Treasuries posted negative total returns, while the Standard and Poor's 500 equity index posted a gain in all but one period. This history is likely behind investors' general impression that fixed income assets should be sold and equities bought in periods of rising rates.

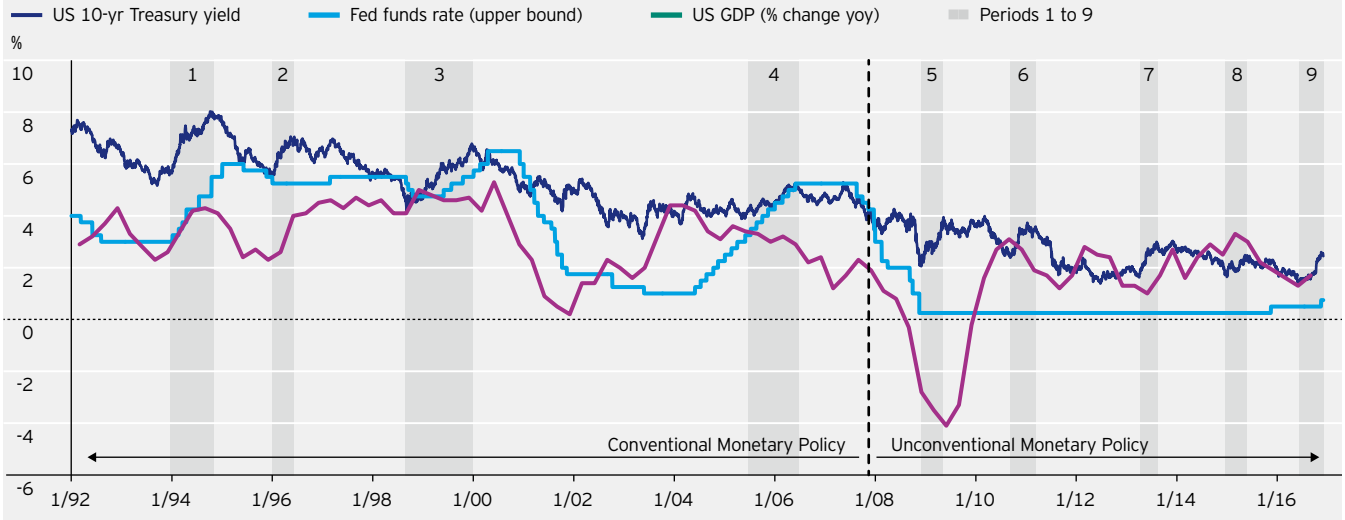
However, as we will show, things are not that simple. Outcomes across the fixed income spectrum can vary widely depending on both the risk attributes of the asset class and the economic and policy landscape in which interest rates are rising. Of particular importance is the regime shift in Fed policy that occurred in 2009. Figure 1 provides an overview.

Table 1
Periods of rising US interest rates

Period	**1** 1/94 to 11/94	**2** 1/96 to 6/96	**3** 10/98 to 1/00	**4** 6/05 to 6/06	**5** 12/08 to 6/09	**6** 10/10 to 2/11	**7** 5/13 to 9/13	**8** 1/15 to 6/15	**9** 7/16 to 12/16
Bonds									
10-yr US Treasury (change in yield, in basis points)	239	154	263	136	189	135	137	84	124
US Treasury Index	-5.94	-4.09	-4.57	-2.16	-6.99	-4.64	-4.52	-3.29	-5.67
Barclays Global Treasury Index	-5.34	0.43	0.01	0.46	-2.34	-3.63	-3.48	-3.19	-4.12
Equities									
S&P 500 Index	-3.85	10.00	46.23	3.64	5.45	14.38	3.60	5.52	6.20
MSCI World Index	-1.22	6.22	52.02	10.84	7.81	11.69	1.90	5.91	5.55

Total returns in USD. US Treasury Index: Bloomberg Barclays US Treasury Index; Barclays Global Treasury: Bloomberg Barclays Global Aggregate Index.
Source: Bloomberg L.P., as at 31 December 2016.

Figure 1
Rising rates: shorter and more frequent in unconventional monetary policy



Source: Bloomberg L.P. Data as at 31 December 2016. GDP is gross domestic product.

Structural shift in policy regime has increased uncertainty

Market participants have typically expected interest rates to rise in response to the Fed's "reaction function"[2]. Given the Fed's dual mandate of maximizing employment and stabilizing prices, it is rational to assume that when growth is very weak (falling employment and prices) the Fed will tend to cut the target policy rate, and when growth is too strong (unsustainable employment gains and surging prices) the Fed will tend to raise the target policy rate. However, our analysis suggests that, following the global financial crisis, there has been a structural break in the Fed's reaction function – and as a consequence, market reactions have changed as well.

As shown in figure 1, during what we call the Conventional Monetary Policy (CMP) regime, there were four periods of rising rates, each of which exhibited characteristics associated with the Fed's traditional reaction function (periods 1 to 4, see box).

Unconventional monetary policy and market responses

We call the period from 2008 onwards the Unconventional Monetary Policy (UMP) regime, because as policy rates approached the zero-bound, the Fed introduced new tools to influence monetary policy: forward guidance and quantitative easing. As such, the UMP regime marked a substantial change from the CMP regime, because almost none of the post-crisis periods of rising interest rates coincided with an actual Fed rate hiking cycle. Because the Fed introduced these new policy tools – to influence not only the cost of overnight borrowing, but also the term structure of interest rates across asset classes – periods of rising rates in the UMP regime have been predominantly driven by bouts of market uncertainty. Even with no adjustment in the federal funds rate, the 10-year US Treasury rate moved in this period due to uncertainty, in our view, about both the effectiveness and longevity of the Fed's new policy tools.

Box
Nine periods of rising rates

Four in the Conventional Monetary Policy regime ...

- **Period 1:** *1994 – Conventional Fed rate hiking cycle where gross domestic product (GDP) was moving above its long-run potential, causing the unemployment rate to fall rapidly[3]. While inflation had yet to pick up, the Fed surprised markets by moving proactively and aggressively (hiking by 300 basis points).*
- **Period 2:** *1996 – Robust economic environment (strong GDP growth trend, falling unemployment, rising inflationary pressure) led to conventional market response, i.e. a higher 10-year US Treasury rate[4]. In this case, with policy rates already restrictive and a higher 10-year US Treasury rate modestly tightening financial conditions, the Fed held rates steady.*
- **Period 3:** *1998 – Tighter financial conditions proved insufficient to slow the economy and annual GDP growth surged to 5%[5]. Despite more moderate inflation, a new 25-year low in the unemployment rate forced the Fed's hand and the 10-year US Treasury rate rose in response[6]. This was the longest and strongest period of rising rates (which subsequently pushed the economy into recession).*
- **Period 4:** *2005 – After cutting its policy rate to a new low in 2003, the Fed began normalizing its policy rate in 2004. Though growth had begun to moderate, an ever-lower unemployment rate and surge in inflation to more than 4.5% caused the Fed to extend its hiking cycle, and the 10-year US Treasury rate finally moved higher[7].*

... and five in the Unconventional Monetary Policy regime

- **Period 5:** *2009 – The 10-year US Treasury rate rose the most in this period, as market participants assumed the Fed was acting under its conventional reaction function. The unemployment rate was still rising, but economic indicators suggested both growth and inflation were heading toward recovery. With policy rates at the zero lower bound, markets assumed the Fed would shortly begin normalizing interest rates. However, the Fed did not act. This was the first Fed reaction function "false-positive."*
- **Period 6:** *2010 – In an attempt to breathe new life into the still struggling US economy, the Fed announced a new USD 600 billion bond buying programme (dubbed QE2, as it was the Fed's second attempt at quantitative easing through expansion of its balance sheet). The market's response ran counter to expectations as investors grew nervous about the prospects for success and the volume of new US Treasury issuance that would need to be absorbed.*
- **Period 7:** *2013 – The second false-positive of the new UMP regime occurred as market participants assumed that a winding down of bond purchases would very quickly transition into a period of policy rate hikes. The so-called "taper tantrum" – when interest rates rose sharply as markets questioned the Fed's commitment to forward guidance – was the most notorious of the recent periods of rising rates, and caused substantial risk-off repercussions.*
- **Period 8:** *2015 – This milder period of rising rates (84 basis point rise in the 10-year US Treasury rate) coincided with better growth and a sub-5.5% unemployment rate, but the main trigger was the Fed's forward guidance. In this respect, the move was another false-positive as market participants took the Fed at its word that inflation would gradually move toward 2%, and that it could begin raising rates as early as March 2015 (which did not happen).*
- **Period 9:** *2016 – The yield on the 10-year US Treasury rate rose as markets began to price in expectations that a Trump presidential win would spur an increase in fiscal spending (underpinning a further recovery in both growth and inflation), which might need to be offset by tighter monetary policy.*

Periods of rising rates in the UMP regime (periods 5 to 9, see box) have been shorter (141 days on average) and less severe (134 basis points on average) than under the CMP regime (323 days on average, rising by an average of nearly 200 basis points). Rising rate periods under UMP have, however, been more frequent, with five in the past eight years – compared to just four periods in 17 years under CMP.

Conventional defences against rising rates eroded under UMP

We believe the shift toward quantitative easing in the US has had a significant impact on global financial markets. First, we observe that the "unconventional" approach to monetary policy was also adopted globally – at least among developed markets – and has resulted in a greater correlation in market reactions. This means that the diversification benefits of global government bonds in rising rate cycles has been diminished under the UMP regime. For example, US Treasuries lost on average 4.2% during the periods of rising rates in the CMP regime, whereas returns on global developed market government bonds were much more differentiated (i.e. not all periods were negative) and fell a smaller 1.1% on average, as shown in figure 2[8]. Under the UMP regime, the performance cushion derived from adding exposure to other global government bonds was preserved (in all periods of rising rates, global government bonds outperformed US Treasuries). However, the cushion was eroded and global government bonds also experienced negative returns more broadly.

Thus, diversifying into other developed market government bonds has been less effective under the UMP policy regime (as monetary policies have become more similar). The same has been true for the potential offset from equities, and equities' outperformance has shrunk under the UMP regime. In the four rising rate periods during the CMP regime, the S&P 500 index was up 14.0% on average, and global equities (as represented by the MSCI World Equity Index) were up 17.0%. These averages have fallen to 7.0% and 6.6%, respectively, during rising rate periods under the UMP regime. We do not mean to suggest that diversification has become less beneficial – but rather that prior relationships have shifted, and must be examined given new global policy regimes and growth dynamics.

Diversification into credit (incl. emerging markets) may offer benefits

When it comes to credit, the implications are more nuanced. Historically, investment grade credit has not offered a sufficient yield cushion to fully offset the effects of rising interest rates. Both the Bloomberg Barclays Global Aggregate Index and Bloomberg Barclays US Corporate Index experienced losses in the majority of rising interest rate periods – regardless of the monetary policy regime in place. That said, there are other sources of diversified credit risk that have exhibited a greater range of outcomes during historical periods of rising rates, such as high yield and emerging markets. Generally speaking, both high yield assets and emerging market assets typically outperformed global government bonds during periods of rising rates, and often produced outright gains during those periods[9].

Our general conclusions suggest that assets correlated with growth have outperformed in periods of rising rates (equities and risk assets generally), and those with initially greater yield (high yield, emerging markets) have been able to offset some of the losses generated by rising interest rates. More practically, we consider the economic conditions prevailing at the time interest rates start rising to be of great significance.

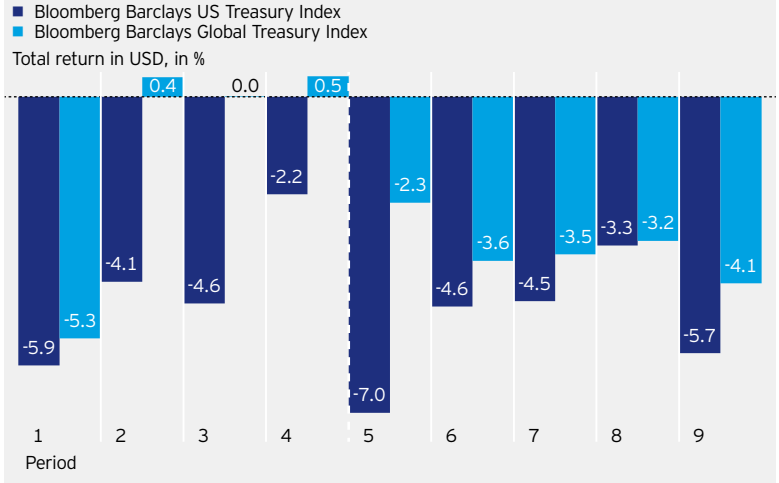
In the next section, we'll delve more deeply into some of the implications for emerging markets, drawing on the dynamics at play during historic periods of rising rates.

Emerging markets bonds performed better in a growth environment

Emerging markets have performed best when rising interest rates were the result of an improving economic backdrop – especially when financial conditions were stable to improving. This was true for most of the CMP regime – when interest rates climbed in response to improved growth prospects. The main mechanism for emerging markets' hard-currency bond outperformance is the "credit spread" (the difference in yields on emerging markets assets and the yield on US Treasuries). If growth prospects improve globally, bolstering the outlook for commodity prices and trade, the "credit risk" component of emerging markets debt may be reduced, resulting in narrower credit spreads. All else equal, stronger growth improves debt ratios and repayment capacity, reducing the "credit risk" premium relative to (presumably) "default-risk free" US Treasury rates in the process. In other words, when growth is strong and US Treasury rates rise, emerging market interest rates may rise to a lesser degree, causing emerging markets credit spreads to tighten[10].

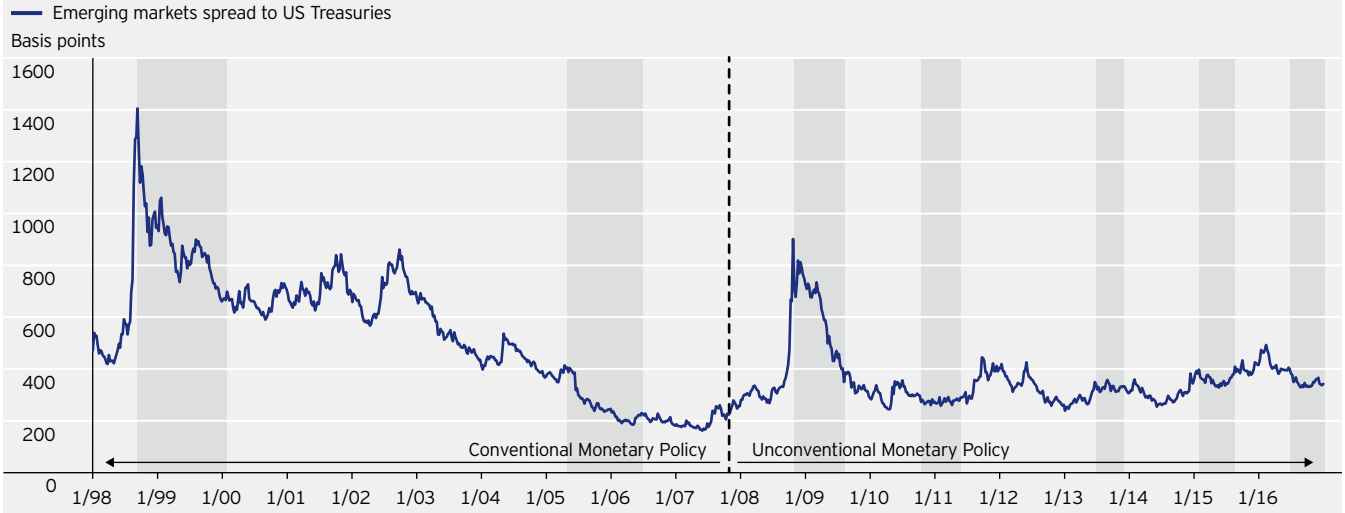
Typically, higher starting yields for emerging markets offer the greatest opportunity for emerging markets to outperform during periods of rising US Treasury rates. Even if emerging markets rates rise in tandem with Treasuries (spread remains constant), the asset with the higher yield should outperform, as its yield

Figure 2
Global government bonds more highly correlated with US Treasuries under conventional policy regime



Source: Bloomberg L.P., as at 31 December 2016.

