Uncommon truths
A change of regime?

An analysis of volatility and correlation over the last one hundred years points to important regime changes. That warns against the blind use of historical covariance matrices when defining optimal asset allocations. Despite more range-bound behaviour in recent decades, cyclicality remains a feature (at least for volatility).

Judging by recent asset class performance, this doesn't seem like a year of deep recession: the S&P 500 recently set a new high and copper is at a two-year peak. These are assets that would normally be expected to lead the economy out of recession but, even so, that is quite extraordinary performance.

However, appearances can be deceptive. **Figure 1** suggests the ranking of US assets so far this year is broadly what one might expect during a recession, with defensive assets such as gold and government bonds leading the way and returns worsening as perceived riskiness increases (note that performance is measured up to end-September).

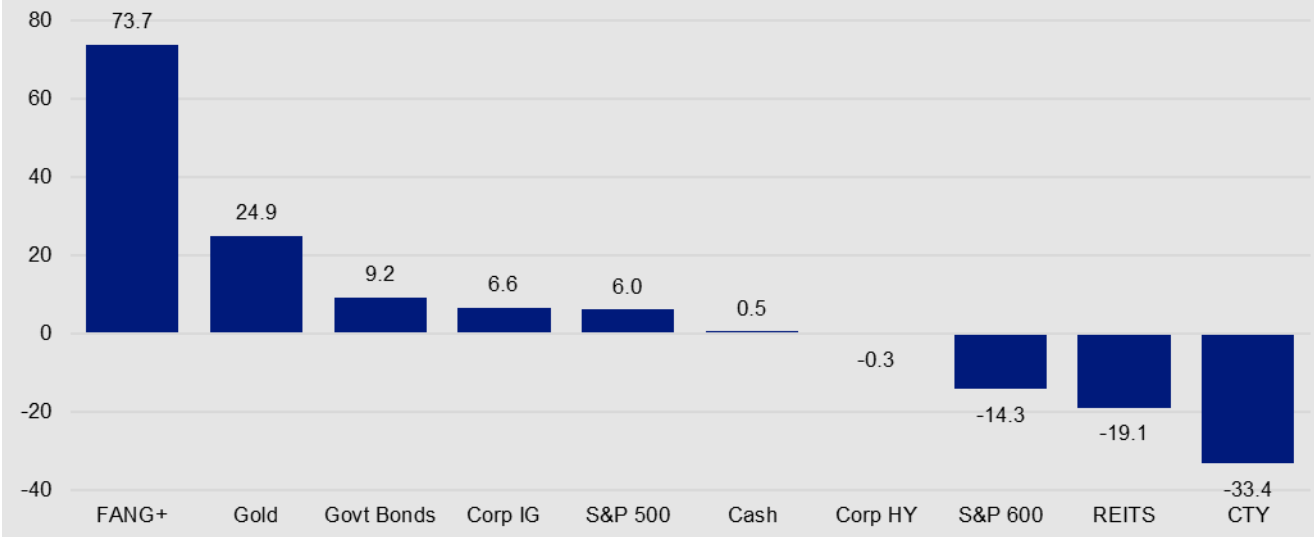
The one glaring exception among traditional assets is the S&P 500, which has produced a total return in line with investment grade credit, despite being one of the more volatile assets. The contrast with the S&P 600 is stark – that small-cap index has produced what we would expect from an equity index during a recession (as have major indices in other developed markets).

The answer to this riddle, we think, lies in the performance of a limited number of tech-related companies that appear to have benefitted from the pandemic (Apple and Netflix, say) and others that have withstood the recessionary pressures (Alphabet, Facebook and Twitter, for example). **Figure 1** shows the performance of the NYSE FANG Plus index, which is comprised of 10 tech-related stocks including those mentioned above. The excellent performance of a concentrated number of big stocks has enabled the S&P 500 to produce a non-recessionary performance during a year of recession.

That is little consolation for those of us holding a wider range of risk assets that have performed as one might expect during a year of recession. Luckily, recessions do not come very often and we would expect a reversal of the broad pattern seen in **Figure 1** as economies recover. Indeed, that is what has happened since markets bottomed in the early stages of the pandemic.

Of course, putting together a portfolio of assets isn't simply a question of asset returns. We also need to allow for volatility and cross asset correlations if we are to achieve an acceptable balance between risk and reward. Risk appetite varies across individuals but we all want efficiency (to achieve the highest possible returns consistent with our risk tolerance). This brings us to the main topic of this edition: an analysis of volatility and correlation regimes.

