UBS

Global Research

March 2017

What's driving correlation?

UBS London Quantitative Conference 2017

David Jessop
Analyst
Tel: +44 20 7567 9882
david.jessop@ubs.com

Nick Baltas
Analyst
Tel: +44 20 7568 3072
nick.baltas@ubs.com

Claire Jones
Analyst
Tel: +44 20 7568 1873
claire-c.jones@ubs.com

Josie Gerken
Analyst
Tel: +44 20 7568 3560
josephine.gerken@ubs.com

Paul Winter
Analyst
Tel: +61 2 93 242 080
paul-j.winter@ubs.com

Desi Ivanova
Analyst
Tel: +44 20 7568
desi.asdfasf@ubs.com

Correlation – some questions

- Measuring (and forecasting) correlations is an important problem
- Over the next few slides we show a few long term correlation series; we will focus in this talk on the bond / equity correlation story

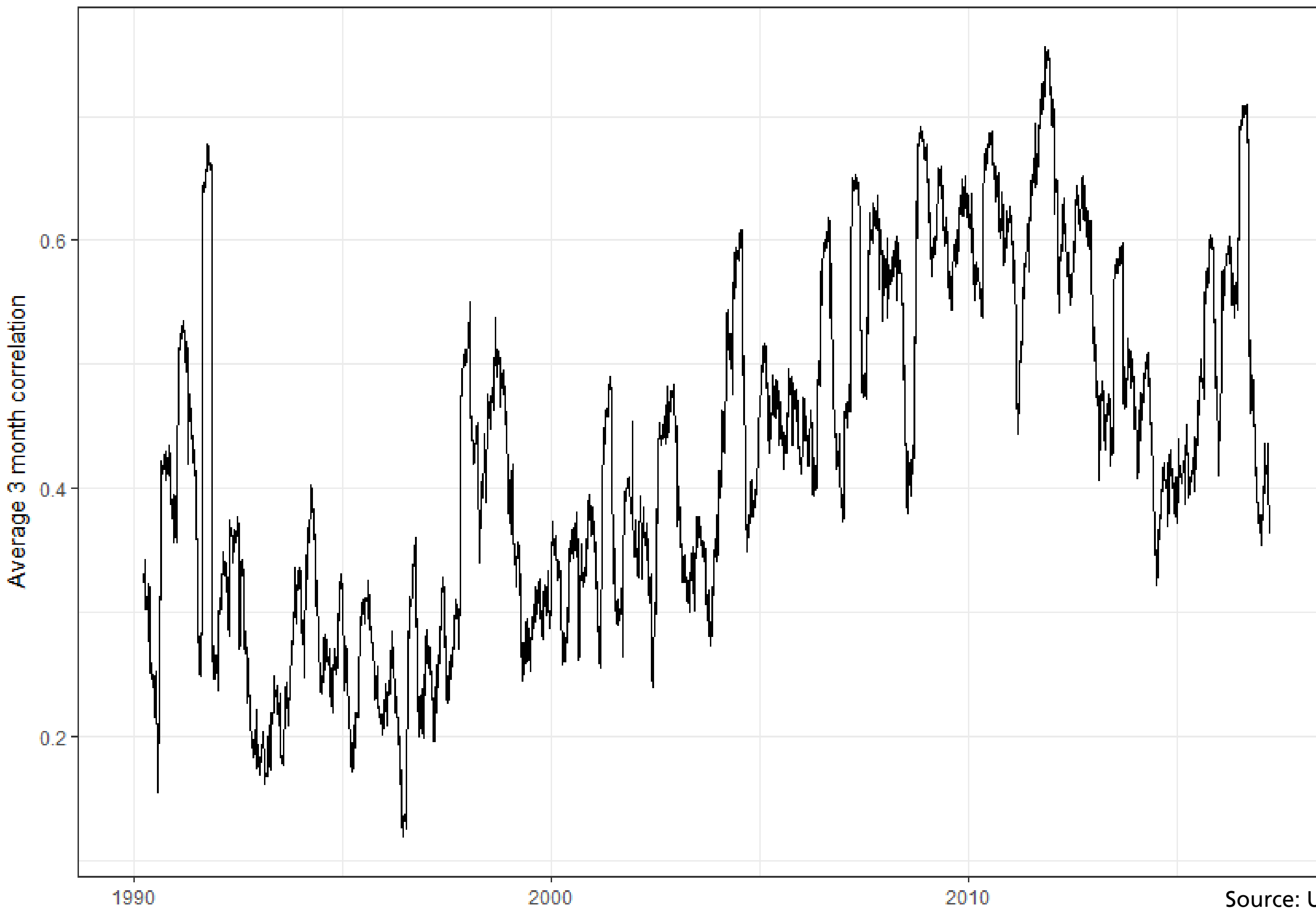
Correlations between equity market have increased

Average pairwise correlation between MSCI World countries – peaked in 2009 but still remains historically high