Figure 3
Performance buffer: emerging market spreads can narrow when US Treasury yields rise



US Treasury total return	-4.6%	-2.2%	-7.0%	-4.6%	-4.5%	-3.3%	-5.7%
EM total return	35.7%	4.8%	14.9%	-3.2%	-10.7%	0.2%	-2.8%
Change in spread	-565bp	-159bp	-326bp	-46bp	69bp	-55bp	-35bp

Total return in USD. US Treasury total return: Bloomberg Barclays U.S. Treasury Index; EM total return: JPMorgan Emerging Markets Bond Index Global Diversified; Change in spread: Change in spread between JPMorgan Emerging Markets Bond Index and US Treasuries.
Source: Bloomberg L.P. Data as at 31 December 2016.

provides some offset or "cushion" to the price decline in terms of total return. As seen in figure 3, when the emerging markets spread to US Treasuries was the greatest (in 1998 and 2008), emerging markets both outperformed and generated outright gains (35.7% and 14.9%, respectively), as spread compression more than offset the rise in US Treasury rates.

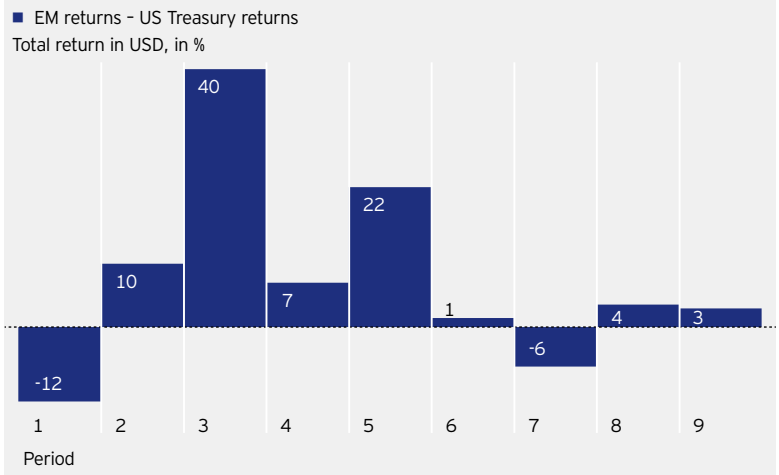
Since the Asian and Russian crises in 1997-98, emerging markets spreads have generally compressed, as emerging market countries embarked on financial liberalization and, in many instances, fiscal reforms. The move to managed floating exchange rates improved the resilience of these economies to external shocks and the introduction of inflation targeting regimes bolstered policy credibility (figure 3).

Before the global financial crisis, emerging markets spreads averaged 535 basis points over US Treasuries. Since the crisis, they have averaged 357 basis points – but have still been able to offer a meaningful cushion against rising rates. In fact, in the rising rates periods under UMP, emerging markets hard currency bonds have outperformed US Treasuries, and spreads have narrowed in four out of five periods (figure 3). The only period when emerging markets have underperformed Treasuries under UMP was during the "taper tantrum" in 2013. Emerging markets corporate debt has exhibited these trends even more clearly due to their often higher yields and credit risk component. This suggests that the benefit of higher yields and a higher correlation to equities (positive correlation with growth) can act as substantial offsets in periods of rising rates, even in today's more volatile global market environment.

Emerging markets relatively worse in an uncertain environment

Our analysis shows that emerging markets assets performed the worst when heightened uncertainty was behind rising rates and when accompanied by tightening financial conditions). As shown in figure 4, emerging markets assets have a strong history of outperforming US Treasuries when rates are rising, but there are two notable periods when emerging markets debt underperformed. During the first rising rate period in 1994, emerging markets bonds

Figure 4
EM typically outperforms US Treasuries when rates are rising



EM returns represented by JPMorgan EMBI Global Diversified Index, US Treasury represented by the Bloomberg Barclays US Treasury Index.
Source: Bloomberg L.P., as at 31 December 2016.

returned -17.6% versus -5.9% for US Treasuries.[11] This was a classic rate-hiking cycle in response to above-potential growth. So, what went wrong? It is worth noting that markets were down broadly, with losses across investment grade, high yield, the US dollar and equities – the only period of rising rates when this was the case. In 1994, the US economy was in its fourth year of expansion with growth improving and the unemployment rates falling, but as yet no real sign of inflation. Importantly, monetary policy makers prior to 1994 believed that, to be effective, it was necessary to surprise markets. In fact, the Fed did not even announce its policy stance, but rather left financial market participants to determine it by watching the Fed's open market desk.

The February hike of 1994 marked the first time the Fed released a statement immediately after a meeting explaining its action, and this change itself created uncertainty which caused financial conditions to tighten sharply, reverberating across asset classes, including emerging markets. While Fed communications have changed dramatically since then, they are still far from unequivocally clear – as evidenced in 2013. At that time, it was the Fed's comments, not actions, which shocked the markets and led to a sharp 10.7% decline for emerging markets. The "taper tantrum" is perhaps the best example of when policy uncertainty associated with the UMP regime has suddenly impacted global financial conditions and wreaked havoc on global risk assets.

Market timing is challenging when interest rates are rising, in our view. Periods of rising rates are often followed by periods of falling rates – regardless of monetary policy regime. US Treasury rates fell and fixed income assets broadly posted positive returns in the six-month period immediately following each period of rising interest rates. The only exception was the brief period of rising rates in 2015 when rates rose by 84 basis points. In the six months that followed, high yield and emerging market corporates and local government bonds experienced negative returns, but we believe (based on our analysis of other drivers mentioned above) that this outcome was more likely the result of oil prices plunging 38%.

EM mixed under unconventional monetary policy regime

Uncertainty and volatility under UMP have resulted in differentiated returns for emerging markets, rather than simply negative outcomes. While in the past, the three categories of emerging markets assets (dollar-denominated sovereigns, corporates and local currency bonds) tended to rise and fall together depending on global conditions and risk sentiment, outcomes have exhibited more incongruity lately. In our view, changes in US Treasury rates have had a greater impact on dollar-denominated assets; growth and risk-on environments have been positive for emerging markets corporates, and currency volatility and domestic drivers have tended to have a greater impact on local currency bonds.

In the case of local currency bonds, it is important to recognize that not all EM domestic rates rise globally when US interest rates are rising. A country may be in a different phase of its economic cycle and as such, idiosyncratic drivers such as inflation and the country's fiscal and monetary policy stance tend to play a more prominent role for local interest rates. As a result, knowing if US Treasury rates will be rising or falling is far from sufficient in forecasting how any one emerging market local currency government bond market might perform (figure 5).

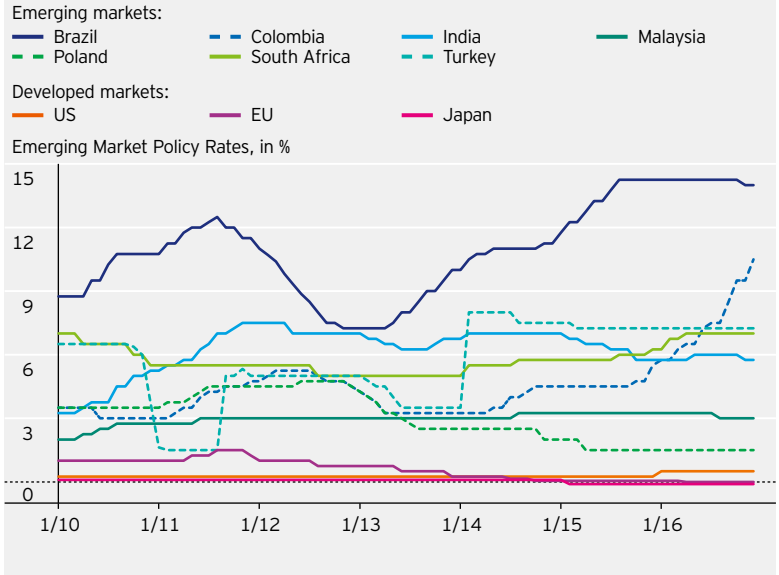
Rising rates an important driver of emerging markets, but not the only one

US Treasury rates matter, but a broader view of the global backdrop is crucial for emerging markets investing, in our view. Our analysis suggests that global growth, oil prices and financial conditions have a greater impact on emerging markets returns than a change in US Treasury rates[12]. We find that, over the past two decades, these four variables combined explained nearly 60% of returns for emerging markets hard currency sovereign bonds[13].

We believe that stronger global growth is a positive factor in emerging markets bond performance. While statistical analysis shows that global growth has been positively correlated with emerging markets returns, we find that oil is a better proxy for this relationship. Typically, oil prices rise during periods of strong global growth, due to stronger demand for oil. But commodities as an asset class also play a crucial role in many emerging markets economies, justifying their role as a predictor of emerging markets returns. Some emerging markets countries are importers of oil, suggesting that there will likely be relative winners and losers but higher oil prices act as a tide that lifts all boats and are generally associated with higher emerging markets returns.

We also find that a change in the US 10-year Treasury rate is negatively correlated with emerging markets returns, as expected, but the statistical relationship

Figure 5
EM rates offer a broader opportunity set



Source: Bloomberg L.P. Data as at 31 December 2016.

has been relatively small. Again, this supports the idea that changes in US interest rates are important – but not one of the largest drivers of emerging markets returns. We therefore prefer to use a broader measure of financial conditions (versus interest rates only) when considering whether the backdrop for emerging markets is favourable or not. Of the four variables we tested, we find that financial conditions have the most statistically significant and largest (negative) correlation to emerging markets returns. In addition, we believe analyzing financial conditions can help identify potential financial shocks. Adjusting our model to a two-variable regression (oil and financial conditions) maintains a 60% correlation, suggesting that these two variables – oil and financial conditions combined – may explain a significant portion of emerging markets returns[14].

Looking ahead
Based on our analysis, we offer three main takeaways:

1. Rising interest rates may be a headwind for many fixed income assets, but are not a sufficient reason to reduce exposure to emerging markets. We believe emerging markets performance depends on much more than rising or falling US interest rates. We find indicators of global growth, particularly commodity prices and financial conditions, to be better indicators of emerging markets returns. This suggests a better outcome may potentially be achieved if asset managers consider a broader view of global economic conditions beyond interest rates when investing in emerging markets.

2. The higher yield on offer for emerging market hard-currency bonds provides a "credit spread" that acts as a cushion against rising US Treasury rates. The correlation between this credit spread and US Treasury rates has been, over time, less than one and, oftentimes, the correlation has been negative. Therefore the empirical duration of emerging market bonds has been lower than the calculated, duration and emerging market bonds can, and have, performed well even during periods of rising rates.

3. The post-global financial crisis period has brought more volatility and dispersion in outcomes across markets, including emerging markets. We believe managers who examine emerging markets by analyzing global macro factor influences, in conjunction with asset class differences and country-specific drivers, are likely to be better positioned to weather bouts of volatility and avail themselves of opportunity.

We understand investors' fears of rising interest rates. However, because not all fixed income assets have experienced losses during historical periods of rising rates, we believe diversification can be a good strategy when interest rates are on the rise. Because there are many potentially important drivers of return, we believe active management is paramount in periods of rising rates. Accordingly, when choosing how to position defensively against rising rates, investors should consider the entire fixed income opportunity set, and select an investment manager equipped and prepared to actively navigate the environment. Given the growing disparity in outcomes for growth, inflation and policies in countries across the globe, we believe exposure to emerging markets fixed income can potentially enhance yield and increase risk diversification – both of which may be beneficial as interest rates rise.

About the authors

Invesco Fixed Income Emerging Markets Team represented by
Julie Salsbery
Senior Client Portfolio Manager,
Invesco Fixed Income Emerging Markets Team
Julie Salsbery is focused on positioning our funds across retail and institutional distribution channels, discussing our investment views and emerging market products with clients, contributing to thought leadership and marketing initiatives, and managing non-investment aspects of the emerging market team.

Notes
1 Periods of rising rates we identified are 1: 31/01/1994-07/11/1994, 2: 18/01/1996-12/06/1996, 3: 05/10/1998-20/01/2000, 4: 01/06/2005-28/06/2006, 5: 31/12/2008-08/02/2009, 6: 07/10/2010-08/02/2011, 7: 02/05/2013-05/09/2013, 8: 30/01/2015-10/06/2015, 9: 08/07/2016-15/12/2016.
2 Fed's reaction function defined as: "the way in which the Committee adjusts policy in response to a given change in macroeconomic conditions." The Effects of Policy Guidance on Perceptions of the Fed's Reaction Function, Federal Reserve Bank of New York Staff Report No. 652.
3 In all cases: GDP refers to year-on-year growth rate of real US GDP, seasonally adjusted, from the Bureau of Economic Analysis. Unemployment Rate refers to U-3 US Unemployment Rate from the Bureau of Labor Statistics. Inflation refers to year-on-year growth rate of US CPI for Urban Consumers from the Bureau of Labor Statistics.
4 Ibid.
5 Ibid.
6 The unemployment rate was 4.4% in June 1998 – the lowest rate since 4.2% in March 1970.
7 See footnote 3.
8 In all cases: US Treasuries refer to the Bloomberg Barclays US Treasury Index. Global government bonds and developed market government bonds refer to the Bloomberg Barclays Global Treasury Index.
9 In all cases: High yield refers to the Bloomberg Barclays Global High Yield Index and emerging market refers to the J.P. Morgan Emerging Market Bond Index (EMBI) Global Diversified.
10 This dynamic has the effect of reducing the empirical duration of EM dollar-denominated bonds, relative to its calculated, modified duration. We find that the empirical duration of the J. P. Morgan EMBI Global Diversified is much lower than the calculated duration of 6.5 years for the JPM EMBI Global Diversified.
11 In all cases: US Treasuries refer to the Bloomberg Barclays US Treasury Index and emerging market refers to the J.P. Morgan Emerging Market Bond Index (EMBI) Global Diversified.
12 All referenced linear regression analysis utilizes emerging market returns (J.P. Morgan EMBI Global Diversified Index) as the dependent variable, with various combinations of the following independent (explanatory) variables: US Treasuries (Bloomberg Barclays US Treasury 7-10 Year Index), the US dollar (US Trade Weighted Broad Dollar, Federal Reserve), oil (Generic Brent Crude Oil, ICE Brent Futures), world growth (IMF World Real GDP, year-on-year percent change) and financial conditions (Goldman Sachs Financial Conditions Index).
13 Ibid.
14 Ibid.

"Global growth, firming commodity prices and moderate inflation could provide a still-favourable backdrop for emerging markets."

Interview with Rashique Rahman and Michael Hyman

Rashique Rahman
Head of Emerging Markets
Invesco Fixed Income

Michael Hyman
CIO, Global Investment Grade and Emerging Markets
Invesco Fixed Income

Given the need for diversification and yield, client interest in emerging markets remains high. With volatility expected to continue as markets react to European elections, US trade policies, Chinese growth and the path of Fed rate hikes, investors are wondering whether they should invest in emerging markets.

We recently sat down with Rashique Rahman and Michael Hyman of the Emerging Markets team of Invesco Fixed Income to get their views on global market conditions and thoughts about investing in emerging markets today.

Risk & Reward
Michael and Rashique, what are the top three issues likely to affect emerging markets assets in 2017?

Michael Hyman
Global growth will be one of the key things to watch in 2017. Right now, most expectations are being revised upward, predominantly related to the US and China. Our team believes these upward revisions may have gone too far, and are thus subject to disappointment in the near term. But, overall we agree that the world is on firmer footing after years of monetary life support. Healthier growth and inflation trends would likely be supportive of risk assets – including emerging markets.