Figure 1 – US asset total returns in 2020 (% in USD, year to 30/9/20)



Based on monthly data from 31 December 2019 to 30 September 2020, using total return indices, except for gold which is based purely on movements in the spot price. All data is sourced from Refinitiv Datastream and the following indices were used: NYSE FANG Plus Index (FANG+); London Bullion Market spot price in US dollars per troy ounce (gold); BoAML US Treasury Index (Govt Bonds); BoAML US Corporate Index (Corp IG); S&P 500 Index, with total return version calculated by Refintiv Datastream (S&P 500); BoAML 0-3 Month Treasury Total Return Index (Cash); BoAML US High Yield Index (Corp HY); S&P Small Cap 600 Index (S&P 600); GPR General US Total Return Index (REITS); S&P GSCI Total Return Index (CTY). Past performance is no guarantee of future results.
Source: BoAML, GPR, NYSE, S&P, S&P GSCI, Refinitiv Datastream and Invesco

Within our asset allocation work, we forecast returns but have so far contented ourselves with using a historical covariance matrix when constructing efficient frontiers and seeking optimal allocations.

This combination of projected returns with a historical covariance matrix has always seemed unsatisfactory – if we are not willing to use historical returns, why should we put up with historical volatility and correlations? However, like many investors, we have continued to do so because doing otherwise is a daunting exercise, the benefits of which are not clear.

Well, we have decided to analyse whether forecasting the covariance matrix is both worthwhile and feasible. This document will not answer fully those questions but is a first step in that direction.

For the moment we are limiting ourselves to US assets because that gives the longest data histories (of just over one hundred years). This allows a first analysis of volatility and correlation regimes over a period that includes World War 2 (WW2), the Great Depression (GD), the Global Financial Crisis (GFC) and a period of high inflation (the 1970s/80s).

Figure 2 shows the standard deviation of real monthly asset returns measured over rolling five-year periods (we use CPI-adjusted indices because we assume investors aim to maximise the future purchasing power of their portfolios).

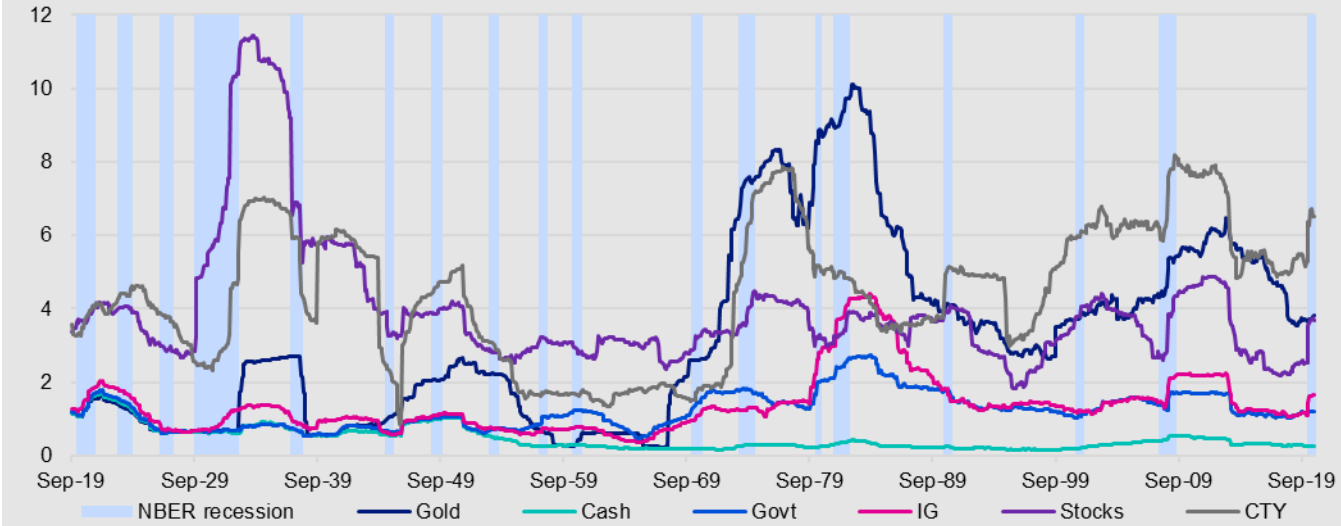
Clearly, volatility is volatile! Though it appears range-bound for many assets over long periods, there are occasional spikes. For risk assets, such as stocks and commodities, those peaks are often associated with recession (GD, GFC, 1970s oil shock, Covid pandemic, for example).

The situation is more complex for fixed income assets such as government debt and investment-grade credit (IG). Volatility has increased during some recessions, especially for IG, but the most noticeable increase in volatility came with the inflation of the 1970s/80s and the Fed policy response of the early 1980s.