Source: UBS

Correlations between equity market have increased

- And we see the same with shorter term data

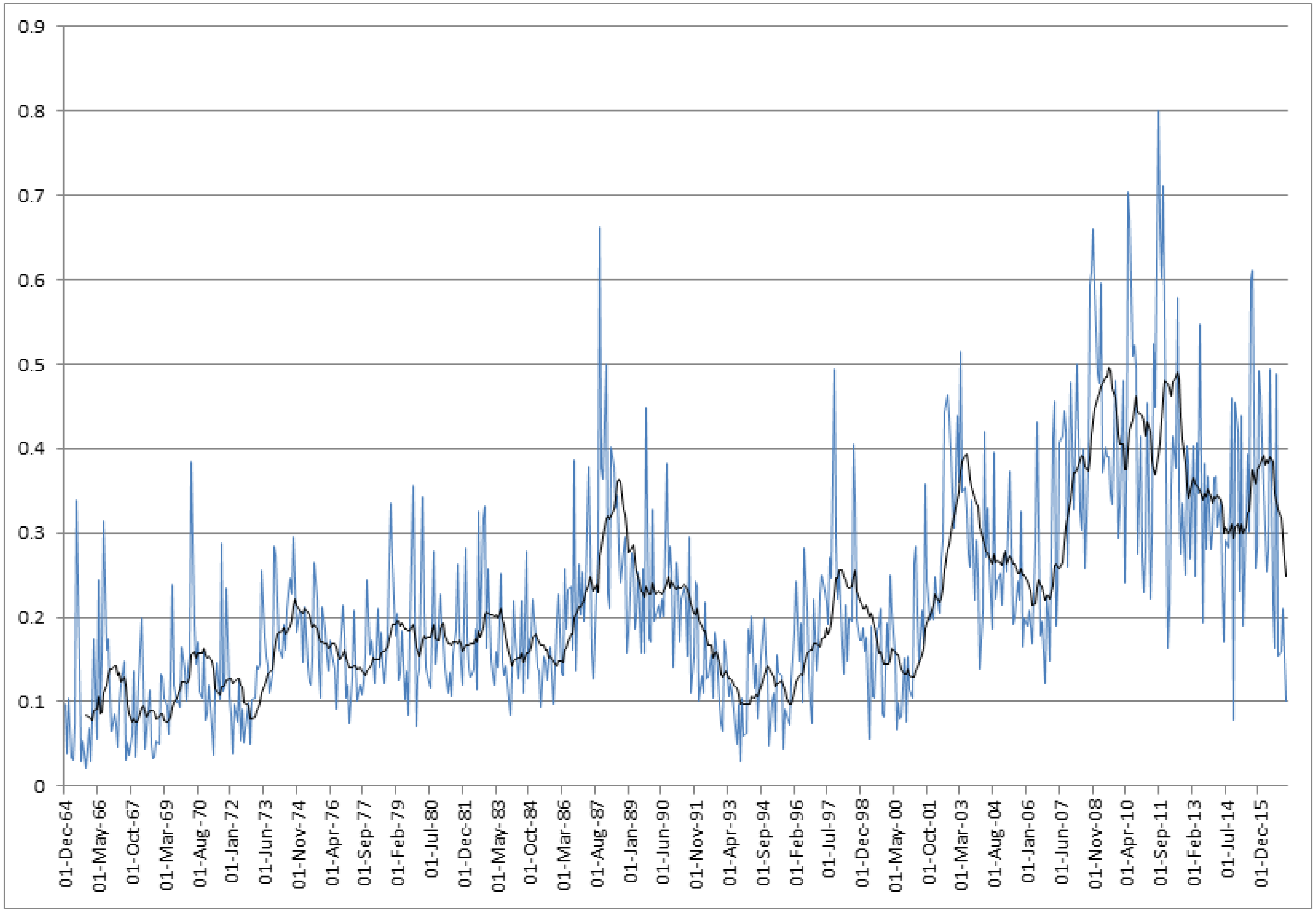


Source: UBS

UBS

Average correlation within US equities

- Correlation rose significantly over the financial crisis – is the fall back to 0.1 a "change of regime"?