Rashique Rahman
The second key issue to watch is the path of US monetary policy, which may be an important driver of fixed income broadly in 2017. While upward growth revisions suggest more Fed hikes rather than fewer, this outcome is far from certain. We don't want to overemphasize the importance of US fiscal and monetary policy, nor their path. But sharp moves in US Treasury yields, or sustained US dollar strength, can be headwinds for emerging markets assets. That said, should growth come in below market expectations, as our team suspects, 2017 could be another year in which markets are overly ambitious when it comes to pricing in Fed hikes. In this regard, we utilize our proprietary 'now-casting' model to monitor real-time growth trends across all G-20 countries and help guide our understanding of whether or not global growth expectations are overpriced.

Michael Hyman
Lastly, the new US administration's proposed changes to both fiscal and trade policy will likely be important drivers for emerging markets assets in 2017. To the extent that fiscal expansion plans impact expectations for monetary policy, they may also influence the direction of US Treasury yields and the US dollar. With respect to trade policy, the potential implementation of selective tariffs or a so-called 'border tax' may adversely impact exports, and thus growth, for a number of countries, particularly Mexico and goods exporters in Asia.

Risk & Reward
You mentioned the possibility of rising rates, and most investors probably regard this as bad news. Are they right?

Rashique Rahman
Rising US interest rates are generally a headwind for fixed income performance. However, they adversely impact fixed income asset classes to varying degrees. There are three specific factors to consider when investing in the emerging markets during periods of rising rates:

First, rising global interest rates in the context of stronger global growth and supportive financial conditions are favourable for emerging markets bonds, in our view. In such a scenario, spread compression can compensate for rising US rates. As long as the growth backdrop is supportive of improving credit trends, emerging markets spreads can narrow and provide a total return cushion against rising US rates.

Second, emerging markets fixed income is a very diverse asset class comprised of investment grade, as well as sub-investment grade debt. Sub-investment grade debt exhibits much less sensitivity to US interest rates, given the large credit component relative to the interest rate component of total yield.

Lastly, EM consists of both US dollar and non-dollar denominated assets. The net exposure of emerging markets countries to US dollar funding has declined as they have built up healthy cushions of foreign exchange reserves. US Dollar-denominated debt, particularly corporate debt, has grown significantly in recent years, but foreign exchange reserves have grown even faster. This provides a crucial buffer for most emerging markets countries when navigating through a period of potentially higher US interest rates, particularly if funding conditions deteriorate. The non-dollar denominated debt tends to respond to domestic interest rate trends and currency movements, which bear watching as US interest rates rise.

Michael Hyman
I totally agree. While rising interest rates may be a challenge for fixed income assets as a whole, many other factors will likely influence emerging markets debt performance. With such a diverse asset class, we believe emerging markets offer enough different levers that can be pulled to help successfully navigate the increasingly complex global financial landscape in the period ahead.

Risk & Reward
Rising rates are one possible headwind, uncertainty is another. What should investors watch out for here?

Rashique Rahman
There are indeed a number of uncertainties, which we expect to lead to volatility – much as it was the case in the last few years. I am thinking of the upcoming European elections, the direction of the US dollar and concerns over economic stability in China. We will also be closely monitoring diplomatic relations between the new US administration and the rest of the world – particularly with China over trade and the South China seas, where there could be rising tensions. As active managers, we seek to assess the likelihood of certain outcomes and their potential market impacts – and to position our portfolios accordingly.

Michael Hyman
We are also attuned to valuations, which can fluctuate dramatically and deviate from fundamentals during periods of volatility. Generally, we seek to reduce market exposure when valuations get rich, according to our models, and add market exposure when valuations become cheap. Emerging markets fixed income is such a diverse asset class that volatility can be an opportunity, as much as a threat. Market disruptions can open up opportunities for investments that were less compelling beforehand. Moreover, such periods provide scope to build allocations to the asset class as intense periods of volatility tend to be temporary.

Risk & Reward
And what about the risk of a stronger US dollar?

Rashique Rahman
Generally, emerging markets countries have become more insulated from US dollar moves, as many countries have accumulated a larger stock of liquid US dollar assets compared to a rising stock of external (primarily private-sector) liabilities. That said, in an environment of a far stronger US dollar, we will tend to reduce overall market exposure. A stronger US dollar can be associated with portfolio outflows from the emerging markets, downward pressure on their currencies and upward pressure on credit spreads.

Michael Hyman
When we expect US dollar strength, we tend to buy dollars against higher-beta emerging markets currencies, particularly those with high external funding needs. We also tend to favour export-oriented corporate issuers over those that rely more on domestic revenues. Exporters tend to fare better in a strong US dollar environment, since they earn US dollars but pay wages in domestic currency. Thus, they benefit from a weaker domestic currency. However, it also depends on the outlook for global growth and, more specifically, commodities. We see a stronger US dollar coupled with stronger commodities for the first half of 2017, which is a more benign environment for the emerging markets, and one that favours commodity-producing countries, currencies and corporate credit. In such a scenario, we may also consider reducing our duration exposure to local government bonds, as stronger commodities and a stronger US dollar may cause domestic inflation pressures to increase.

Risk & Reward
Another important factor is the price of oil. OPEC is cutting supply, while supply from Libya and Nigeria is coming on-line. What do you expect for 2017, and what does this mean for emerging market bonds?

Michael Hyman
We retain a favourable view toward oil prices and commodity-oriented currencies and corporate credit for two reasons. First, we believe, the recent OPEC agreement to curtail supply will continue to have both a psychological and an actual effect on oil prices. Should OPEC members comply with the agreement, as current indicators suggest, we see the marginal increase in supply from much smaller producers as being an insignificant offset to OPEC's cutbacks. Notably, visible reductions in output by the top two producers, Saudi Arabia and Russia, amid stronger demand due to improving global growth, should underpin prices. Stabilization in oil prices, if sustained, should in turn support emerging markets fixed income.

Rashique Rahman
It is important to note that, statistically, oil tends to be one of the most important factors driving emerging markets currency and credit returns. For one thing, many emerging markets countries and companies are oil exporters or producers, and for another, investors often view oil as a proxy for global economic conditions. In this context, commodity exporters will tend to outperform commodity importers – but a rising tide of oil tends to lift all boats.

Risk & Reward
We have talked about US rates, global uncertainties, the US dollar and oil. But one important factor is still missing: political risks. Are they still as important in the emerging markets as they used to be?

Michael Hyman
There are few scheduled elections in the emerging markets countries this year, but many more are in play for 2018. In 2017, political events in developed markets are much more likely to impact emerging markets. Most importantly, diplomatic relations between the US and the rest of the world will likely dominate headlines. We are most focused on how markets will calibrate political risk related to President Trump's policies and rhetoric toward China, and to a slightly lesser extent Mexico. Moreover, elections in Europe – including the Netherlands, France and Germany – will be a key focus throughout the year, given concerns over a rise in populism and the fate of the euro and eurozone membership. Should the future of the euro be called into question, spread compression in Eastern European bonds – the so-called euro convergence trade – could begin to unwind.

Rashique Rahman
But there are also risks originating in the emerging markets themselves. China is holding the 19th National Party Congress later this year, which is likely to see changes in the top leadership of the Communist Party, and signal the direction of policy and reform going forward. Furthermore, the mid-term legislative elections in Argentina, presidential elections in Chile and general elections in Ecuador all bear watching. In Argentina, the elections can be seen as a referendum on President Macri's policies, and whether there is scope to rein in recent fiscal expansion – which will likely be a barometer of the country's bond issuance needs and creditworthiness. Chile will swear in a new president after its November election, as the incumbent President Bachelet cannot seek immediate re-election. Similarly, in Ecuador, the February election casts uncertainty over who will govern the country for the next five years.

We will also be closely monitoring political developments in Brazil, South Africa and Turkey. Though the so-called 'Lava Jato' investigation, and related plea-bargaining in Brazil is winding down, other corruption investigations are continuing. We are monitoring events that may compromise President Temer's popularity, and his administration's ability to push through much needed fiscal and pension reforms. In South Africa, the African National Congress (ANC) Conference in December 2017 may provide clarity on the party's future leadership. President Zuma has confirmed that he will not run, but there is considerable uncertainty regarding his ability to position one of his allies for the post. ANC leadership is important, as the president of the ANC is widely considered to be the front-runner for the presidential elections in 2019. In Turkey, the country is gearing up for constitutional reform and referendum to transform itself from a parliamentary to a presidential republic.

Risk & Reward
Finally, where do you see the biggest opportunities right now?

Michael Hyman
Stability in global growth and generally more favourable supply/demand dynamics have supported commodity prices, and we see this persisting in the first half of 2017. Emerging markets bonds' relatively high correlation with equities – growth being the common factor – suggests that they can perform well under these circumstances. We therefore currently favour exposure to commodity-producing countries, currencies and credits. This stability in commodities, coupled with a stronger US dollar, is also likely to lead to higher inflation in many countries later this year. Commodity producers themselves are an exception, such as Brazil, Chile, Colombia, Russia and South Africa, where in most cases a disinflation dynamic has taken hold – arguing for overexposure to their local bonds.

Risk & Reward
And where are the biggest risks?

Rashique Rahman
We expect capital outflows from China to continue, which is likely to lead to further depreciation of the renminbi. This depreciation pressure is likely to lead to weakness in many other Asian currencies – particularly versus the US dollar. Given lingering headwinds for China, we believe that a less certain outlook for Chinese growth, or global growth more broadly, would pose a downside risk for emerging markets in the year ahead. Though we don't expect this, our research suggests that an unanticipated and aggressive Fed rate-hiking cycle may negatively impact emerging markets if capital flows suddenly reverse.

Risk & Reward
One last question – emerging markets posted strong returns in 2016. What might investors expect in 2017?

Michael Hyman
Emerging markets fixed income is unlikely to repeat its stellar 2016 performance, as US interest rates are biased to rise over the course of 2017. We expect a year of mid-single digit returns for emerging markets credit, supported predominantly by positive carry. Sovereign credit is likely to outperform corporate credit, as valuations are much more attractive for sovereigns as we begin 2017. Relatively stable, if subdued, global growth, firming commodity prices and moderate inflation could provide a still-favourable backdrop, in our view.

Rashique Rahman
The prospect for steady US dollar gains during 2017 may put downward pressure on local assets via currency depreciation and the pass-through to higher inflation. That said, fundamental emerging markets currency valuations have improved, and in most cases external deficits have moderated from just a few years ago. On balance, as with hard-currency emerging markets credit, we forecast mid-single digit returns for local currency investments in 2017. Importantly, the ongoing search for yield, and the under-allocation to the emerging markets that prevails among institutional investors, suggest that the momentum of flows into emerging markets assets will likely continue and support the asset class.

Thank you both.

Factor investing: building balanced factor portfolios

by Edward Leung and Andy Waisburd

In brief

We examine a sample of US equities over the past 24 years and find that a simple, balanced factor portfolio of value and momentum outperforms a cap-weighted benchmark. This is true whether the balanced factor portfolio is formed from a combination of two individual factor portfolios or implemented via a single portfolio built from a multi-factor model (the "multi-factor portfolio"). We also find that, relative to a combination of single factor portfolios, the multi-factor portfolio more effectively accounts for the relationship between factors. As a result, it tends to have higher exposure to the intended factors so that, ultimately, the multi-factor portfolio outperforms the combination. Importantly, we find that there are ways to construct single factor portfolios such that their combination delivers both factor exposure and performance that is similar in magnitude to that of the multi-factor approach.

As factors become an increasingly more important part of the way in which we invest, there are many critical questions to be considered. Based on the premise that factors are investments with risk and return properties, the relevant decision is how to allocate between factors to appropriately trade-off risk and return. Specifically, what are the factors in which to invest? What is the appropriate balance between these factors? And, what is the best method for implementing the balanced approach?

In recent years, we have observed growing demand for factor-based approaches to investing. According to the Invesco Global Factor Investing Study (2016) conducted by NMG consulting, 70% of the investors surveyed currently use factors in portfolio construction, and 71% of respondents expect to increase factor product allocations in the future. Several drivers have likely led to this growth. Among these is an increased awareness of factor investing thanks to a well-established and growing body of research on factors such as value, size, momentum, volatility and quality. Another contributor to this growth is better access to factor-based products via quantitative asset managers and exchange traded funds (ETFs) focused on smart beta. Perhaps most importantly, the growth in factor investing stems from an increasing appreciation by members of the investment community that a meaningful proportion of their portfolios' performance is explained by exposure to factors as systematic drivers of risk and return.

Investment managers have responded to the growth in demand. For decades, quantitative asset managers have been creating multi-factor portfolios that take into account the relationship between various factors, from both a risk and return perspective. In recent years, we have also seen the introduction of single-factor "smart beta" portfolios (often in the form of ETFs) offering exposure to individual factors. These single-factor portfolios can be combined to produce a balanced factor allocation as well. While both multi-factor portfolios and combinations of single-factor portfolios generate balanced exposure to multiple factors, the portfolios can differ in fundamental ways.

In this article, we consider both approaches. First, we combine two individual portfolios where each is formed from a single factor only. We compare this combination to a single portfolio built from a multi-factor model, "the multi-factor portfolio". Intuitively, if all information on the factors is applied simultaneously, as is the case with the multi-factor portfolio, the decision-making process tends to be more informed and outcomes are improved. As a result, the multi-factor portfolio outperforms the combination of single factors. This finding is consistent with Bender and Wang (2016), Fitzgibbons, Friedman, Pomorski and Serban (2016), and Clarke, de Silva and Thorley (2016), all of whom find that "the whole is worth more than the sum of the parts." But, unlike these studies, this article also shows that there are ways to construct single factor portfolios in such a way that their combination delivers both factor exposure and performance that is similar in magnitude to that of the multi-factor portfolio.

> "The whole is worth more than the sum of the parts."

Factors and models

In the first section, we consider two commonly used factors: value and momentum. Both factors are used by practitioners and have been shown in academic literature to have forecasting power in the cross-section. High value stocks tend to outperform low value (or expensive) stocks, and high momentum stocks, or stocks with high positive returns in the past, tend to outperform low momentum stocks. A large body of literature follows the early work on value by Basu (1977) and momentum by Jegadeesh and Titman (1993).

We consider simple, easy to understand, and commonly used definitions of value and momentum. Momentum is computed as the cumulative return over the past 12 months excluding the most recent month. Value is measured using earnings yield, or earnings over price, where earnings is the average over the past four quarters. Each month, both factors are computed and standardized over a large/midcap universe of approximately 1,300 US equities. Finally, we define a model as an equally weighted combination of momentum and value. The factors and the model are estimated over the 25-year period beginning April 1991 and ending October 2016.

Table 1
Factor and model performance

1-month information coefficients	Value	Momentum	Model
Average	0.021	0.031	0.040
Standard error	0.008	0.011	0.009
t-statistic	2.72	2.87	4.65

Source: Invesco calculations.

Table 1 reports the performance of each factor and the overall model. Factor performance is measured using one-month information coefficients, or the correlation of factor readings with realized returns over the subsequent month. Both momentum and value factors are significantly positively correlated with subsequent returns. The information coefficients of momentum and value are 3.1% (t-statistic = 2.9) and 2.1% (t-statistic = 2.7), respectively.

Stocks with strong model readings tend to possess the properties of both value and momentum stocks. These are stocks that have been increasing in price over the past year and are still trading at attractive multiples. As might be expected, this is not especially common. All other things being equal, stocks that tend to increase in price are not necessarily those that look most attractive from a valuation perspective. In fact, the cross-sectional correlation between momentum and value is consistently negative, at -13% on average over the sample period. Combining drivers of return that are uncorrelated with one another to create balanced factor exposures is a key to successful factor investing. In table 1, we see that the combination of momentum and value outperforms each factor individually, with an information coefficient of 4% (t-statistic = 4.7). As we will now discuss, not all methods of building balanced factor portfolios take advantage of these correlation structures as effectively as others.