Though the price of gold was largely fixed until the early 1970s, the use of CPI-adjusted returns gives some volatility in those early periods due to the variability of inflation. Since the US suspended the convertibility of the dollar into gold at a fixed price in 1971, it has sometimes been the most volatile asset, especially during the high inflation 1970s and 1980s. Even during recent low inflation decades, it has been one of the more volatile assets. Though the volatility of gold increased during the GFC and the subsequent Eurozone crisis, it has not so far reacted to the Covid recession. As might be expected, the volatility of gold seems to be correlated to that of US treasuries.

Cash return volatility appears likewise related to that of treasuries but at a much lower absolute level. Cash appears to be the most stable asset.

Figure 2 – Volatility of monthly inflation-adjusted US asset returns 1919-2020 (%)



Notes: Chart is based on monthly data from September 1919 to September 2020 and shows standard deviation of monthly inflation-adjusted returns over rolling five-year periods (inflation adjustment is done using US consumer price index). Calculated using: spot price of gold (Gold); Global Financial Data (GFD) US Treasury Bill total return index until December 2018 and then BoAML 0-3 Month Treasury Total Return Index (Cash); our own calculation of government bond total returns using 10-year treasury yield until January 1978 and then BoAML US Treasury Index (Govt); GFD US AAA Corporate Bond total return index until February 1976 and the BoAML US Corporate Index (IG); Reuters CRB total return index until November 1969 and then the S&P GSCI total return index for commodities (CTY) and our own calculation of total returns on US equities based Robert Shiller's US equity index and dividend data (Stocks). "NBER recession" shows periods identified by the US National Bureau of Economic Research as being recessionary (NBER has not identified the end date of the 2020 recession). Past performance is no guarantee of future results. Source: BoAML,Global Financial Data, Reuters CRB, S&P GSCI, Robert Shiller and Invesco

So, volatility can be explained in relatively simple terms: it is higher for commodities, stocks and gold, than for cash and bonds and it spikes during periods of recession and/or high inflation but there is usually some element of mean-reversion.

Despite that latter point, there have been important changes in volatility regimes at various moments. In particular, the volatility of commodities (including gold) appeared to move to a durably higher level after the early 1970s. The same can be said for both government and corporate bonds. This may be linked to the inflation of the 1970s/80s but it is interesting that volatility has not returned to pre-1970 norms, despite the conquest of inflation.

A simple analysis of correlation suggests matters are not so easy. In **Figure 3** we show a summary of five-year rolling correlations versus the other assets in the study (expressed as a simple average of the correlation with those other assets). What we lose in detail, we gain in simplicity.

The first point to note is that the range of correlations became narrower after WW2. Before that, cash, bonds and gold were markedly more correlated to other assets than were stocks and commodities (perhaps because there are more of the former group in the averages and they are all related to inflation).

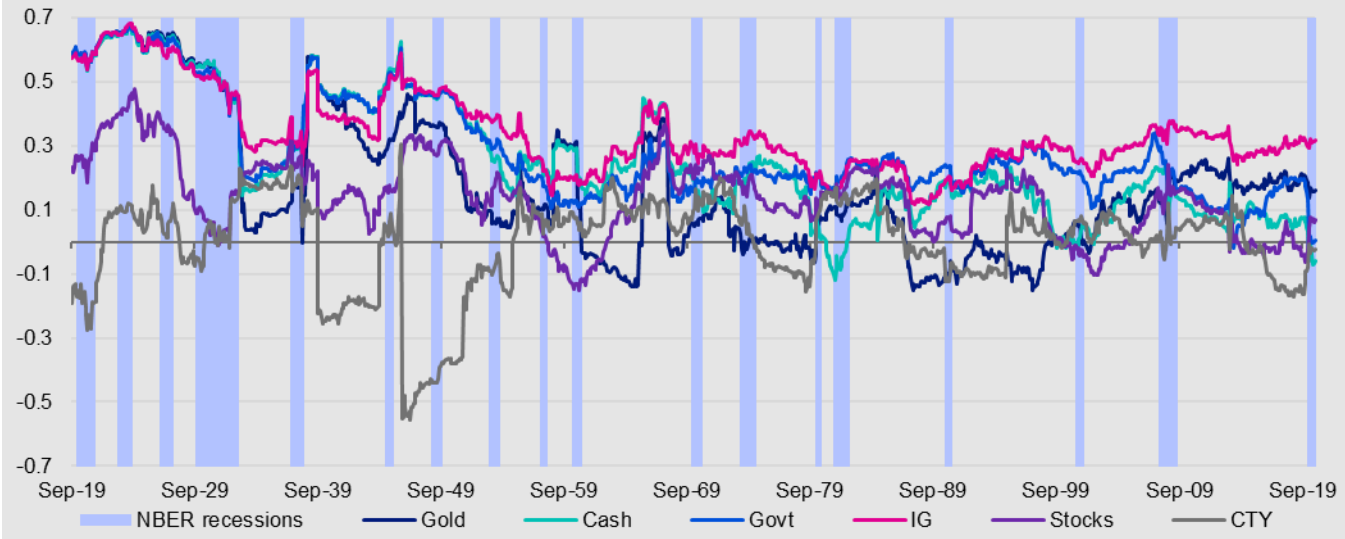
Second, since WW2, IG has been consistently among the most correlated assets (thus offering least diversification), while CTY has been consistently among the least correlated (most diversified). Gold has sometimes been among the least correlated assets but since the GFC has been among the most correlated. The correlation of cash has been variable but in recent decades it has been among the least correlated to other assets (and government debt has been less correlated than it was).