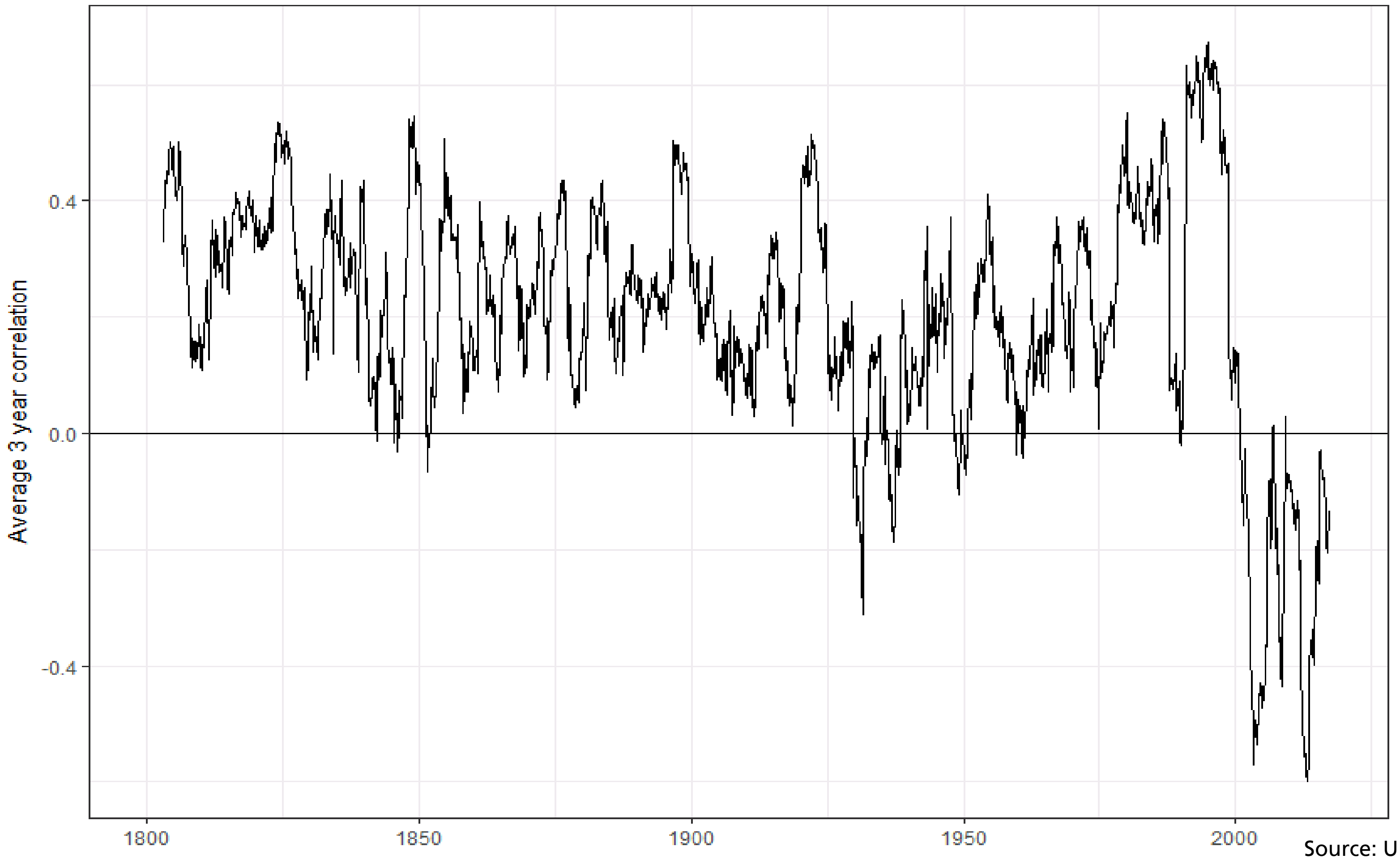


Source: UBS

UBS

Bond and equity correlation

- Chart shows correlation between bonds and equities (averaged across UK and US) from 1800. This century's negative correlation is unprecedented.