Multi-factor portfolios versus combinations of single-factor portfolios

In this second section, we explore different ways of achieving balanced exposure to multiple factors in tradable portfolios. We consider two common approaches to building balanced factor portfolios. First, we build a single portfolio using the multi-factor model described in the previous section. This approach is a common one that has been used by quantitative asset managers for decades. The multi-factor forecast simultaneously considers the information contained in both the momentum and value factors, and the portfolio formed from this joint forecast incorporates the inverse relationship between the two factors.

We also consider a portfolio of momentum and value formed from two single-factor portfolios, a momentum portfolio and a value portfolio. This is a very practical approach. There are a large and increasing number of single-factor portfolios available in the marketplace that can be used as potential building blocks for this type of exercise. These smart beta portfolios offer the consumer a wide array of choices regarding provider, factor definition and portfolio construction methodology.

They provide the ability to combine factors at customized weightings, and all of this flexibility often comes at highly competitive prices. One potential drawback of using combinations of independently formed, single-factor portfolios is that the approach may be less effective at capturing relationships between factors.

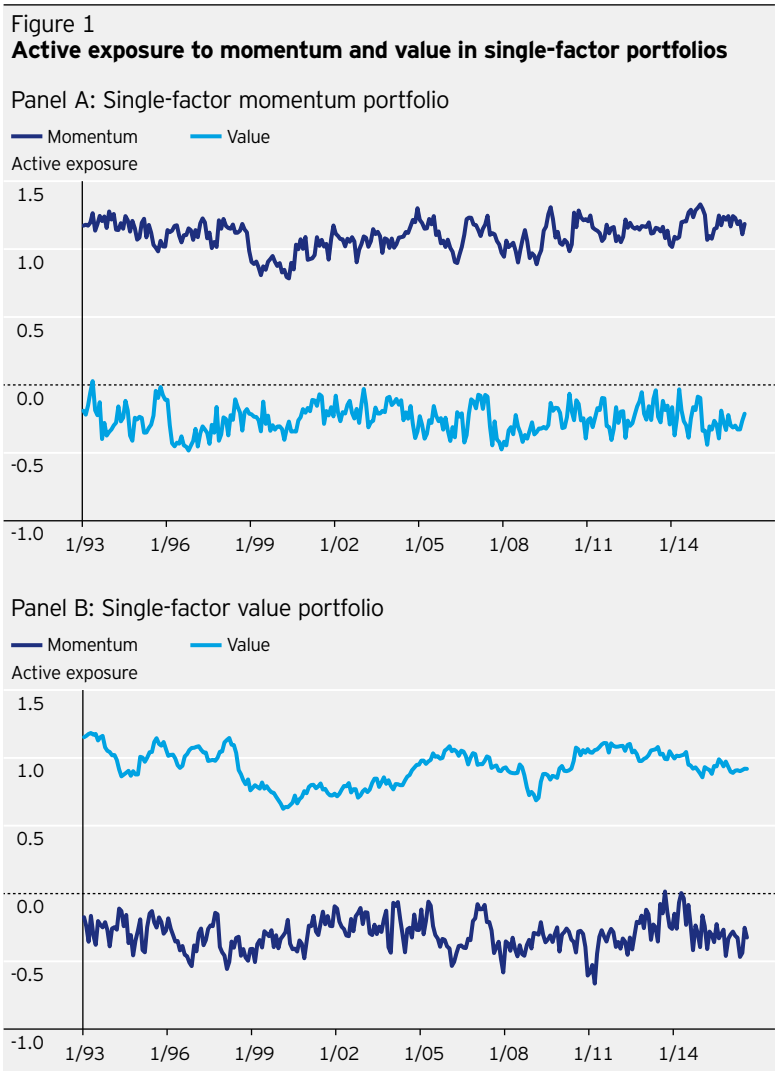
We simulate equal investments in separate momentum and value portfolios, and compare the properties and performance of a combined portfolio to that of a multi-factor momentum-value portfolio of equal total value over the same period. Each of the portfolios has been built using a mean-variance optimization framework, in which return forecasts are either one of the single-factor forecasts or the multi-factor forecast described earlier. Risk is estimated using a fundamental risk model that includes value and momentum factors, as previously defined. We constrain active exposure to all style factors other than value or momentum. Since we use a large/midcap U.S. investment universe, we optimize against the Russell 1000 Index. The maximum active weight in any individual security is constrained to be within two percent of the benchmark, and GICS industries and sectors are limited to be within three percent of the benchmark. The active risk level is calibrated to be approximately three percent for both the combination of single-factor portfolios and the multi-factor portfolio.[1]

Importantly, in this article we do not address the issue of which portfolio construction methodology to use when building factor portfolios. Instead, we attempt to compare combinations of single factor portfolios with a multi-factor portfolio where the portfolio construction methodology is held constant. For convenience, we choose mean variance optimization against a benchmark.

The momentum portfolio has consistently negative exposure to value, and the value portfolio has consistently negative exposure to momentum.

Figure 1 shows the active exposure to momentum and value through time in the single-factor portfolios. Panel A describes the momentum portfolio, and panel B describes the value portfolio. We observe that the momentum portfolio and the value portfolio each have high positive exposure to their respective factors. However, we also note that the momentum portfolio has consistently negative exposure to value, and the value portfolio has consistently negative exposure to momentum. This second finding is critical. It follows from the fact that momentum and value are negatively correlated with one another, and the fact that each of the single-factor portfolios was constructed with the intention of capitalizing exclusively on the factor of relevance.

Figure 1
Active exposure to momentum and value in single-factor portfolios



Based on data from April 1991 onwards; however, due to the calculation methodology, exposure data is only available from January 1993 onwards.
Source: Invesco calculations.

Figure 2 shows the active exposure to momentum and value through time in the multi-factor portfolio (panel A) and in the combined single-factor portfolios (panel B). In these graphs, active exposure to both momentum and value are positive through time. This follows from the fact that in both cases we are building portfolios that allocate to assets with high exposure to each of the factors individually. Importantly, we observe that the level of active exposure for both momentum and value is substantially higher for the multi-factor portfolio than for the combination of single-factor portfolios. This is because the multi-factor portfolio is not building a portfolio of assets merely having high individual exposure to momentum and value – the assets also have high exposure to momentum and value jointly. The combination of single-factor portfolios, on the other hand, has its positive momentum exposure offset by the negative exposure in the value portfolio, and has its positive value exposure reduced by the negative exposure in the momentum portfolio.

The increased exposure to factors with the ability to forecast return translates directly into portfolio performance. The first two columns of table 2 report

the active performance of the multi-factor portfolio and the combination of two single-factor portfolios, respectively. By construction, both portfolios have approximately 280bp of active risk, but the multi-factor portfolio offers an annual return of 222bp. This is almost 70bp more per year than the 154bp of active return delivered by the portfolio formed from a combination of single factors. Ultimately, the information ratios for both portfolios are positive and significant, but the multi-factor portfolio is notably stronger (0.78 vs. 0.55).

Multi-factor portfolios outperform combinations of single factors.

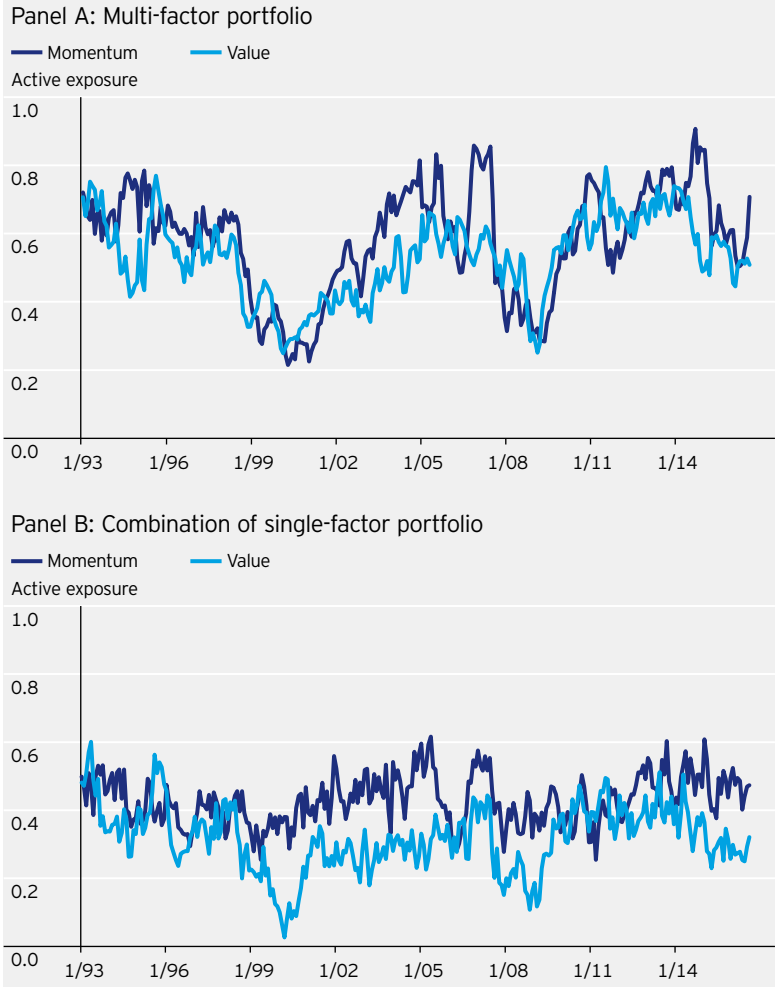
Portfolio construction matters

Consistent with Bender and Wang (2016), Fitzgibbons, Friedman, Pomorski and Serban (2016), and Clarke, de Silva and Thorley (2016), we find that multi-factor portfolios outperform combinations of single factors. This occurs because the multi-factor portfolios are built to more effectively account for the correlation between factors and, as a result, relevant exposures in the multi-factor portfolio are higher than those in the equivalent combination of single factors. Given the ubiquity of single-factor options for delivering factor exposures, it might be worthwhile to construct combinations of single-factor portfolios that offer benefits similar to the multi-factor return forecast. Let us explore this possibility next.

Recall that our single-factor momentum portfolio has negative value exposure, and our single-factor value portfolio has negative momentum exposure – both of which lead to diminished exposures in the combined portfolio. As a practical matter, if we were able to create single-factor portfolios based on factors that were negatively correlated with one another but were not negatively exposed to the complementary factor, we might be able to mitigate the issue and generate a combined portfolio of single factors that performs similarly to the multi-factor portfolio.

We build the single-factor portfolios identical to those in the second section, except for the additional requirement that the momentum portfolio has zero value exposure, and the value portfolio has zero momentum exposure. In this way, we avoid creating single-factor portfolios that have deleterious effects on the contributions of other factors when held in combination. Column 3 of table 2 shows the performance of the combination of these "enhanced" single-factor portfolios.

Figure 2
Active exposure to momentum and value in balanced factor portfolios



Based on data from April 1991 onwards; however, due to the calculation methodology, exposure data is only available from January 1993 onwards.
Source: Invesco calculations.

Table 2
Portfolio performance

	Multi-factor portfolio	Combination of single factors	Enhanced combination of single factors
Active return	2.22%	1.54%	2.12%
Active risk	2.83%	2.80%	2.88%
Information ratio	0.78	0.55	0.73
t-statistic	3.81	2.68	3.57

Source: Invesco calculations in USD.

The average value exposure (not tabulated) in the combination of single-factor portfolios increases by 32%, from 0.32 to 0.42, and the average momentum exposure increases by 29%, from 0.43 to 0.55. These increases in exposure to factors with positive returns lead to increases in portfolio return at similar levels of risk. The combination of single-factor portfolios now has an information ratio of 0.73, an increase of 33% over the 0.55 information ratio for the previous combination of single factors. This risk-adjusted return is hardly distinguishable from the 0.78 information ratio associated with the multi-factor portfolio.

Conclusion

We have provided empirical evidence for two well-established factors: value and momentum. We have demonstrated the efficacy of each factor for forecasting US equity returns and shown that a multi-factor model capturing a balanced combination of uncorrelated factors has been beneficial. The main focus of this article is on how to implement the model as a portfolio of balanced factor exposures. We examined implementations via combinations of single-factor portfolios and via one multi-factor portfolio. Regardless of the approach chosen, we found that a simple, balanced factor portfolio of value and momentum outperforms a cap-weighted benchmark. Similar to other research, we also found that single-factor portfolios, when combined, have lower exposures to the intended factors, and, as a result, inferior performance compared to an analogous multi-factor implementation. However, we also found that, if single-factor portfolios are built in specific ways, it is possible to combine them to achieve many of the benefits of the multi-factor approach. Ultimately, the way in which a balanced portfolio of factors is constructed should reflect the preceding points, but it should also take into account practical concerns, including, but not limited to, existing factor exposures in a portfolio and intended factor allocations. Such considerations would likely lead to use cases for both single factor and multi-factor portfolios.

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Note

1 None of the calculations in this article takes into account trading costs, management charges and other fees.

Risk-based currency management

by Dr. Martin Kolrep and Dr. Harald Lohre

In brief
Dealing with a portfolio's currency risk is no clear-cut matter. Using a minimum variance hedging strategy, we explore a middle road between full hedging of all currency risks and no hedging at all. Past performance analysis suggests that a minimum variance hedge is often superior to either extreme. Given the quite stable correlation between exchange rates and asset classes, the minimum variance hedge can reduce portfolio risk substantially in many cases.

Currency management is becoming increasingly important in today's extreme low interest rate environment: on the one hand, interest rates are higher in nearly every region outside the euro and US dollar spheres; on the other, portfolio volatility can often be reduced using forecast-free optimization of currency positions.

The quest for diversification usually leads to investing in international stocks and bonds. But, this can involve a substantial currency risk. For instance, the annualized volatility of the US dollar from a euro investor perspective was roughly 10% over the last 15 years[1] – and thus nearly double that of a traditional bond investment.[2] Investors often react in a rather extreme fashion to currency risk: conservative investors may hedge currency risk completely, while more aggressive investors often accept the risk by not hedging at all.

In an earlier article,[3] we showed that a decision for or against currency hedging depends in large part on individual investment objectives. But, there is also a role played by the base currency. There is simply no ideal solution for all investors: a decision to do away with hedging entirely can have significant negative impacts on performance in some phases; but, full hedging is too broad, and the potential diversification benefits of foreign-exchange holdings might go unnoticed. The optimal FX exposure very likely lies somewhere between these two extreme poles, and can change significantly over time. Thus, a static approach is often inadequate.

In this article, we will first analyze the performance of portfolios with and without currency hedging. By way of illustration we will take the perspective of a euro investor. What we find are very different characteristics across individual currencies. Accordingly, an investor who does not hedge foreign currency positions thus takes on different risks depending on the currency in question. This also explains why FX strategies can be very different depending on the underlying asset classes and base currency. After this, we show the results of a forecast-free portfolio optimization, designed to reduce portfolio volatility through a variable FX hedge ratio.

Interest rate differential and currency difference
The difference between a currency-hedged and an unhedged portfolio has two components: the interest rate differential and the currency difference. For a euro-based investor, the interest rate differential is the difference between the interest rate on a euro-money market investment and the weighted interest rate of money market investments in the foreign currencies. The currency difference is the average of exchange rate movements.

Figure 1 shows the interest rate differential and currency difference using the MSCI World index. Over the past 15 years, currency hedging in an international equity portfolio would have given a euro investor a slight 2% advantage (dark blue line, ending at 98). This is the difference between a cumulative interest rate disadvantage of roughly 7% (light blue line, ending at 107) and a currency advantage of nearly 9% (light green line, ending at around 91).