Finally, there is no obvious consistent effect during recessions: sometimes correlations rise, sometimes they fall and often go in different directions. This has been the case during 2020, with the correlation of cash and government bonds falling (thus offering more diversification) and that of stocks and commodities rising (offering less diversification).

In conclusion, volatilities and correlations vary over time and there have been examples of important regime changes that could have derailed asset allocation frameworks reliant on historical patterns. However, components of the covariance matrix have been more rangebound over recent decades, though volatility appears to be cyclical. So, the covariance matrix may be predictable, the question being whether it is worth the effort. Of which, more in future editions.

Unless stated otherwise, all data as of 23 October 2020

Figure 3 – Correlation across US assets 1919-2020 (average of correlation to other assets)



Notes: Chart is based on monthly data from September 1919 to September 2020 and shows the correlation of monthly inflation-adjusted returns over rolling five-year periods (inflation adjustment is done using US consumer price index). For each asset class, the chart shows the average correlation with all the other assets. Calculated using: spot price of gold (Gold); Global Financial Data (GFD) US Treasury Bill total return index until December 2018 and then BoAML 0-3 Month Treasury Total Return Index (Cash); our own calculation of government bond total returns using 10-year treasury yield until January 1978 and then BoAML US Treasury Index (Govt); GFD US AAA Corporate Bond total return index until February 1976 and the BoAML US Corporate Index (IG); Reuters CRB total return index until November 1969 and then the S&P GSCI total return index for commodities (CTY) and our own calculation of total returns on US equities based Robert Shiller's US equity index and dividend data (Stocks). "NBER recession" shows periods identified by the US National Bureau of Economic Research as being recessionary (NBER has not identified the end date of the 2020 recession). Past performance is no guarantee of future results.
Source: BoAML,Global Financial Data, Reuters CRB, S&P GSCI, Robert Shiller and Invesco