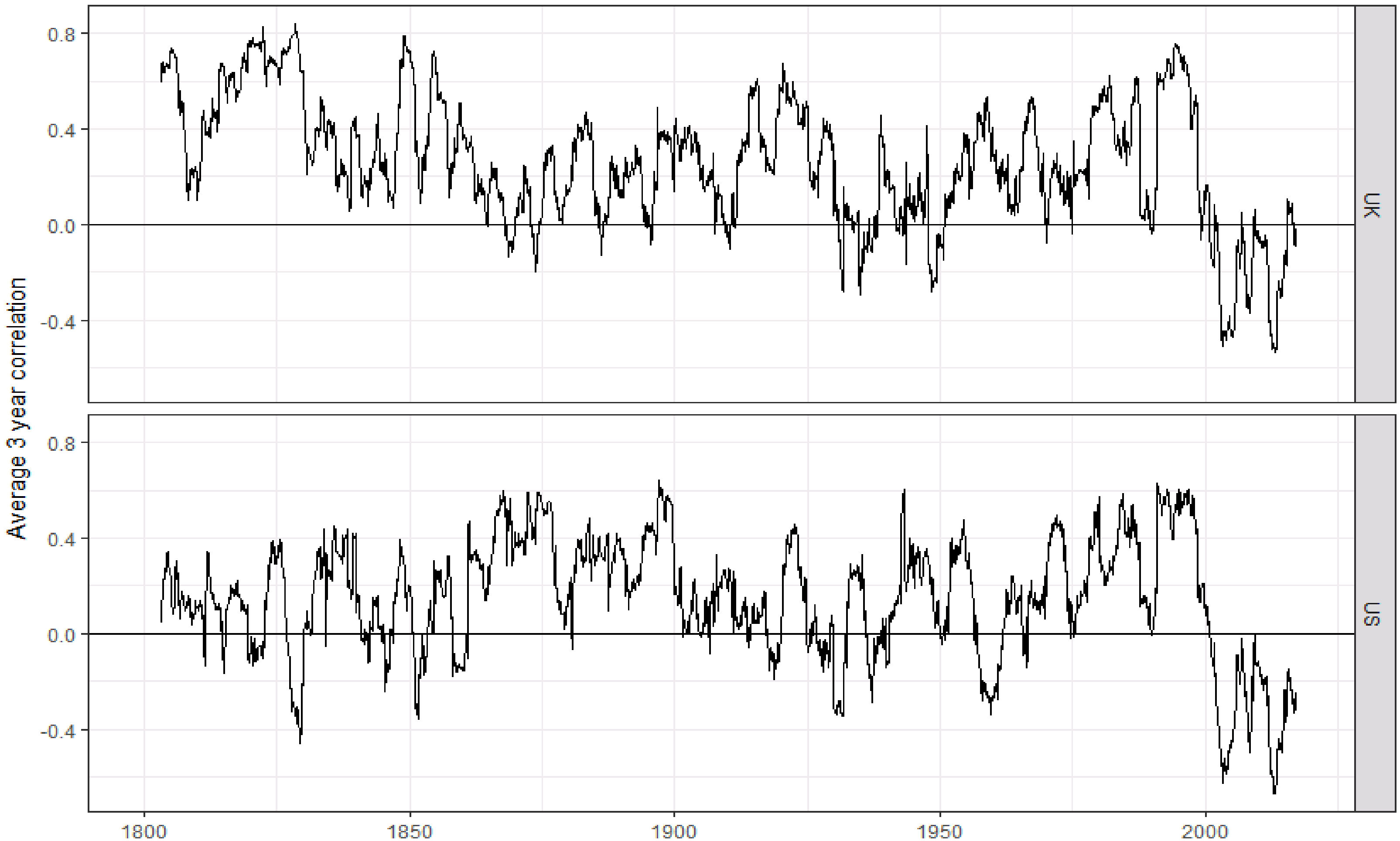


Source: UBS

UBS

Bond and equity correlation

- Separating the UK and US, the US goes negative more often.

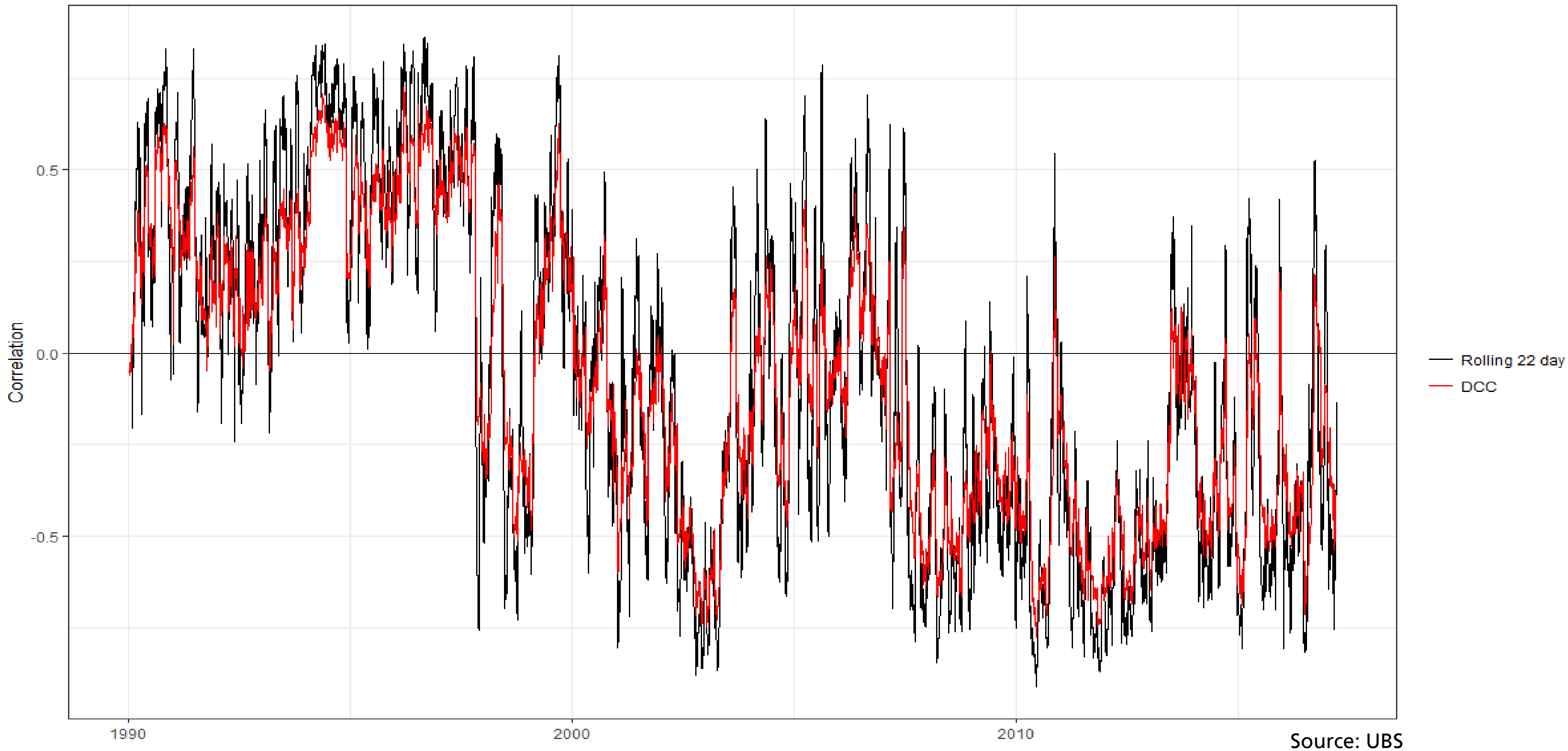


Source: UBS

UBS

US Bond vs Equity – shorter term

- Chart shows daily rolling correlation (black) and the correlation estimated from a GARCH-DCC model (red). We see the same change of sign around 2000.