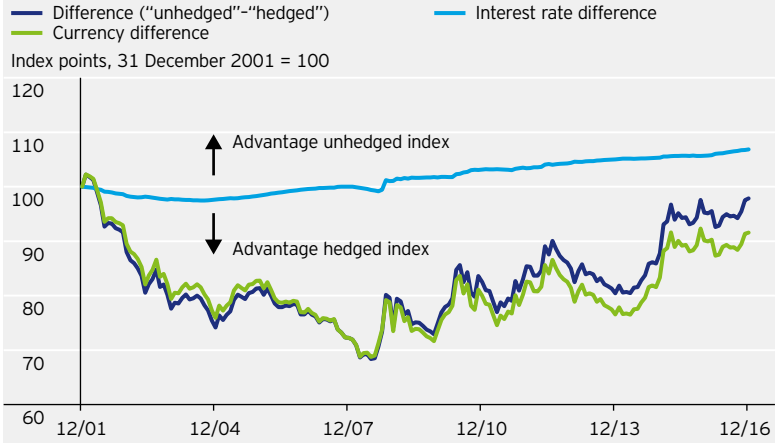
The period since 2001 can be separated into two phases: from 2001 to 2007, the hedged investor was clearly in the lead – by roughly 30%; the interest rate differential was close to zero (meaning that the difference stemmed solely from the euro strength against the currency basket). After 2007, this advantage nearly completely disappears, and the unhedged portfolio takes a significant lead, driven by both the interest rate and currency components alike.

In the 12 months of 2016 alone, the interest rate differential was 1.1%, and the currency difference 1.6% – bringing the aggregate difference to 2.7%. Tracking the unhedged MSCI World, a euro investor would thus have earned 10.7% in 2016; with the hedged alternative, only 7.8%. For emerging market stocks, the difference would have been even more substantial, at 8.5% (roughly 4% interest rate differential and 4.5% currency difference, as emerging market currencies have strengthened against the euro).[4] A euro investor would therefore have paid a high price for currency hedging.

Correlation between equities and exchange rates

Looking at the numbers suggests that it is sensible to only partially hedge currency risks. It is interesting in this context to note the historical correlation between currencies and equities (table 1): clearly and constantly positive is the correlation between the MSCI World and the Canadian dollar (CAD), Norwegian krone (NOK), Swedish krona (SEK), Australian dollar (AUD) and New Zealand dollar (NZD). Constantly negative correlations can be seen with the Swiss franc (CHF) and the Japanese yen (JPY). Relatively low or alternating correlations are exhibited by the UK pound (GBP), US dollar (USD), Hong Kong dollar (HKD) and Singapore dollar (SGD).

Figure 1
MSCI World hedged vs. MSCI World unhedged



Difference in performance of a hedged vs. an unhedged international equity portfolio (MSCI World hedged and MSCI World unhedged) from the perspective of a euro investor (dark blue line), broken down into the interest rate differential (light blue line) and currency difference (light green line). A rising line reflects an advantage for the unhedged index; a falling line indicates an advantage from hedging. In the sample period, the overall difference between the hedged and unhedged portfolio is minimal, and results from an interest rate disadvantage (higher interest rates outside the eurozone) and a currency advantage (slight euro strengthening against a currency basket).
Sources: MSCI, Bloomberg, Invesco. Data as at 31 December 2016.

> Looking at the numbers suggests that it is sensible to only partially hedge currency risks.

Table 1
Correlations of currencies to MSCI World

- Indicates a positive correlation
- Indicates a negative correlation
- Indicates low or alternating correlation

Correlation with equities	EUR/ USD	EUR/ CAD	EUR/ GBP	EUR/ CHF	EUR/ NOK	EUR/ SEK	EUR/ DKK	EUR/ JPY	EUR/ SGD	EUR/ HKD	EUR/ AUD	EUR/ NZD
15 years	-0.13	0.36	0.11	-0.21	0.29	0.35	0.02	-0.41	0.06	-0.12	0.51	0.39
10 years	-0.23	0.38	0.12	-0.21	0.37	0.38	0.00	-0.54	0.00	-0.22	0.57	0.44
5 years	0.10	0.35	0.24	-0.08	0.37	0.27	-0.02	-0.34	0.21	0.11	0.37	0.25
3 years	0.30	0.50	0.37	-0.06	0.43	0.26	-0.03	-0.27	0.42	0.32	0.51	0.29
1 year	0.40	0.60	0.35	-0.08	0.47	0.63	0.01	-0.39	0.57	0.44	0.64	0.38

Correlations of currency returns (from the perspective of a euro investor) to the local currency return of the MSCI World Index.
Sources: MSCI, Bloomberg, Invesco. Data period: 31 December 2001 to 31 December 2016, based on weekly data.

In many cases, the following pattern can be discerned: currencies with interest rates higher than those of the base currency (as a rule US dollars and euros, in our example: euros), rise in tandem with the equity market. This derives in part from so-called 'carry trades': as long as equity prices are rising and the overall economy is thriving, investors take on debt in a currency with low interest rates, and invest this money in a currency with higher interest rates. This often leads to a slight strengthening of the higher interest rate currency, meaning that, alongside the interest rate advantage, a marginal currency advantage can develop as well. Figure 1 has already shown that interest rate and currency movements often go hand-in-hand over the long term.

But, if there is a crisis with rising volatility, investors tend to unwind their carry trades in order to avoid risk. They are therefore forced to buy back the currencies with low interest rates, which explains the negative correlation of equities to CHF and JPY (table 1) – which rise when equity markets fall.

Positions in currencies with a high correlation to the equity market can increase the overall risk of a portfolio, whereas a certain degree of diversification potential likely exists in other currencies. An important role in this context is played by those currencies with an alternating correlation: EUR/USD, for instance, was long-term negative, but recently turned positive in correlation with international equities. Accordingly, it would seem that a static approach is inadequate.

Optimal currency allocation to minimize portfolio volatility

As with any allocation, currency allocation can be optimized by the trade-off of risk and return expectations. Exchange rate forecasts, however, are difficult to make accurately. Nonetheless, our correlation analysis shows that open currency positions can reduce portfolio risk. In fact, academic studies suggest that investors should strongly hedge their currency risk, albeit not completely.[5]

To estimate a reasonable size for the foreign-currency position, we will determine the risk-minimizing currency allocation of two international investment portfolios: a conservative multi-asset portfolio and a conventional MSCI World equity portfolio.

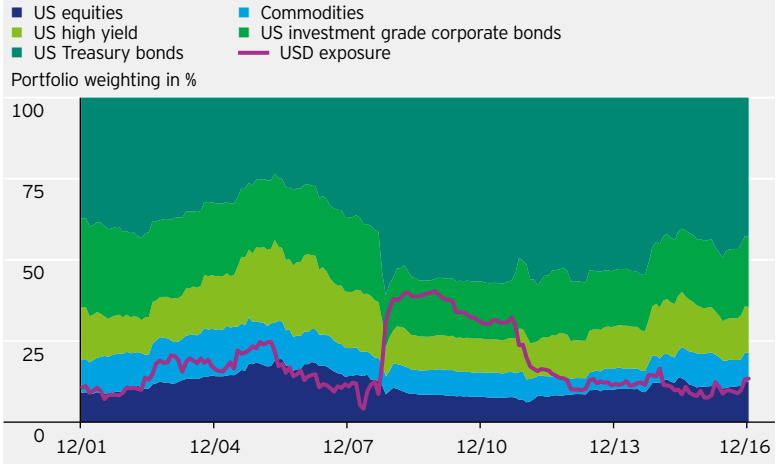
Case study I: Conservative multi-asset portfolio

Our first example is a euro investor following a risk parity strategy along US equities, US Treasuries, US investment-grade corporate bonds, US high-yield and commodities. This means that the five asset classes are weighted such that they contribute equally to portfolio volatility. Portfolio weightings are based solely on the variance-covariance matrix of the asset classes, using a rolling 36-month window for backtesting with monthly rebalancing. This ensures that changes to risks are taken into account for portfolio allocation, while maintaining a suitable level of stability in portfolio weightings.

Figure 2 shows the portfolio weightings over time. From a US dollar perspective, the profile is conservative: bonds dominate, with a supporting role played by equities and commodities. For a euro investor, however, this investment bears the full currency risk against the US dollar, in addition to asset class-specific market risks. Portfolio volatility averages 8.8% p.a. – which seems high. Complete US dollar hedging reduces volatility by half, to 4.5% p.a. (table 2).

The question now is whether partial hedging of the US dollar risk can further reduce portfolio volatility. To find out, we implement a portfolio optimization determining the variance-minimizing currency allocation of the portfolio – the so-called minimum variance hedge. The remaining dollar position varies between the two extremes 0% (full hedge) and 100% (no hedge). Within the backtest from 2001 to 2016, it ranges between 4.1% and 40.4% (figure 2), and averages 18.0%. The highest level would have been during the international financial crisis beginning in 2008, when the US dollar served as a 'safe haven' emphasizing its favourable correlation characteristics.

Figure 2
Minimum variance hedge of a multi-asset portfolio over time



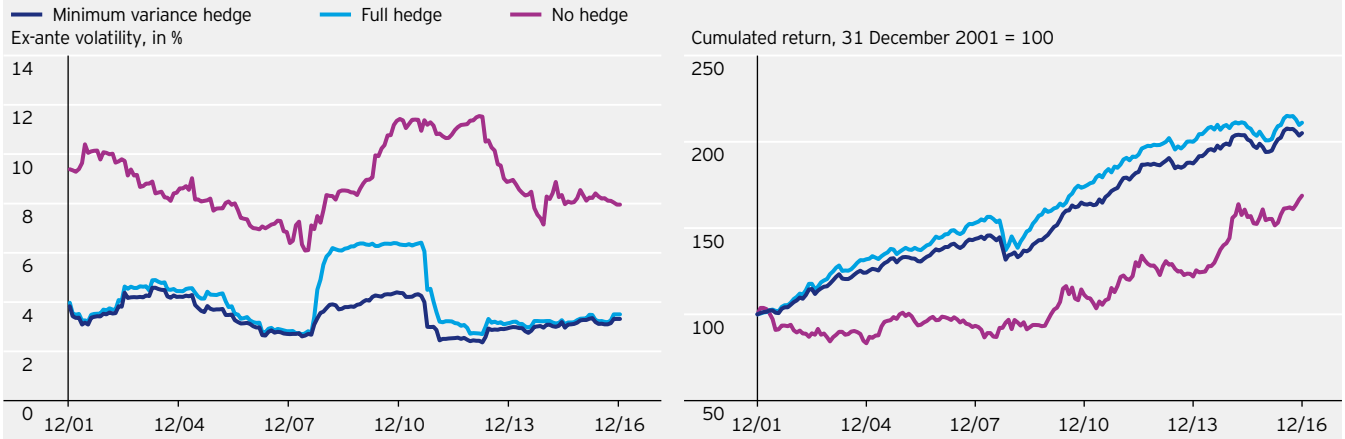
US equities: MSCI USA; US Treasury bonds: Barclays US Aggregate Government Treasury; US investment grade corporate bonds: Barclays US Aggregate Credit; US high yield: Barclays US Aggregate Credit Corporate High Yield; commodities: Bloomberg Commodity Index.
Sources: MSCI, Bloomberg, Barclays, Invesco. Data as at 31 December 2016.

Table 2
Multi-asset portfolio with and without currency hedging

	No hedge	Full hedge	Minimum variance hedge
Minimum FX exposure	100.0%	0.0%	4.1%
Mean FX exposure	100.0%	0.0%	18.0%
Maximum FX exposure	100.0%	0.0%	40.4%
Return p.a.	3.9%	5.1%	4.9%
Volatility p.a.	8.8%	4.5%	3.9%
Sharpe ratio	0.24	0.75	0.80
Maximum drawdown	-19.8%	-12.3%	-9.6%

Total return in EUR. The "no hedge" portfolio is completely exposed to USD, whereas the "full hedge" portfolio is hedging any USD exposure into EUR. The "minimum variance hedge" is only partially hedging the USD exposure into EUR. For a description of the multi-asset portfolio, please see the note under figure 2.
Sources: MSCI, Bloomberg, Invesco. Data period: 31 December 2001 to 31 December 2016.

Figure 3
Volatility and performance of the multi-asset portfolio over time



Total return in EUR. The "no hedge" portfolio is completely exposed to USD, whereas the "full hedge" portfolio is hedging any USD exposure into EUR. The "minimum variance hedge" is only partially hedging the USD exposure into EUR. For a description of the multi-asset portfolio, please see the note under figure 2.
Sources: MSCI, Bloomberg, Invesco. Data as at 31 December 2016.

Also interesting is a comparison of portfolio volatility during the financial crisis (figure 3): whereas the minimum variance hedge strategy results in volatility of roughly 4%, it reaches above 6% with full hedging. No doubt, a nearly 50% increase in risk is not the desired outcome of a full hedge – but, even in less volatile phases, the minimum variance hedge serves to smooth the risk profile, resulting in volatility of 3.9% over the entire period (compared to 4.5% with full hedging, table 2).

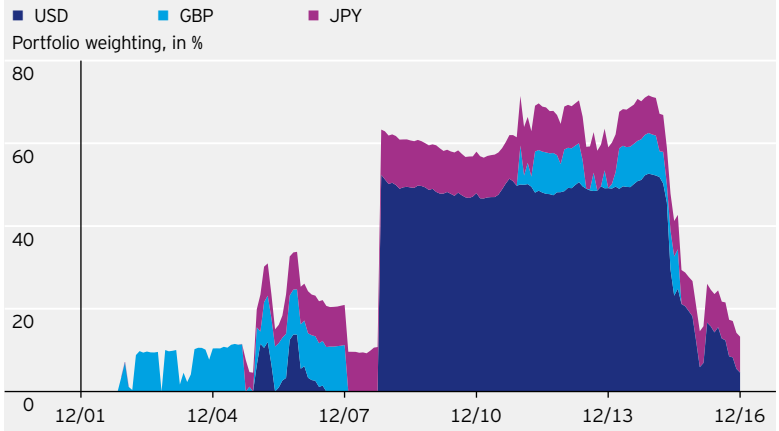
Figure 3 also shows how inconsistent the performance of a multi-asset portfolio can be without currency hedging. In the first half of the sample period, US dollar weakness completely eradicates returns from the five asset classes. And, although this is more-or-less offset by the strengthening of the dollar over time, the value of the investment develops much more consistently in the case of full hedging or a minimum variance hedge. An outstanding feature of the minimum variance hedge is its stable long-term performance – and low maximum drawdown during the financial crisis which reached -12.3% in the fully hedged portfolio, and -9.6% with the minimum variance hedge (table 2).

Case study II: MSCI World equity portfolio
Another common use case is an international equity portfolio invested in the MSCI World index. Absent currency hedging, a euro investor is exposed to currencies totalling more than 80%, deriving largely from three currencies: the US dollar, the Japanese yen and pound sterling. Portfolio allocation is at all times 100% MSCI World.

The equity portfolio is riskier than the multi-asset portfolio. Without hedging, portfolio volatility reaches 13.4%; it is even higher (14.0%) with full hedging (table 3) – an astounding result that shows the strong diversification potential of some currencies in an international equity portfolio. So, can optimization of currency allocation achieve a noticeable improvement?