Figure 4 – Asset class total returns

Data as at 23/10/2020		Current	Total Return (USD, %)					Total Return (Local Currency, %)				
	Index	Level/RY	1w	1m	QTD	YTD	12m	1w	1m	QTD	YTD	12m
Equities												
World	MSCI	582	-0.2	5.6	3.0	4.9	12.6	-0.4	5.1	2.7	4.3	11.4
Emerging Markets	MSCI	1136	1.1	5.6	5.1	4.2	13.1	0.8	4.6	4.1	7.2	15.2
US	MSCI	3359	-0.6	7.4	3.3	10.8	19.7	-0.6	7.4	3.3	10.8	19.7
Europe	MSCI	1618	-0.3	2.3	1.5	-7.1	-1.2	-1.2	0.6	0.4	-10.5	-6.5
Europe ex-UK	MSCI	2049	-0.4	2.5	1.7	-1.6	4.4	-1.4	1.0	0.6	-6.8	-2.6
UK	MSCI	892	0.1	1.3	0.7	-22.9	-17.4	-0.8	-0.9	-0.2	-21.7	-18.4
Japan	MSCI	3377	1.0	0.2	0.9	0.5	5.5	0.4	-0.2	0.2	-3.0	1.8
Government Bonds												
World	BofA-ML	0.25	-0.1	0.2	0.1	6.9	6.4	-0.6	-0.4	-0.4	4.5	3.5
Emerging Markets	BBloom	4.39	-1.6	-0.3	0.1	0.3	3.3	-1.6	-0.3	0.1	0.3	3.3
US (10y)	Datastream	0.84	-0.9	-1.5	-1.5	13.1	11.7	-0.9	-1.5	-1.5	13.1	11.7
Europe	Bofa-ML	-0.16	0.4	1.9	1.4	10.0	9.5	-0.6	0.5	0.5	4.3	2.8
Europe ex-UK (EMU, 10y)	Datastream	-0.57	0.5	2.1	1.4	9.8	8.6	-0.5	0.7	0.5	4.1	2.0
UK (10y)	Datastream	0.33	-0.2	1.5	0.3	4.0	5.7	-1.0	-0.7	-0.6	5.7	4.4
Japan (10y)	Datastream	0.03	0.4	0.2	0.5	3.4	2.1	-0.2	-0.2	-0.1	-0.3	-1.4
IG Corporate Bonds												
Global	BofA-ML	1.64	0.0	0.4	0.6	6.5	7.7	-0.3	-0.1	0.2	5.2	6.0
Emerging Markets	BBloom	4.33	0.2	0.4	1.1	6.5	9.2	0.2	0.4	1.1	6.5	9.2
US	BofA-ML	2.09	-0.5	-0.4	0.1	6.7	7.9	-0.5	-0.4	0.1	6.7	7.9
Europe	BofA-ML	0.46	0.9	2.2	1.7	7.0	8.0	-0.1	0.8	0.8	1.5	1.4
UK	BofA-ML	1.79	0.5	2.5	1.2	3.4	6.8	-0.4	0.3	0.3	5.0	5.5
Japan	BofA-ML	0.49	0.5	0.4	0.7	3.6	3.3	-0.1	0.0	0.0	-0.1	-0.3
HY Corporate Bonds												
Global	BofA-ML	5.70	0.4	1.6	1.6	2.1	4.6	0.2	1.3	1.4	1.2	3.4
US	BofA-ML	5.75	0.2	1.8	1.6	1.3	3.5	0.2	1.8	1.6	1.3	3.5
Europe	BofA-ML	3.97	1.3	2.1	2.2	4.1	7.0	0.3	0.7	1.3	-1.3	0.5
Cash (Overnight LIBOR)												
US		0.08	0.0	0.0	0.0	0.4	0.7	0.0	0.0	0.0	0.4	0.7
Euro Area		-0.58	1.2	1.7	1.2	5.3	6.0	0.0	0.0	0.0	-0.5	-0.6
UK		0.05	1.0	2.5	1.0	-1.5	1.3	0.0	0.0	0.0	0.2	0.3
Japan		-0.11	0.7	0.6	0.7	3.7	3.7	0.0	0.0	0.0	-0.1	-0.1
Real Estate (REITs)												
Global	FTSE	1613	0.6	4.2	1.7	-18.1	-17.6	-0.3	2.8	0.7	-22.4	-22.6
Emerging Markets	FTSE	1863	0.7	1.2	1.1	-21.7	-11.8	-0.3	-0.2	0.1	-25.7	-17.2
US	FTSE	2580	0.7	7.2	2.9	-17.7	-20.2	0.7	7.2	2.9	-17.7	-20.2
Europe ex-UK	FTSE	3228	-0.5	2.0	-0.5	-11.9	-7.1	-1.5	0.6	-1.4	-16.4	-12.8
UK	FTSE	1180	4.4	7.2	4.6	-24.6	-17.9	3.5	4.9	3.7	-23.4	-18.9
Japan	FTSE	2414	0.9	-0.3	-0.8	-17.5	-19.9	0.3	-0.7	-1.4	-20.4	-22.7
Commodities												
All	GSCI	1753	-1.1	2.2	1.5	-32.4	-28.5	-	-	-	-	-
Energy	GSCI	227	-2.8	-0.8	-0.8	-54.4	-50.7	-	-	-	-	-
Industrial Metals	GSCI	1277	0.9	4.4	3.9	4.8	4.7	-	-	-	-	-
Precious Metals	GSCI	2202	0.1	2.5	1.0	23.1	25.1	-	-	-	-	-
Agricultural Goods	GSCI	363	2.6	11.0	8.2	4.3	8.5	-	-	-	-	-
Currencies (vs USD)*												
EUR		1.19	1.2	1.7	1.2	5.8	6.6	-	-	-	-	-
JPY		104.71	0.7	0.6	0.7	3.7	3.8	-	-	-	-	-
GBP		1.30	0.9	2.2	0.9	-1.5	1.2	-	-	-	-	-
CHF		1.11	1.2	2.2	1.8	7.0	9.5	-	-	-	-	-
CNY		6.69	0.2	1.9	1.6	4.1	5.7	-	-	-	-	-

Notes: *The currency section is organised so that in all cases the numbers show the movement in the mentioned currency versus USD (+ve indicates appreciation, -ve indicates depreciation). Past performance is no guarantee of future results. Please see appendix for definitions, methodology and disclaimers.
Source: Refinitiv Datastream and Invesco

Figure 5 – World equity sector total returns relative to market (%)