Source: UBS

UBS

Section 1

Bonds vs equities

Bond vs equity correlation

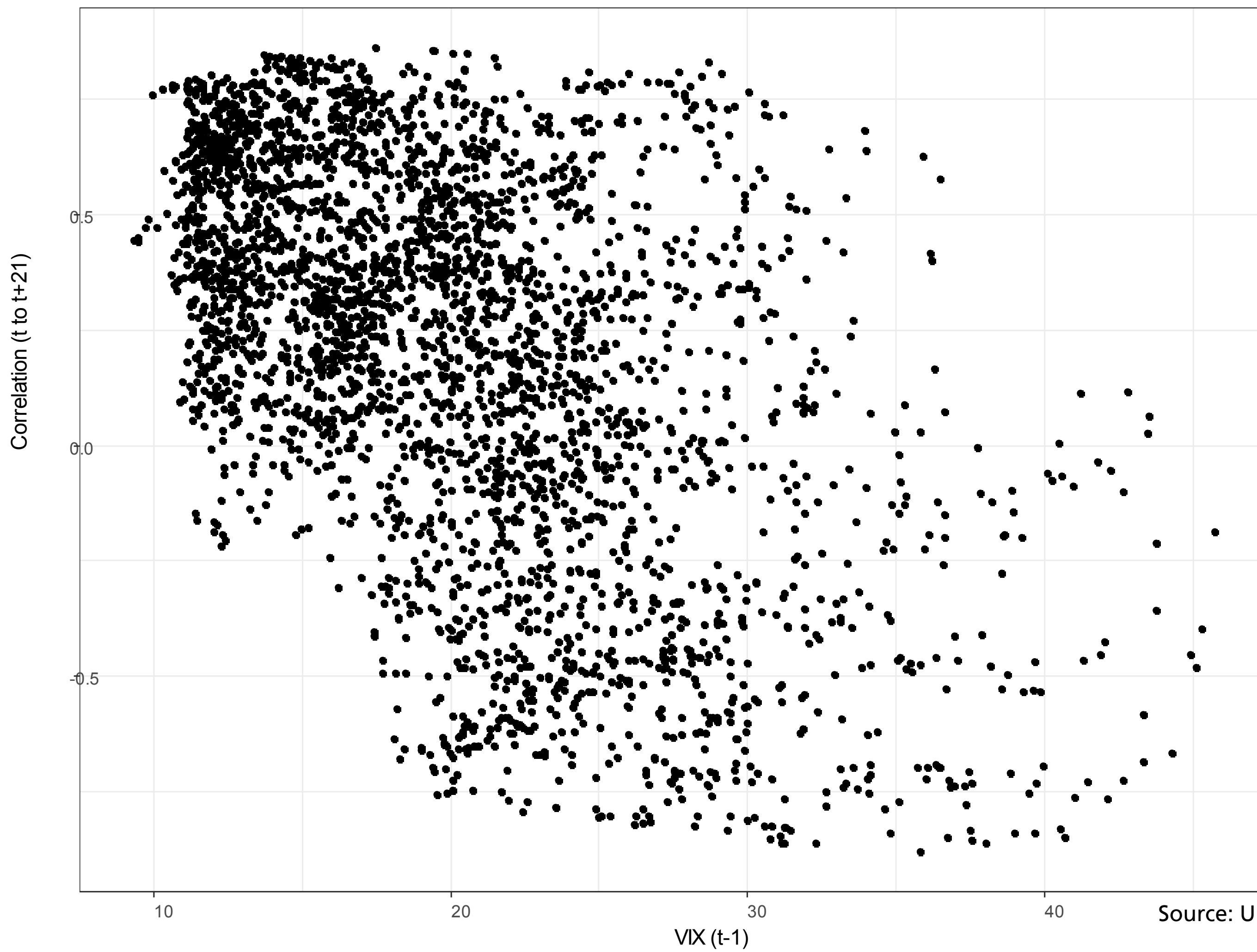
- What drives the changing nature of bond vs. equity correlation?
- Various academic papers have looked into this. The suggested drivers include
  - Inflation (expected, unexpected, uncertainty)
  - Volatility (VIX)
  - Recessions
  - Real interest rates
- We will investigate these different macroeconomic effects.

Volatility

- The effect of stock implied volatility on the stock-bond correlation was investigated by Connolly et al (2005 & 2007). They suggest "higher stock market uncertainty may be associated with more frequent revisions in investors' assessment of stock risk and the relative attractiveness of stocks vs. bonds. If so, then during times of higher stock market uncertainty it seem plausible that a temporary negative stock-bond return correlation is more likely to be observed."
- Their data goes from 1986-2000 (or to 2002 in the later paper), so ending just as the structural break in correlations occurs. Our daily data is from 1990 – 2017.

VIX and Correlation

- Chart shows data from 1990 – 2002 (as in the later paper) – higher VIX apparently leads to lower correlation.
- This done with 22 day rolling correlation; the picture with the DCC correlation is the same.