Figure 4 shows that the minimum variance hedge only attains its maximum allocation in the second half of the sample period. On average, the foreign currency

Figure 4
Minimum variance hedge of the MSCI World portfolio over time



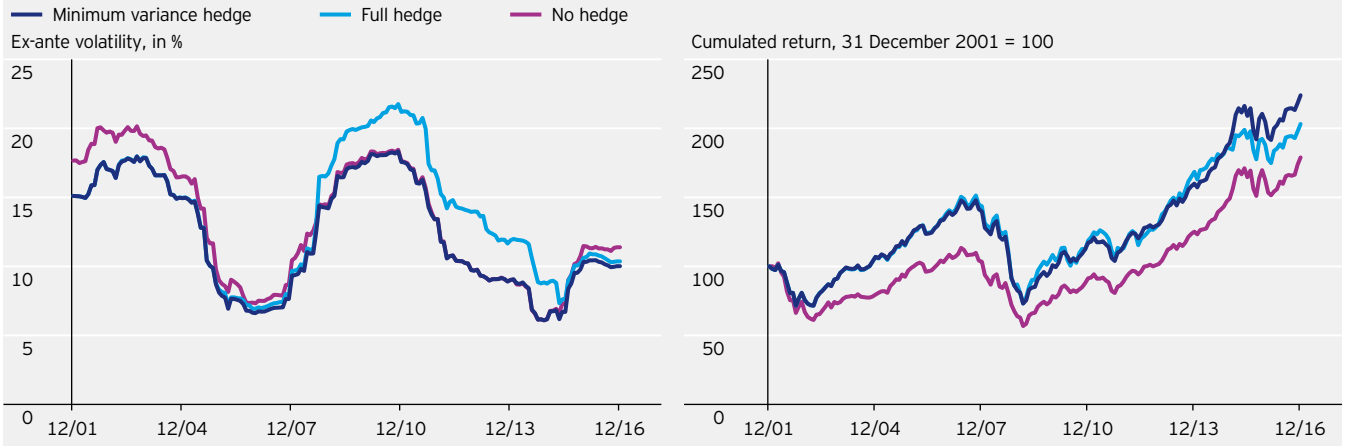
The figure shows the currency exposure arising for a minimum variance hedge strategy of the MSCI World. In this case, the strategy is focusing on the three major currencies USD, GBP and JPY, and other currency exposures pertaining to the MSCI World are not hedged into EUR.
Sources: MSCI, Bloomberg, Invesco. Data as at 31 December 2016.

Table 3
MSCI World portfolio with and without currency hedging

	No hedge	Full hedge	Minimum variance hedge
Minimum FX exposure	84.7%	0.0%	0.0%
Mean FX exposure	87.9%	0.0%	35.7%
Maximum FX exposure	90.4%	0.0%	71.6%
Return p.a.	4.8%	5.7%	6.2%
Volatility p.a.	13.4%	14.0%	12.9%
Sharpe ratio	0.23	0.28	0.35
Maximum drawdown	-50.0%	-51.7%	-50.6%

Total return in EUR. The "no hedge" portfolio is exposed to the complete foreign currency exposure pertaining to an MSCI World investment. The "full hedge" portfolio is hedging any USD, GBP and JPY exposure into EUR. The "minimum variance hedge" is only partially hedging the USD, GBP and JPY exposures into EUR.
Sources: MSCI, Bloomberg, Invesco. Data period: 31 December 2001 to 31 December 2016.

Figure 5
Volatility and performance of the MSCI World portfolio over time



Total return in EUR. The "no hedge" portfolio is exposed to the complete foreign currency exposure pertaining to an MSCI World investment. The "full hedge" portfolio is hedging any USD, GBP and JPY exposure into EUR. The "minimum variance hedge" is only partially hedging the USD, GBP and JPY exposures into EUR.
Sources: MSCI, Bloomberg, Invesco. Data as at 31 December 2016.

exposure was 35.7%. Thus, it comes as no surprise that the expected portfolio volatility initially closely matches that of the fully hedged portfolio, which later shows its inadequacies during the financial crisis: from 2009 to mid-2015, the minimum variance hedge lowers expected portfolio volatility by roughly 4 percentage points.

Most recently, only the Japanese yen, and – marginally so – the US dollar, provide any diversification effects, while the unhedged equity portfolio increases risk. Regression analysis shows that the minimum variance hedge results in overall volatility of 12.9% – slightly below that of an unhedged investment (table 3).

On the whole, the various hedging strategies have a less pronounced impact on performance here than in the multi-asset portfolio example. It is notable, however, that the unhedged equity strategy, at 4.8% return p.a., lags clearly behind the portfolio using the minimum variance hedge (6.2% p.a.). For this reason – and due to the lower volatility – the risk-adjusted return (Sharpe ratio) improves from 0.23 to 0.35. It is also logical to assume that expected portfolio return can be further improved by accurate currency forecasting – as will be the subject of an upcoming article.

Conclusion
Based on the past performance analysis, we have found that full hedging of currency risks does not always deliver the reduction in risk sought by investors; but a complete lack of hedging is not always a solution either. Depending on foreign currency weightings and the investor's base currency, risk-based currency management can be used to substantially reduce the overall risk profile. We believe this is best achieved by pursuing a dynamic approach, taking into account changes in interest rates and correlations between currencies and various asset classes.

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Notes
1 Volatility of the EUR-USD exchange rate, 31 December 2001 to 31 December 2016 (daily data): 9.7%.
2 Volatility of the Barclays US Aggregate Government Treasury index, 31 December 2001 to 31 December 2016 (daily data): 4.5%.
3 Martin Kolrep, Currency management in multi-asset portfolios, Risk & Reward Q4/2015.
4 MSCI Emerging Market index in local currency and euro.
5 See e.g., Fischer Black (1989): Optimizing Currency Risk and Reward in International Equity Portfolios, Financial Analysts Journal, July/August 1989, pp. 16-22; Fischer Black (1990): Equilibrium Exchange Rate Hedging, Journal of Finance, vol. 45 (3), pp. 899-907.

What makes a successful forecaster?

by Scott E. Wolle

In brief

Without successful forecasting there is no chance of ever beating the market. But forecasting isn't easy – though investors have an advantage over some other groups whose views of the future are an important part of their work: investors can succeed with even a small majority of correct views, and can hold multiple, unrelated views at once. We consider three levels of decision making relevant to investors. These are: the quality of inputs, the combination of inputs to form a decision and the combination of decisions to create a portfolio. In this way, good judgement is absolutely possible – but it does not come naturally. It is the product of processes and team structures that explicitly pursue it.

Economic forecasting has a reputation for always getting it wrong. Yet it can't be denied that everybody eagerly awaits the most recent estimates of future growth, interest rates and stock market returns. We give an overview of common forecasting pitfalls, and show what can be done methodologically and conceptually to improve forecast quality.

> "The only function of economic forecasting is to make astrology look respectable." John Kenneth Galbraith

2016 may be remembered for many things – but excellence in forecasting will most assuredly not be one of them. Voters' choices in favour of "Brexit" in the UK and of Donald Trump for President in the US stand as remarkably egregious misses by the experts. Yet, our surprise at these failures must itself be viewed as surprising, given the well-documented inaccuracy of expert forecasters[1]. Philip Tetlock, perhaps the most prominent researcher of expert judgement, famously stated that, "the average expert was roughly as accurate as a dart-throwing chimpanzee."[2] Ironically, it seems that the uncertainty associated with last year's forecast errors has actually served to increase demand for forecasts.

Fortunately, the research on forecasting and judgement does contain some hopeful news. First, the fact that the average forecaster performs poorly allows for some forecasters to do well. Second, the forecasters who do perform well tend to exhibit behaviours that overcome the weaknesses that make forecasting so difficult. Investors have an advantage over some other groups whose views of the future are an important part of their work. We can succeed with even a small majority of correct views, and can hold multiple, unrelated views at once. This article considers three levels of decision making relevant to investors: the quality of inputs, the combination of inputs to form a decision and the combination of decisions to create a portfolio.

Inputs

Quantopian, a website and self-described crowd-sourced quantitative investment firm, provides a wealth of tools to aspiring quantitative investors, including tutorials, fourteen years of data on stocks and the opportunity to license successful strategies

to the firm. Membership has doubled in each of the past few years, and has now reached over 100,000. These members have developed over 300,000 investing algorithms.

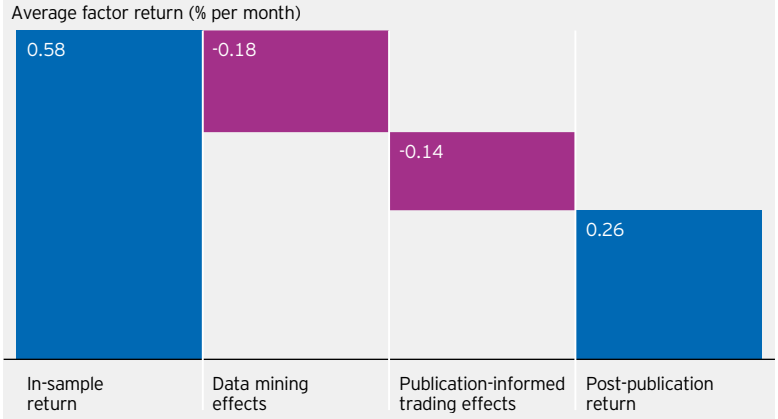
> "Where is all the knowledge we have lost in information?"
> Thomas Stearns Eliot

Quantopian reflects both the opportunity and vulnerability of vast increases in data availability. Expanded information can help fundamental investors narrow their investment universe through the use of screens, as well as reduce the likelihood of certain cognitive errors [see Jones[3] for a good summary]. The benefit for quantitative investors, of course, is more direct.

Yet, information has a cost in terms of false positives. Consider the 300,000 algorithms mentioned above: even if none of them had any information whatsoever, approximately 15,000 would pass standard statistical tests of significance, simply by random chance[4].

For example, McLean and Pontiff[5] review nearly 100 variables from peer-reviewed journals that purportedly explain the cross-section of stock returns. According to their findings, the variables lost on average more than half of their effectiveness from the period studied to post-publication (figure 1). The authors further dissect the information loss into potential data mining and publication-informed trading effects (i.e., practitioners using a variable and thereby degrading its effectiveness). None of these include trading costs or fees, which make the effective returns even smaller.

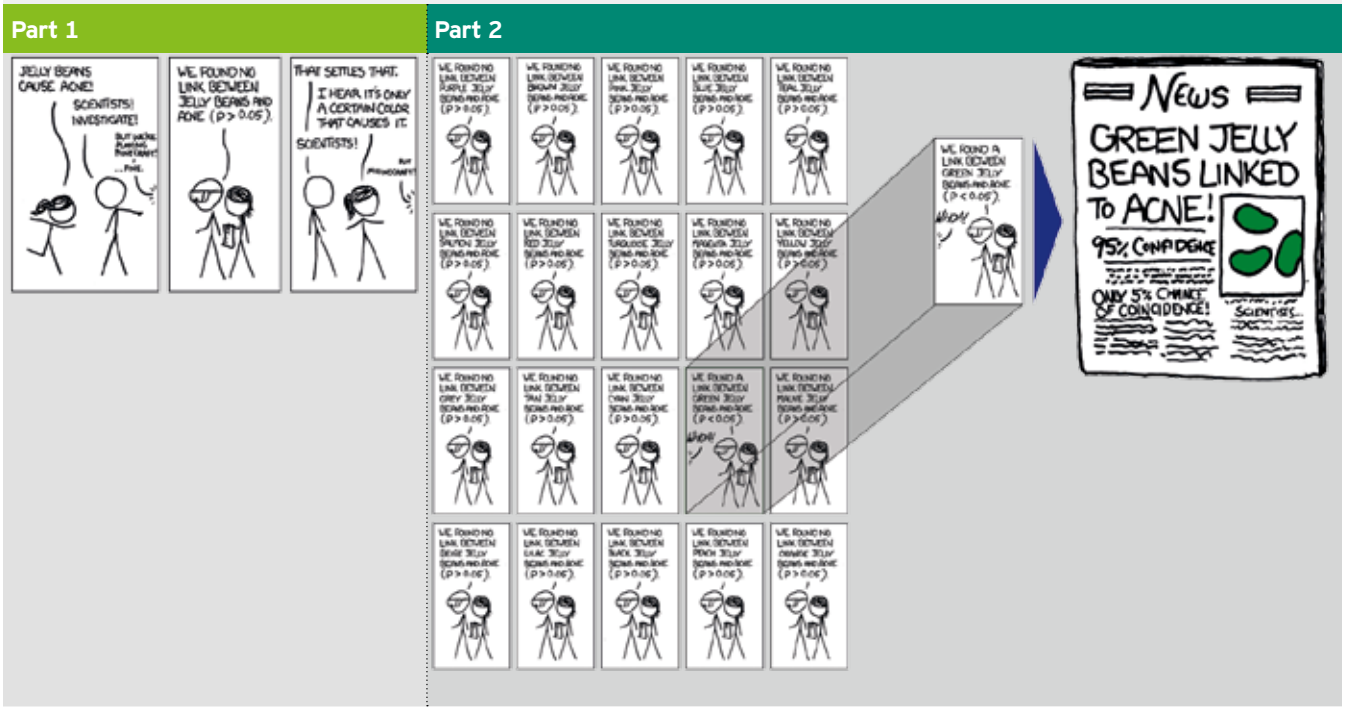
Figure 1
The disappearance of forecast returns



Data was collected for 97 variables from peer-reviewed journals dating from 1973 to 2013. Source: McLean, R. D. and J. Pontiff. 2015. Does academic research destroy return predictability? Journal of Finance, 2016.

The one-third loss of information from data mining is particularly worrying given the source of the information. Harvey, Liu, and Zhu[6] reviewed an even larger sample of factors: a nearly unimaginable 316 from peer-reviewed journals. They find that the majority are likely to fail significance tests once account is taken of multiple testing. Professor Harvey used a cartoon to explain the problem (figure 2).

Figure 2
The jelly bean problem



Source: XKCD.com, as at 31 December 2016. Available at https://xkcd.com/882.

In the first frame, scientists are conducting tests to find out whether jelly beans cause acne, and conclude that they do not, based on the p value (convention considers only scores below 0.05 to be significant). The follow-on hypothesis posits that only certain colours of jelly beans cause acne – so the scientists test twenty different colours, concluding with 95% confidence that it is green jelly beans that cause acne. The same holds true with investment factors – testing many variations on a theme will almost certainly reveal a winning strategy, even if only by chance, unless we adjust the results appropriately.

Failure to account for multiple testing represents only one of many potential statistical and behavioural challenges facing investors, who must incorporate practices into their investment processes to help alleviate the risks. For example, the views of individuals within a team can, when aggregated, surpass the quality of the most knowledgeable member. But, a team squanders this virtue without a structure that prevents a minority of members from dominating the discussion.

Combining inputs

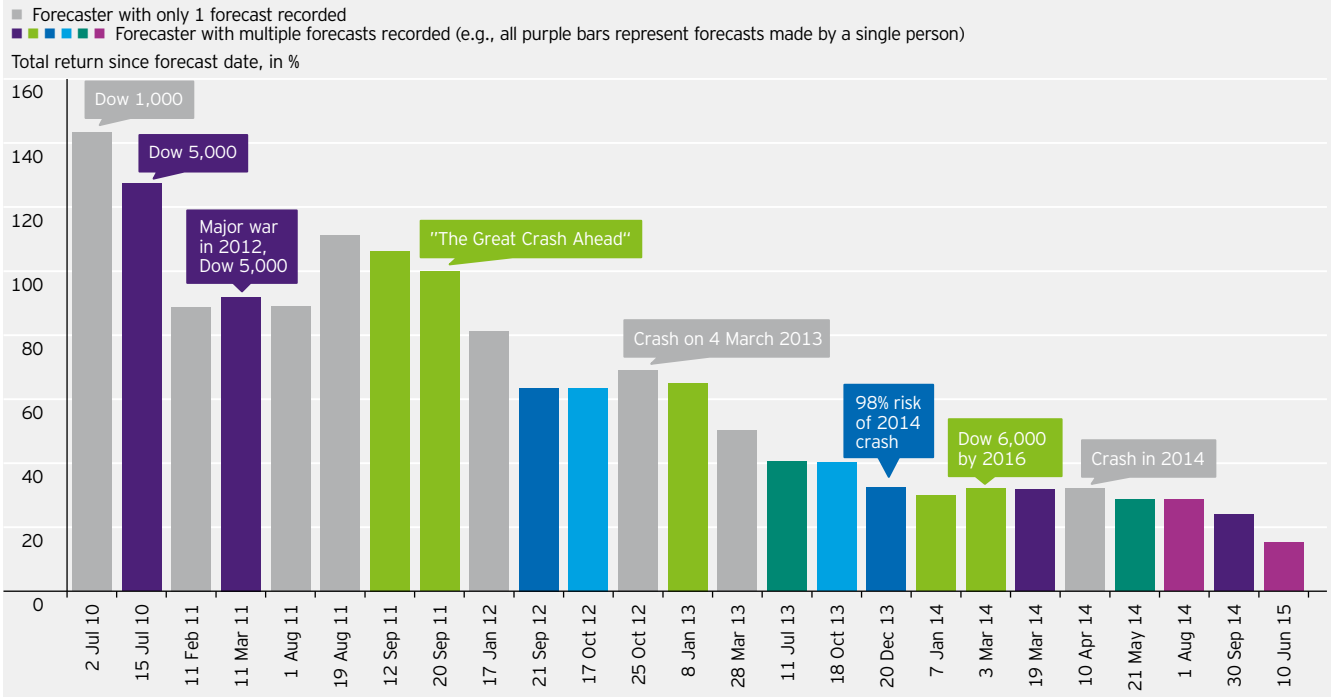
The years following the financial crisis witnessed a variety of financial commentators portending an imminent relapse into crisis. Michael Johnston counts twenty-five bearish predictions made from July 2010 through June 2015 from reputable outlets like The New York Times and CNBC.[7] The predictions certainly made for interesting news and conversation – but all have proved incorrect (figure 3). The language used by these commentators seems to identify them, in Tetlock's taxonomy, as "hedgehogs".