Data as at 23/10/2020	Global				
	1w	1m	QTD	YTD	12m
Energy	**-0.4**	**-6.1**	**-2.9**	**-34.1**	**-34.2**
Basic Materials	**0.7**	**-0.6**	**0.7**	**2.2**	**3.9**
Basic Resources	1.1	0.2	1.5	3.1	6.9
Chemicals	0.1	-1.6	-0.4	1.2	0.1
Industrials	**-0.1**	**0.0**	**0.3**	**-2.1**	**-2.7**
Construction & Materials	-0.1	-0.1	0.3	-4.4	-5.5
Industrial Goods & Services	-0.1	0.1	0.2	-1.7	-2.3
Consumer Discretionary	**0.3**	**1.5**	**0.7**	**11.0**	**9.7**
Automobiles & Parts	1.0	2.7	1.0	15.8	11.7
Media	0.0	1.6	0.8	-2.9	-1.5
Retailers	-0.8	2.2	0.2	30.4	28.7
Travel & Leisure	2.8	1.0	1.3	-17.4	-18.1
Consumer Products & Services	0.5	-0.1	1.0	9.3	8.3
Consumer Staples	**-0.7**	**-2.8**	**-2.1**	**-3.9**	**-6.8**
Food, Beverage & Tobacco	-0.2	-2.4	-1.9	-7.6	-9.8
Personal Care, Drug & Grocery Stores	-1.4	-3.6	-2.4	3.2	-1.1
Healthcare	**-0.9**	**-2.4**	**-2.3**	**6.9**	**9.1**
Financials	**1.9**	**1.5**	**2.0**	**-19.5**	**-19.3**
Banks	3.0	2.6	3.5	-26.8	-26.9
Financial Services	0.6	2.2	1.6	-9.2	-7.6
Insurance	1.5	-1.2	-0.2	-15.9	-16.6
Real Estate	**-0.1**	**-2.2**	**-2.2**	**-14.8**	**-17.3**
Technology	**-0.7**	**2.7**	**1.1**	**30.0**	**35.5**
Telecommunications	**0.0**	**-1.9**	**-1.5**	**-3.7**	**-7.2**
Utilities	**0.6**	**2.4**	**2.5**	**-2.7**	**-5.8**

Notes: Returns shown are for Datastream sector indices versus the total market index. Past performance is no guarantee of future results.
Source: Refinitiv Datastream and Invesco

Figure 6a – US factor index total returns (%)

Data as at 23/10/2020	Absolute					Relative to Market				
	1w	1m	QTD	YTD	12m	1w	1m	QTD	YTD	12m
Growth	-0.1	8.1	4.9	15.3	25.6	0.4	0.9	1.7	5.9	6.8
Low volatility	-0.6	6.8	3.4	12.0	13.4	-0.1	-0.3	0.3	2.8	-3.5
Price momentum	-1.0	7.9	3.7	11.5	16.4	-0.5	0.7	0.5	2.4	-1.0
Quality	-0.6	7.7	4.2	2.2	11.5	-0.1	0.5	1.1	-6.2	-5.2
Size	2.5	10.1	7.7	-13.6	-7.5	3.0	2.7	4.4	-20.6	-21.3
Value	2.7	9.7	6.9	-18.7	-12.0	3.2	2.3	3.7	-25.3	-25.1
Market	-0.5	7.2	3.1	8.9	17.5					
Market - Equal-Weighted	0.7	8.9	5.5	0.5	7.2					

Notes: All indices are subsets of the S&P 500 index, they are rebalanced monthly, use data in US dollars and are equal-weighted. Growth includes stocks in the top third based on both their 5-year sales per share trend and their internal growth rate (the product of the 5-year average return on equity and the retention ratio); Low volatility includes stocks in the bottom quintile based on the standard deviation of their daily returns in the previous three months; Price momentum includes stocks in the top quintile based on their performance in the previous 12 months; Quality includes stocks in the top third based on both their return on invested capital and their EBIT to EV ratio (earnings before interest and taxes to enterprise value); Size includes stocks in the bottom quintile based on their market value in US dollars. Value includes stocks in the bottom quintile based on their price to book value ratios. The market represents the S&P 500 index. Past performance is no guarantee of future results.
Source: Refinitiv Datastream and Invesco

Figure 6b – European factor index total returns relative to market (%)