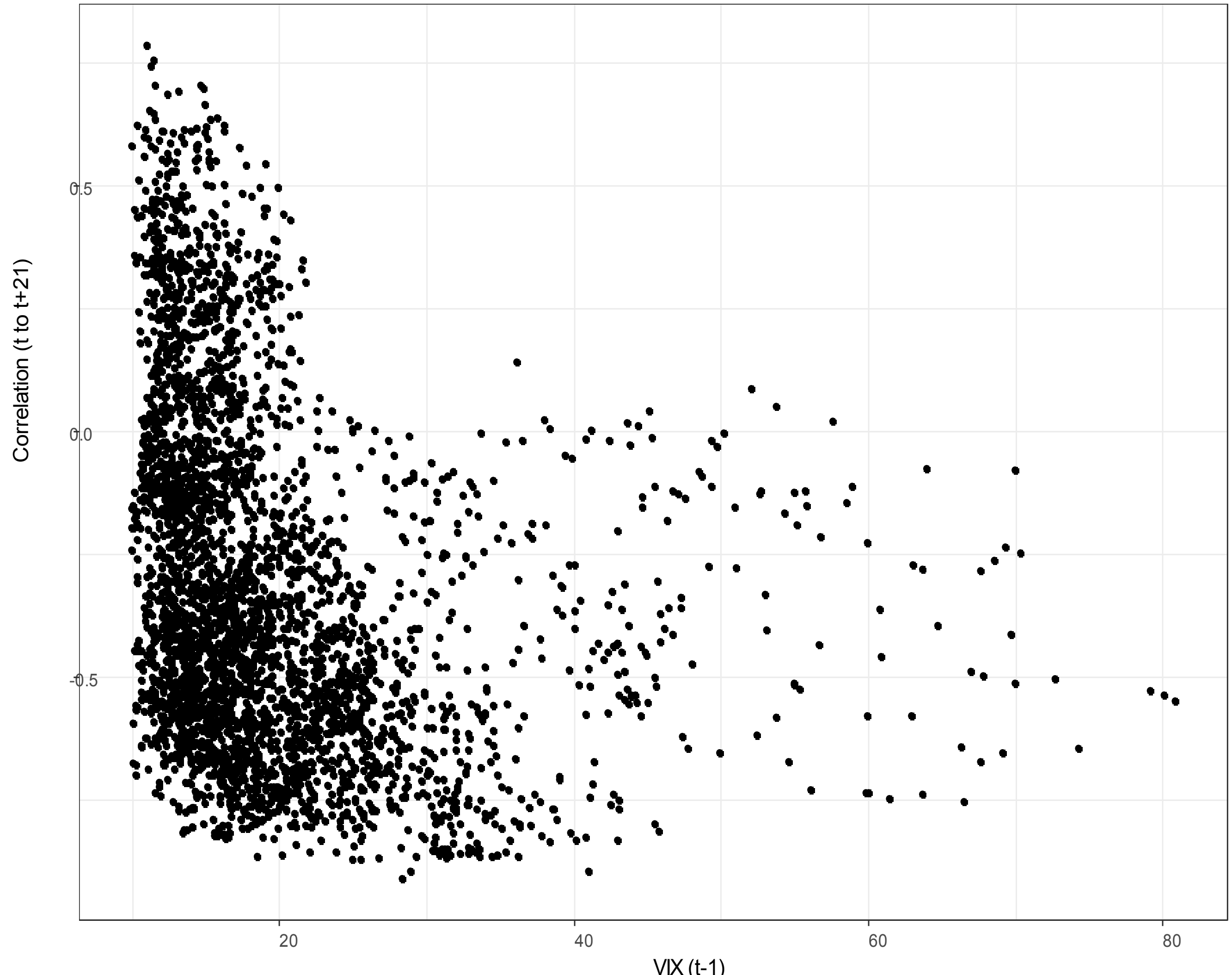


Source: UBS

UBS

VIX and Correlation

- Chart shows data from 2003 to date.
- The picture is similar but a little less convincing.



Source: UBS

UBS

Modelling the interaction

- The next test was to fit the following regression model
- $B_t = a_0 + (a_1 + a_2 \ln(VIX_{t-1}))S_t + \epsilon_t$
- where B_t and S_t are daily returns and ln ($VIX_{t\text{-}1}$) is the log of the VIX (logs to reduce the skewness). The parameter of interest is a_2 which controls the interaction between today's VIX and tomorrow's stock and bond interaction.
- If a_2 is restricted to zero then this is calculating the beta of bonds to equities. This does not have to imply a causal link. This was pointed out by Barr Rosenberg and James Guy back in 1976 :
  - "from an economic viewpoint, the market return does not cause the security return. Instead, both are caused by economic events. This point has created some confusion among analysts who interpret beta […] as necessarily stating the causal relationship of market returns upon the security returns: That is, if beta is two, a market return of 10 percent causes a security return of 20 percent. The correct wording of this statement is that, as a consequence of the dependence of both market return and security return upon economic events, if a market return of 10 percent is observed, then the most likely value for the associated security return is 20 percent."

Modelling the interaction - results

- The relationship changes over time. The sign of a_1 switches from positive to negative after 98; and the coefficient on a_2 from negative to positive after 2008.

	a0	a1	a2	a1+a2 ln(VIX) VIX = 11.5%	a1+a2 ln(VIX) VIX = 17.75%	a1+a2 ln(VIX) VIX = 33.5%
Jan 90-Dec 97	0.0002	0.198				
	(2.28)	(8.05)				
	0.0002	0.965	-0.259	0.331	0.219	0.054
	(2.20)	(5.12)	(-3.87)			
Jan 98 - Dec 07	0.0002	-0.084				
	(2.88)	(-8.00)				
	0.0002	0.317	-0.124	0.014	-0.040	-0.119
	(2.95)	(3.23)	(-4.09)			
Jan 08 - Mar 17	0.0002	-0.160				
	(2.66)	(-9.342)				
	0.0003	-0.579	0.119	-0.288	-0.236	-0.161
	(2.81)	(-6.57)	(4.44)			

Source: UBS

UBS

Changing VIX and correlations

- Correlation tends to become more negative when the VIX is rising. This is dividing the data into subsets (not forward looking).