> "The whole problem with the world is that fools and fanatics are always so certain of themselves, but wiser people so full of doubts." Bertrand Russell

In his book 'Expert Political Judgment' (2006), Tetlock documents the results of his work, gathering and analyzing thousands of opinions from over two hundred experts over the course of two decades. His work finds no substantial difference in results between liberals and conservatives, optimists and pessimists, or any other obvious category. Rather, he classifies forecasters by how they think. Hedgehogs view the world through a single lens – a single big idea. The other group, "foxes," takes a broader perspective, continually looking for additional information to test their views. Foxes are shown to generate vastly superior performance, and this result prompted Tetlock to explore how good forecasting could become through applying best practices. The promising solutions are documented in his book, "Superforecasters".

In investment terms, the outperformance of foxes is simple to explain, even assuming equally informative inputs[8]: foxes effectively have a diversified portfolio of inputs, while the hedgehogs have the equivalent of a one stock portfolio. Grinold and Kahn have developed a framework, the "Fundamental Law of

Figure 3
Hedgehogs get it wrong



Source: "A Visual History of Market Crash Predictions," Michael Johnston. 16 July 2015. Available at http://financialgroup.com/wp-content/uploads/2016/02/A-Visual-History-of-Market-Crash-Predictions.pdf.

Active Management" (figure 4), that explains how the quality of inputs and the number of independent inputs impact the quality of a decision[9]. Applying this to hedgehogs and foxes helps us see the massive advantage of the latter. By seeing the world through two independent lenses, rather than one, the fox has a 40% advantage over the hedgehog. In other words, the hedgehog's lens has to be 40% better than the average of the fox's lenses to have the same expected accuracy! The advantage, of course, builds with the number of additional independent factors (assuming a similar quality of input).

Investors have many alternative means of combining inputs to form a decision. Perhaps surprisingly, research by Timmerman[10] finds that a simple average outperforms most more-complicated alternatives, at least when it matters – out of sample[11]. He explains that part of the appeal of simple averages lies in the possibility of structural breaks, which are difficult to discern in real time, and certainly plague financial variables, but not all of them at the same time. The key lesson is clear: investors should require exceptionally compelling evidence before veering from the simplest approach to combining inputs.

A portfolio of decisions

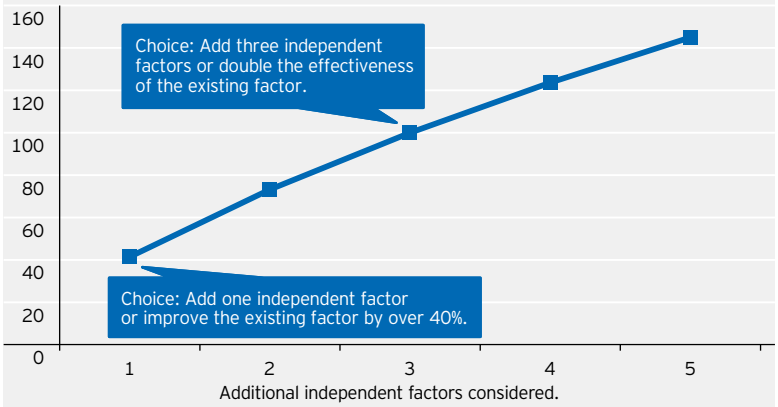
The work of combining decisions to create a portfolio resembles what was outlined in the prior section. In this case, however, one aspect requires some additional thought: how to handle differences in volatility among decisions. When combining inputs into a decision, all of the inputs likely possess similar volatility, since they all relate to a single phenomenon – such as the attractiveness of stocks relative to bonds. But, the volatility of the various decisions arrived at can vary considerably (figure 5). In this example, global stocks relative to bonds exhibit more than twice the historical volatility as the duration decision (18% vs. 8%). Accordingly, the global stocks vs. bonds decision contributes more than half of the volatility.

"All models are wrong, but some are useful." George Box

The concentration of risk means that these four decisions – even if completely independent – have less effective breadth than four with a similar level of volatility, because expected return per unit of risk also falls. Investors can address this by adjusting the allocation ranges for each decision, such that the product of the allocation range and the volatility are equal for each decision. In this example, the following allocation ranges would result in an equal risk contribution for each decision:

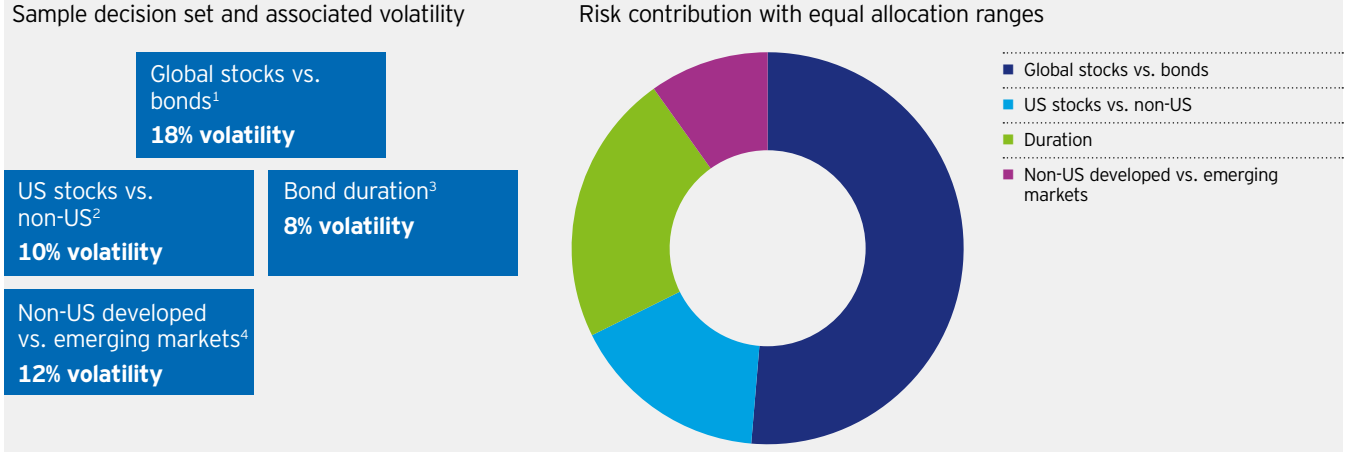
- Global stocks vs. bonds: +/- 7%
- US stocks vs. non-US: +/- 12%
- Duration: +/- 16%
- Non-US developed vs. emerging markets: +/- 11%

Figure 4
The fundamental law of active management



Sources: Grinold and Kahn, Invesco analysis.

Figure 5
Contributions to portfolio volatility



Decisions represented by 1: MSCI All Country World Index (ACWI) relative to Barclays Global Aggregate; 2: MSCI USA relative to MSCI ACWI ex-US; 3: Barclays US 10 Year Treasury Bellwether Index; 4: MSCI ACWI ex-US relative to MSCI Emerging.
Source: Datastream. Period considered: 31 December 2006 – 31 December 2016.

The same principle can apply when allocating assets to managers: all things equal, higher tracking error managers should receive smaller allocations than lower tracking error managers, to avoid an over-concentration of risk in one manager.

Summary

More than forty years have passed since Tversky and Kahneman[12] alerted us to the frailties of human judgement. Since that time, forecasters across many disciplines have continued to fall for the same errors. The proliferation of financial data and analytical tools has helped solve some problems – but created new ones as well.

> "Whenever there is a simple error that most laymen fall for, there is always a slightly more sophisticated version of the same problem that experts fall for." Amos Tversky

The good news is that good judgement is absolutely possible. But it does not come naturally. It is the product of processes and team structures that explicitly pursue it. Of the traits that Tetlock identifies in successful forecasters, two stand out: a drive to improve and the discipline to keep score. One could do far worse than to start with those.

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Scott Wolle serves as the Chief Investment Officer for Invesco's Global Asset Allocation team which focuses on alternative investment strategies including risk parity, risk-balanced commodities and global macro solutions.

Notes

1 Grove, W. M., Zald, D. H., Lebow, B. S., Snitz, B. E., & Nelson, C. (2000). Clinical versus mechanical prediction: a meta-analysis. Psychological assessment, 12(1), 19.
2 Tetlock, Philip E., and Dan Gardner. 2015. Superforecasting: the art and science of prediction.
3 Making Better (Investment) Decisions The Journal of Portfolio Management, vol. 40, no. 2. (January 2014), pp. 128-143, doi:10.3905/jpm.2014.40.2.128 by Robert C. Jones
4 A common test of significance is for a p value below 0.05 (Z score 1.645). In a normal distribution, 5% of observations will meet this criterion. 5% x 300,000 = 15,000. This assumes that the 300,000 were the total number of algorithms tested which may be a low estimate given that unsuccessful algorithms may not have been saved.
5 McLean, R. David and Pontiff, Jeffrey, Does Academic Research Destroy Stock Return Predictability? (January 7, 2015). Journal of Finance, Forthcoming. Available at SSRN: https://ssrn.com/abstract=2156623 or http://dx.doi.org/10.2139/ssrn.2156623
6 Harvey, Campbell R. and Liu, Yan and Zhu, Heqing, ...and the Cross-Section of Expected Returns (February 3, 2015). Available at SSRN: https://ssrn.com/abstract=2249314 or http://dx.doi.org/10.2139/ssrn.2249314
7 Johnston, M. (2014 July 17). A Visual History of Market Crash Predictions. Retrieved from URL.
8 Given the extreme nature of many of the forecasts, one could assume that at least some of the forecasters suffered from confirmation bias or overconfidence. These would serve to reduce the quality of their forecasts relative to an unbiased observer.
9 Grinold, Richard C., and Ronald N. Kahn. 2000. Active portfolio management: a quantitative approach for providing superior returns and controlling risk. New York: McGraw-Hill.
10 Timmermann, Allan G., Forecast Combinations (November 2005). CEPR Discussion Paper No. 5361. Available at SSRN: https://ssrn.com/abstract=878546
11 The formula is Information Ratio = Information Coefficient × $\sqrt{\text{Breadth}}$
12 Kahneman, Daniel and Amos Tversky. Judgment under Uncertainty: Heuristics and Biases (September 27, 1974). Science.

Econometric time series models: part 6

by Dr. Bernhard Pfaff

In brief

Since the 2nd quarter 2015 we have been presenting models for analyzing economic time series in Risk & Reward. These often complex processes make it possible to not only precisely describe time series but also forecast them. As can be seen, modern time series analysis is far more than a combination of different auto-regressive (AR) and moving-average (MA) processes which some readers might have encountered in their statistics lectures. Part 6 of our series deals with so-called structural time series models. Introduced at the end of the 1980s, they have proved a workable concept. This article also includes an explanation of Bayesian inference and an empirical example.

Part 6 of our series again deals with linear state space models. This time we present a further application, structural time series models. Then we show how unknown model parameters can be determined using a Bayesian inference model instead of a maximum likelihood model. As usual, this is followed by an empirical example, a forecast of real gross domestic product for Germany in 2017.

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Structural time series models

A classic method of describing a time series is the time series model according to Harvey (1991). This explains a time series by means of its components, for example a trend component (μ_t) and/or a season component (γ_t). There is also an error process ε_t, the so-called "irregular component":

$$(1) \quad y_t = \mu_t \circ \gamma_t \circ \varepsilon_t \text{ for } t = 1,\ldots,n.$$

The components can be linked by way of addition or multiplication. The model is then said to be additive or multiplicative.[1]

In the literature, equation (1) is also referred to as the basic structural model, or BSM. While explaining a time series with only two systematic components, it still offers a wide range of specification possibilities and is therefore very flexible.[2] This is particularly due to the fact that the systematic components can be both deterministic as well as stochastic.

With deterministic components, the BSM corresponds to a single equation model with a deterministic trend and a deterministic seasonal component, i.e. seasonal dummy variables. The unknown parameters can be estimated with the least squares method, assuming a constant trend parameter and a constant seasonal pattern. However, these assumptions are quite restrictive. Alternatively, the systematic components can be understood as latent – i.e. non-observable – random processes. In this case, the BSM can be understood as a state space model, with the Kalman filter being used to determine the parameter development.[3]

The trend component

Without seasonal components, the additive BSM is simplified to:

(2) $y_t = \mu_t + \varepsilon_t$

with white noise of an expected value of zero and variance σ_ε^2 assumed to be the irregular component ε_t.

The simplest modeling of a time series is the local level model. According to this model, the value of a time series is the sum of its prior period value and a normally distributed random effect, in other words: $\mu_t = \mu_{t-1} + \nu_t$ with $\nu_t \sim \mathcal{N}(0, \sigma_\nu^2)$. Such a time series follows a random walk with noise.[4]

The local level model can be extended by a (stochastic) trend component. The model is then said to be a local linear trend model that is written as $\mu_t = \mu_{t-1} + \beta_{t-1} + \nu_t$, with the trend component β following a random walk, in other words $\beta_t = \beta_{t-1} + \zeta_t$ with $\zeta_t \sim \mathcal{N}(0, \sigma_\zeta^2)$.[5]

In a next step, we integrate the trend component into our state space model

(3) $y_t = Z_t\alpha_t + \varepsilon_t$, observation equation
$\alpha_{t+1} = T_t\alpha_t + R_t\eta_t$, state equation

with $\varepsilon \sim \mathcal{N}(0, V)$ and $\eta \sim \mathcal{N}(0, W)$.[6]

The state variables for the trend components are $\alpha_t = [\mu_t \ \beta_t]'$. This results in the observation equation

(4) $$y_t = \begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}\mu_t \\ \beta_t\end{bmatrix} + \varepsilon_t$$

and the state equation

(5) $$\alpha_{t+1} = \begin{bmatrix}\mu_{t+1} \\ \beta_{t+1}\end{bmatrix} = \begin{bmatrix}1 & 1 \\ 0 & 1\end{bmatrix}\begin{bmatrix}\mu_t \\ \beta_t\end{bmatrix} + \begin{bmatrix}\nu_t \\ \zeta_t\end{bmatrix}$$

The seasonal component
Many time series, especially macroeconomic ones, show a seasonal pattern. This is the case with gross domestic product, for example, or with the unemployment rate. For the analysis of both the flows and the stocks, seasonally-adjusted values are used since it is usually the trends that matter. For this, the seasonal effects need to be quantified.

Many time series, especially macroeconomic ones, show a seasonal pattern.

This can be carried out purely deterministically at first, using multiple regression models with seasonal dummy variables, although this is based on the assumption of constant seasonality. Such models do not reveal whether the seasonal effects change over time. The seasonal effects can be modeled more flexibly using a state space model.