Data as at 23/10/2020	Absolute					Relative to Market				
	1w	1m	QTD	YTD	12m	1w	1m	QTD	YTD	12m
Growth	-1.0	3.8	1.9	10.4	22.7	0.4	2.8	1.4	23.7	30.2
Low volatility	-1.3	0.1	-0.1	-3.2	-0.3	0.0	-0.8	-0.5	8.4	5.8
Price momentum	-3.8	1.9	0.3	8.3	17.7	-2.5	1.0	-0.2	21.4	24.9
Quality	-0.9	3.0	2.0	-8.2	-0.4	0.5	2.0	1.5	2.8	5.7
Size	-0.7	4.2	1.9	-13.0	-4.5	0.7	3.3	1.4	-2.6	1.4
Value	1.8	6.4	4.4	-28.2	-25.2	3.2	5.5	3.9	-19.5	-20.6
Market	-1.3	0.9	0.5	-10.7	-5.8					
Market - Equal-Weighted	-0.9	2.8	1.6	-9.8	-3.8					

Notes: All indices are subsets of the STOXX 600 index, they are rebalanced monthly, use data in euros and are equal-weighted. Growth includes stocks in the top third based on both their 5-year sales per share trend and their internal growth rate (the product of the 5-year average return on equity and the retention ratio); Low volatility includes stocks in the bottom quintile based on the standard deviation of their daily returns in the previous three months; Price momentum includes stocks in the top quintile based on their performance in the previous 12 months; Quality includes stocks in the top third based on both their return on invested capital and their EBIT to EV ratio (earnings before interest and taxes to enterprise value); Size includes stocks in the bottom quintile based on their market value in euros; Value includes stocks in the bottom quintile based on their price to book value ratios. The market represents the STOXX 600 index. Past performance is no guarantee of future results.
Source: Refinitiv Datastream and Invesco

Figure 7 – Model asset allocation

	Neutral	Policy Range		Allocation	Position vs Neutral	Hedged	Currency
Cash	**5%**	**0-10%**		**10%**			
Cash	2.5%			10%			
Gold	2.5%			0%			
Bonds	**45%**	**10-80%**	↓	**45%**			
Government	30%	10-50%	↓	15%			
US	10%		↓	4%			
Europe ex-UK (Eurozone)	8%		↑	2%			
UK	2%		↓	0%			
Japan	8%			5%			
Emerging Markets	2%			4%			
Corporate IG	10%	0-20%		20%			
US Dollar	5%		↓	5%			
Euro	2%		↑	3%			
Sterling	1%			4%			
Japanese Yen	1%		↑	4%			
Emerging Markets	1%		↑	4%			
Corporate HY	5%	0-10%	↑	10%			
US Dollar	4%		↑	8%			
Euro	1%		↑	2%			
Equities	**40%**	**20-60%**	↑	**30%**			
US	24%			14%			
Europe ex-UK	6%		↑	5%			
UK	3%			3%			
Japan	3%		↑	6%			
Emerging Markets	4%		↓	2%			
Real Estate	**8%**	**0-16%**	↑	**15%**			
US	2%			2%			
Europe ex-UK	2%		↑	4%			
UK	1%		↑	3%			
Japan	2%		↓	4%			
Emerging Markets	1%		↓	2%			
Commodities	**2%**	**0-4%**	↓	**0%**			
Energy	1%		↓	0%			
Industrial Metals	0.3%			0%			
Precious Metals	0.3%			0%			
Agriculture	0.3%		↓	0%			
Total	**100%**			**100%**			

Currency Exposure (including effect of hedging)							
USD	49%		↓	38%			
EUR	20%		↑	18%			
GBP	7%		↓	11%			
JPY	15%		↑	21%			
EM	8%		↓	12%			
Total	**100%**			**100%**			

Notes: This is a theoretical portfolio and is for illustrative purposes only. See the latest The Big Picture document for more details. It does not represent an actual portfolio and is not a recommendation of any investment or trading strategy. Arrows indicate the direction of the most recent changes.
Source: Invesco

Figure 8 – Model allocation for global sectors

	Neutral	Invesco	Preferred Region
Energy	**6.0%**	**Neutral**	**US**
Basic Materials	**4.1%**	**Neutral**	**Europe**
Basic Resources	2.2%	Underweight	Europe
Chemicals	1.9%	Overweight	US
Industrials	**12.6%**	**Underweight**	**US**
Construction & Materials	1.6%	Neutral ↑	Europe
Industrial Goods & Services	11.1%	Overweight ↑	US
Consumer Discretionary	**16.3%**	**Underweight**	**Japan**
Automobiles & Parts	2.3%	Underweight	Japan
Media	1.3%	Underweight	US
Retailers	6.9%	Neutral	EM
Travel & Leisure	2.0%	Underweight	Japan
Consumer Products & Services	3.9%	Neutral	Japan
Consumer Staples	**7.0%**	**Overweight**	**Europe**
Food, Beverage & Tobacco	4.5%	Overweight	Europe
Personal Care, Drug & Grocery Stores	2.5%	Underweight ↓	US
Healthcare	**10.9%**	**Neutral**	**Europe**
Financials	**12.8%**	**Neutral**	**EM**
Banks	5.8%	Neutral ↓	EM
Financial Services	3.8%	Overweight ↑	US
Insurance	3.2%	Underweight	Japan
Real Estate	**3.7%**	**Overweight**	**Europe**
Technology	**18.9%**	**Overweight**	**US**
Telecommunications	**4.2%**	**Neutral**	**US**
Utilities	**3.5%**	**Neutral**	**Europe**