To Dec 2000						
	n	Mean Bond	SD Bond	Mean Equity	SD Equity	Correlation
0 - 5th %ile	144	0.135	0.399	1.253	1.112	0.331
0 - 25th %ile	717	0.124	0.386	0.764	0.848	0.292
25th - 50th %ile	691	0.056	0.355	0.260	0.580	0.255
50th - 75th %ile	743	0.009	0.335	-0.081	0.595	0.222
75th - 100th %ile	717	-0.071	0.470	-0.695	0.968	0.161
95th - 100th %ile	144	-0.104	0.616	-1.509	1.257	0.059
Jan 98 - Dec 07						
	n	Mean Bond	SD Bond	Mean Equity	SD Equity	Correlation
0 - 5th %ile	131	-0.084	0.437	1.870	1.113	-0.248
0 - 25th %ile	652	-0.044	0.452	1.086	0.950	-0.212
25th - 50th %ile	652	-0.008	0.403	0.240	0.608	-0.015
50th - 75th %ile	652	0.034	0.376	-0.173	0.616	-0.125
75th - 100th %ile	652	0.103	0.466	-1.039	0.988	-0.352
95th - 100th %ile	131	0.225	0.492	-1.886	1.070	-0.522
Jan 08 - Mar 17						
	n	Mean Bond	SD Bond	Mean Equity	SD Equity	Correlation
0 - 5th %ile	121	-0.311	0.539	2.101	1.816	-0.496
0 - 25th %ile	601	-0.183	0.507	1.145	1.239	-0.400
25th - 50th %ile	600	-0.027	0.479	0.339	0.647	-0.187
50th - 75th %ile	600	0.036	0.419	-0.131	0.590	-0.200
75th - 100th %ile	601	0.248	0.546	-1.204	1.299	-0.579
95th - 100th %ile	121	0.522	0.594	-2.377	1.663	-0.723

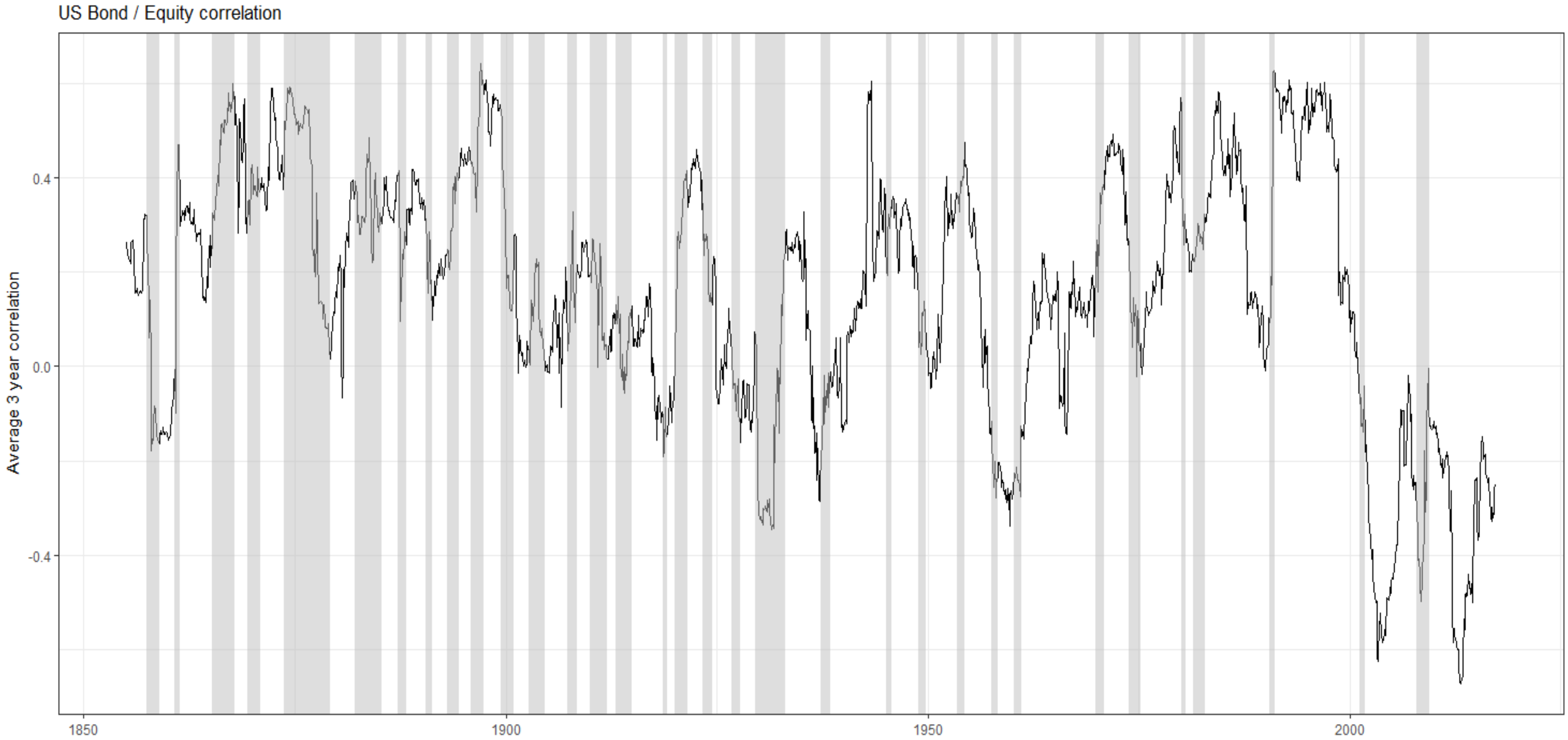
Source: UBS. The change in VIX is measured by percentage change. The correlation is calculated using a zero mean.