It is often assumed that seasonal effects even out over the year. For quarterly data with periodicity $s = 4$, this is equivalent to $\sum_{j=1}^{4} \gamma_j = 0$. This linear restriction implies that the estimate of $s - 1$ seasonal effects suffices; the last one can then be easily determined through subtraction. However, other identification restrictions need to be added to the state space model so that the effects can be classified to the particular quarters. For the state vector $\alpha_t = [\gamma_{1,t} \ \gamma_{2,t} \ \gamma_{3,t}]'$ and the obscuring error process $\omega_t \sim \mathcal{N}(0, \sigma_\omega^2)$ for the state equation, the restrictions can be formulated in the following way:

(6) $$\begin{aligned}\gamma_{1,t+1} &= -\gamma_{1,t} - \gamma_{2,t} - \gamma_{3,t} + \omega_t \\ \gamma_{2,t+1} &= \gamma_{1,t} \\ \gamma_{3,t+1} &= \gamma_{2,t}\end{aligned}$$

The second and third equations are identities. They simply describe the order of the quarters over time. As identities, they cannot be obscured by error effects. The first equation can be rewritten as $\gamma_{t+1} = -\gamma_t - \gamma_{t-1} - \gamma_{t-2} + \omega_t$. With $\sigma_\omega^2 = 0$, a deterministic seasonal component exists; the sum of the seasonal effects then always equals zero. The stochastic seasonal component, the case of interest to us, is derived with $\sigma_\omega^2 > 0$, with the sum of the seasonal effects fluctuating around the expected value of zero.

The BSM with trend component, seasonal component and error process
For $s = 4$ and $t = s - 1,\ldots,n$, the basic structural model with trend component, seasonal component and error process, $y_t = \mu_t + \gamma_t + \varepsilon_t$, can be written as state space model with the observation equation

(7) $$y_t = \begin{bmatrix}1 & 0 & 1 & 0 & 0\end{bmatrix}\begin{bmatrix}\mu_t \\ \beta_t \\ \gamma_t \\ \gamma_{t-1} \\ \gamma_{t-2}\end{bmatrix} + \varepsilon_t$$

and the state equation

(8) $$\alpha_t = \begin{bmatrix}\mu_{t+1} \\ \beta_{t+1} \\ \gamma_{t+1} \\ \gamma_t \\ \gamma_{t-1}\end{bmatrix} = \begin{bmatrix}1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & -1 & -1 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0\end{bmatrix}\begin{bmatrix}\mu_t \\ \beta_t \\ \gamma_t \\ \gamma_{t-1} \\ \gamma_{t-2}\end{bmatrix} + \begin{bmatrix}\nu_t \\ \zeta_t \\ \omega_t \\ 0 \\ 0\end{bmatrix}$$

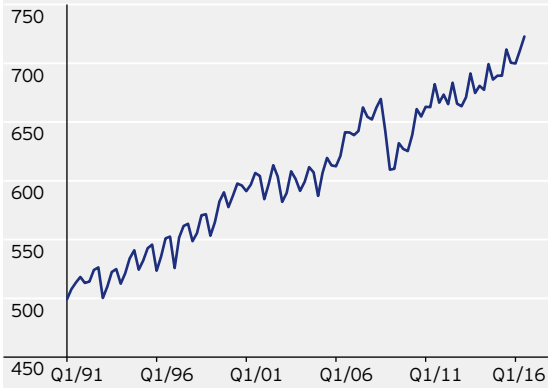
The state vector is $\alpha_t = [\mu_t \ \beta_t \ \gamma_t \ \gamma_{t-1} \ \gamma_{t-2}]'$.

Bayesian inference
In part 5 of this series, we solved a state space model with the Kalman filter and estimated the unknown variables using the maximum likelihood method. Use was made of numerical optimizations whose solutions can depend on the starting values. If, for example, the likelihood function has several local maximums, different estimates can be obtained for the model parameter, depending on the starting value.

This problem can be avoided with a Bayesian interpretation of state space models (see Durbin and Koopman (2012)). A-priori distributions are specified for the unknown model parameters. Of interest to us is the joint a-posteriori distribution of the state vectors

Figure 1
German GDP

EUR bn, in constant prices from 2010, non-seasonally adjusted



Source: Statistisches Bundesamt. Data as at Q3/2016.

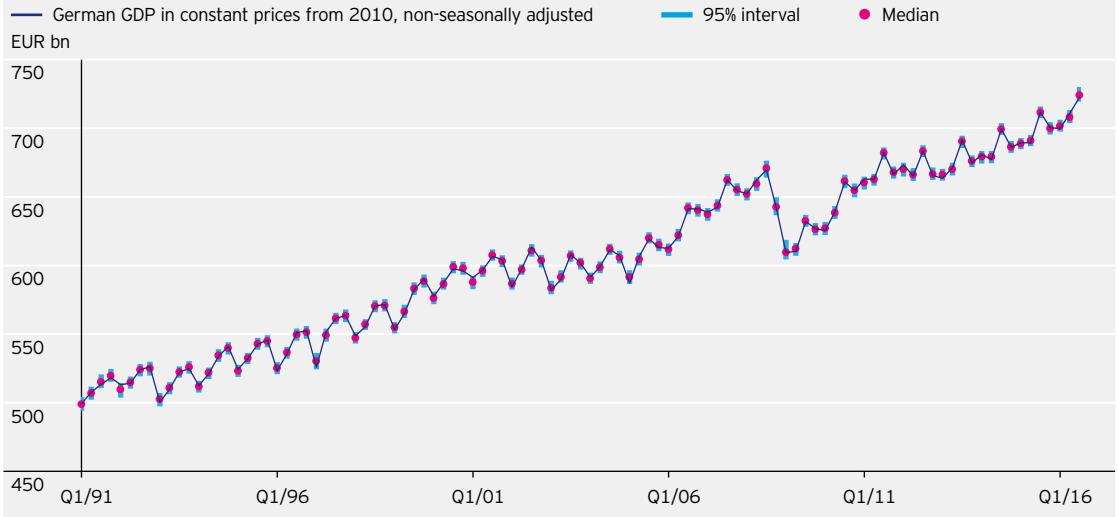
and model parameters. This is proportional to the product of the likelihood function and a-priori distribution:

$$(9)\quad p(\alpha,\varphi) \propto \prod_{t=1}^{n} p(y_t \mid \alpha_t, V) \times \prod_{t=1}^{n-1} p(\alpha_{t+1} \mid \alpha_t, W) \times p(\alpha_0) \times p(V) \times p(W)$$

with $\alpha = (\alpha_1,\ldots,\alpha_n)$ and $\psi = (V, W)$.

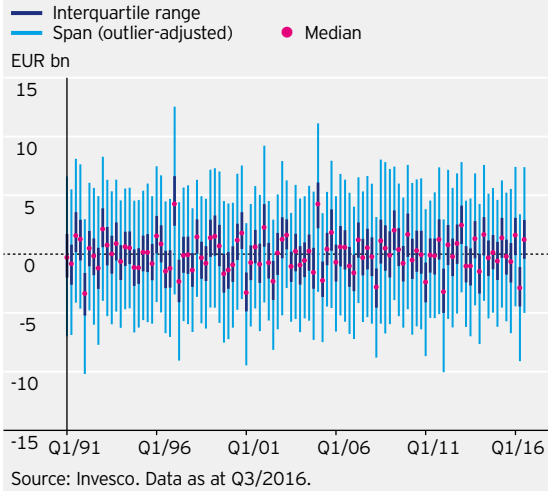
Because it is often not possible to evaluate the right side of equation 9 in a closed analytical form, we use a Markov chain Monte Carlo (MCMC) method. Based on the Kalman recursions, using known values of equation 9 it is possible to calculate the distributions of the state vectors, the forecast distributions of y_t as well as the hyperparameters V and W. In the literature, various methods are suggested for this, for example the so-called Gibbs sampler.[7]

Figure 2
A-posteriori distributions of the states



Source: Invesco, Statistisches Bundesamt. Data as at Q3/2016.

Figure 3
Boxplots of the smoothed returns



Source: Invesco. Data as at Q3/2016.

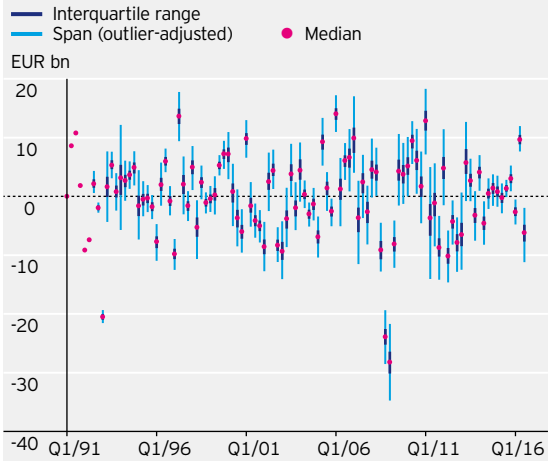
Empirical example

We now apply a BSM to Germany's non seasonally-adjusted, real gross domestic product from the first quarter 1991 to the third quarter 2016.[8]

Figure 1 shows this time series. A distinct trend can be noted as well as a clear seasonality. The decline during the financial crisis 2008/09 is also striking.

Below, a BSM with a linear trend component and a seasonal component (with $s = 4$) is used. The striking decline in GDP in the wake of the financial crisis could be recorded by an intervention variable, but the Bayesian method offers another possibility: instead of the normal distribution, an a-priori distribution with more distribution mass at the side can be used. For both the random effect in the local level model (ν_t) as well as the random effect in the trend component (ζ_t), we therefore use a Student's t distribution.

Figure 4
Boxplots of the forecast errors



Source: Invesco. Data as at Q3/2016.

Figure 5
History and forecast of the GDP

Source: Invesco, Statistisches Bundesamt. Data as at Q3/2016.

Figure 2 shows the a-posteriori distributions of the states. The model provides an altogether good explanation for the GDP development. The standard error of the estimate is some 3 billion euros; the coefficient of determination amounts to 0.998.

As a consequence, the distribution of the smoothed irregular component fluctuates strongly (figure 3).

Figure 4 shows the dynamic distribution of the one-step forecast errors. Their median values are naturally higher than the levels of the smoothed irregular component. The standard error of the one-step forecast is 7 billion euros. The relatively high forecast error during the financial crisis is striking, as are the marked fluctuations afterwards.

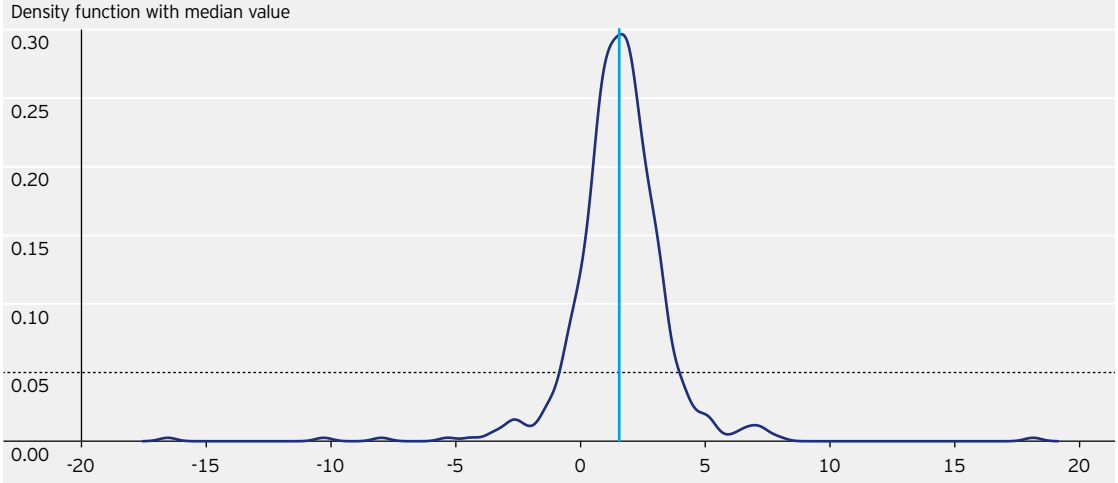
The forecast quality can be assessed using the Harvey's goodness of fit statistic. It is similar to the coefficient of determination, the only difference being that the basic structural model is a random walk with drift. The statistic can therefore also accept values smaller than one if the forecasts turn out to be worse than those of the basic structural model. For the one-step forecast errors, the statistic is 0.712.

Finally, we use the model for an ex-ante forecast of GDP in 2017. Figure 5 shows the dynamic development of the forecast distributions. Starting from the third quarter 2016, we forecast the next five quarters so that the whole of 2017 is included.

As can be seen, the longer the time horizon, the more uncertain the forecast becomes. This is partially due to the fact that we have assumed a Student's t-distribution for the random effect on the trend component.[9]

The median forecast for the fourth quarter 2016 amounts to 712.2 billion euros, which already implies a statistical overhang of 0.11 percentage points for 2017. As for every forecast quarter there is a distribution in the amount of the Markov chain length, the trend forecasts can be added together

Figure 6
Distribution of the forecasted growth rate



Source: Invesco. Data as at Q3/2016.

and placed in relation to the expected GDP of the year 2016. The result is a distribution of the forecast GDP growth rates in 2017 (figure 6). Their median – as a point estimation for the growth rate – is about 1.6%.

Numerous questions can be answered with the distribution thus derived, a typical example being "how great is the probability that growth in 2017 will be at least 1%?" The answer would be 67%. The probability of GDP contracting in 2017 would be 13%.

Numerous questions can be answered with the distribution thus derived.

Summary and outlook

In part 6 of our series, we have shown how structural time series models can be formulated as state space models and how the latent – non-observable – state vector can be analyzed with the Bayesian inference method. The method was illustrated using the example of a forecast of German gross domestic product.

Owing to the delay in publishing the GDP figures, the reading for the fourth quarter 2016 was still not available at the time the calculation was made. This problem was pragmatically solved by using the median of the forecast distribution. Alternatively, additional data with a higher frequency can be entered into the GDP forecast. This will be the subject of our next article in this series.

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Notes

1 Since a multiplicative model can be transformed into an additive linear model by taking the logarithm, we will only examine additive models from now on.
2 Of course other components can also be added, for example a cyclical component.
3 Cf. "Econometric time series models: Part 5", Risk & Reward, 3rd quarter 2016.
4 This simple specification already contains two special cases: (1) With $\sigma_\nu^2 = 0$, the time series becomes deterministic; in each period, constant ν_t is added. The LS estimator for the unknown position parameter is the arithmetic mean of y_t for $t = 1,...,T$. (2) With $\sigma_\varepsilon^2 = 0$, y_t becomes a pure random walk (i.e. without noise).
5 The local linear trend model also contains some special cases of interest: (1) If the variance of the trend is set at zero ($\sigma_\varepsilon^2 = 0$), a local level model with drift exists: $\mu_t = \mu_{t-1} + \beta + \nu_t$. (2) The variance of the level can also be set at zero ($\sigma_\nu^2 = 0$), so that only the slope varies stochastically. (3) If both variances amount to zero ($\sigma_\nu^2 = \sigma_\varepsilon^2 = 0$) , a deterministic linear trend model exists. (4) Instead of modeling the trend as a random walk, it can be modeled as a stable AR(1) process: $\beta_t = \rho\beta_{t-1} + \zeta_t$ with $0 < \rho < 1$. The damping factor ρ diminishes the effect of the prior period value.
6 Cf. "Econometric time series models: Part 5", Risk & Reward, 3rd quarter 2016.
7 See Carter and Kohn (1994), Frühwirth-Schnatter (1994), Jong and Shephard (1995) as well as Durbin and Koopman (2002), Reis, Salazar, and Gamerman (2006), etc.
8 All calculations were carried out using the free statistical programming environment R 3.3.2 (R Core Team (2016)) as well as the CRAN packages bsts (Scott (2016)) and xts (Ryan and Ulrich (2014)).
9 Alternatively, the trend components could be modeled as a stable AR(1) process with a damping factor, as already explained above.

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