Notes: These are theoretical allocations which are for illustrative purposes only. They do not represent an actual portfolio and are not a recommendation of any investment or trading strategy. See the latest Strategic Sector Selector for more details.
Source: Refinitiv Datastream and Invesco

Appendix

Methodology for asset allocation, expected returns and optimal portfolios

Portfolio construction process

The optimal portfolios are theoretical and not real. We use optimisation processes to guide our allocations around "neutral" and within prescribed policy ranges based on our estimations of expected returns and using historical covariance information. This guides the allocation to global asset groups (equities, government bonds etc.), which is the most important level of decision. For the purposes of this document the optimal portfolios are constructed with a one-year horizon.

Which asset classes?

We look for investibility, size and liquidity. We have chosen to include: equities, bonds (government, corporate investment grade and corporate high-yield), REITs to represent real estate, commodities and cash (all across a range of geographies). We use cross-asset correlations to determine which decisions are the most important.

Neutral allocations and policy ranges

We use market capitalisation in USD for major benchmark indices to calculate neutral allocations. For commodities, we use industry estimates for total ETP market cap + assets under management in hedge funds + direct investments. We use an arbitrary 5% for the combination of cash and gold. We impose diversification by using policy ranges for each asset category (the range is usually symmetric around neutral).

Expected/projected returns

The process for estimating expected returns is based upon yield (except commodities, of course). After analysing how yields vary with the economic cycle, and where they are situated within historical ranges, we forecast the direction and amplitude of moves over the next year. Cash returns are calculated assuming a straight-line move in short term rates towards our targets (with, of course, no capital gain or loss). Bond returns assume a straight-line progression in yields, with capital gains/losses predicated upon constant maturity (effectively supposing constant turnover to achieve that). Forecasts of corporate investment-grade and high-yield spreads are based upon our view of the economic cycle (as are forecasts of credit losses). Coupon payments are added to give total returns. Equity and REIT returns are based on dividend growth assumptions. We calculate total returns by applying those growth assumptions and adding the forecast dividend yield. No such metrics exist for commodities; therefore, we base our projections on US CPI-adjusted real prices relative to their long-term averages and views on the economic cycle. All expected returns are first calculated in local currency and then, where necessary, converted into other currency bases using our exchange rate forecasts.

Optimising the portfolio

Using a covariance matrix based on monthly local currency total returns for the last 5 years and we run an optimisation process that maximises the Sharpe Ratio. Another version maximises Return subject to volatility not exceeding that of our Neutral Portfolio. The optimiser is based on the Markowitz model.

Currency hedging

We adopt a cautious approach when it comes to currency hedging as currency movements are notoriously difficult to accurately predict and sometimes hedging can be costly. Also, some of our asset allocation choices are based on currency forecasts. We use an amalgam of central bank rate forecasts, policy expectations and real exchange rates relative to their historical averages to predict the direction and amplitude of currency moves.

Definitions of data and benchmarks for Figure 4

Sources: we source data from Datastream unless otherwise indicated.

Cash: returns are based on a proprietary index calculated using the Intercontinental Exchange Benchmark Administration overnight LIBOR (London Interbank Offer Rate). The global rate is the average of the euro, British pound, US dollar and Japanese yen rates. The series started on 1st January 2001 with a value of 100.

Gold: London bullion market spot price in USD/troy ounce.

Government bonds: Current levels, yields and total returns use Datastream benchmark 10-year yields for the US, Eurozone, Japan and the UK, and the Bank of America Merrill Lynch government bond total return index for the World and Europe. The emerging markets yields and returns are based on the Barclays Bloomberg emerging markets sovereign US dollar bond index.

Corporate investment grade (IG) bonds: Bank of America Merrill Lynch investment grade corporate bond total return indices, except for in emerging markets where we use the Barclays Bloomberg emerging markets corporate US dollar bond index.

Corporate high yield (HY) bonds: Bank of America Merrill Lynch high yield total return indices

Equities: We use MSCI benchmark gross total return indices for all regions.

Commodities: Goldman Sachs Commodity total return indices

Real estate: FTSE EPRA/NAREIT total return indices

Currencies: Global Trade Information Services spot rates

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