Recessions

- Yang et al (2009) investigate the effect of recessions on correlation.
- However the sign of the relationships is not always consistent! They find "in the US, the stock-bond correlations during recessions are lower than those during expansions [...]. By contrast, the high correlations occur during recessions than during expansion in the UK".
- On our data (similar but not exactly the same) over the period from 1857 to date we find that the correlation within US recessions is 0.177 and in expansions is 0.101; if we exclude the data after 2000 these numbers change to 0.215 and 0.183 (Yang has 0.155 and 0.162).
- So our data shows a small increase in correlations during recessions, but the effect is small and seemingly somewhat inconsistent.
- Li (2002) says "the results [using data from 1980 to 2001] do not indicate that the business cycle has any effect on the stock-bond correlation, either in the U.S. or in the G7 panel."

US Bond vs Equity

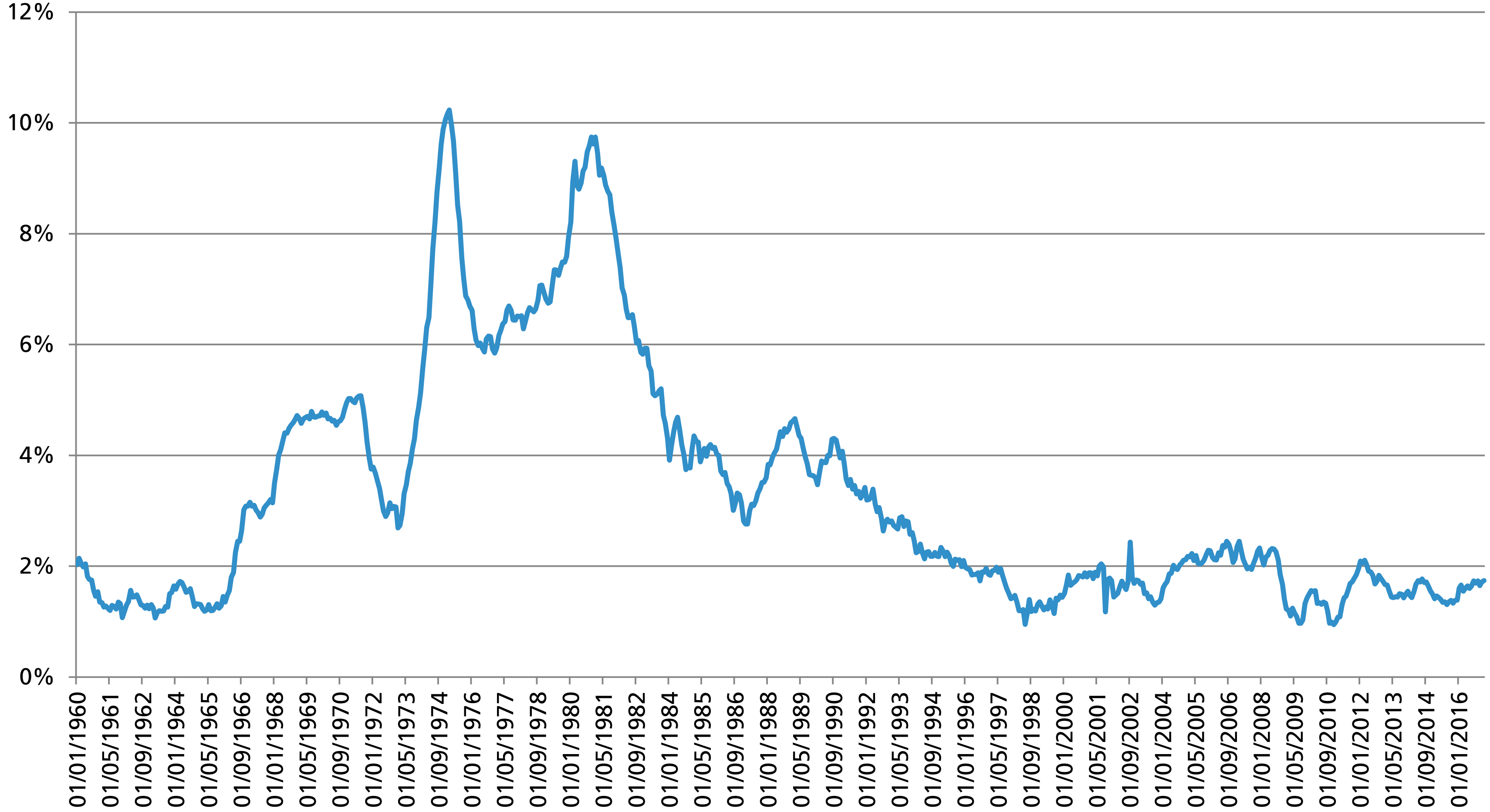
- US Equity / Bond correlation and recessions.



Source: UBS, recession dates from NBER

US Bond vs Equity

- What about inflation? Chart shows 12m change in Core PCE, the Fed's preferred inflation measure. As we are very aware, inflation has remained in the 1-2% range for some time.



Source: UBS, NBER

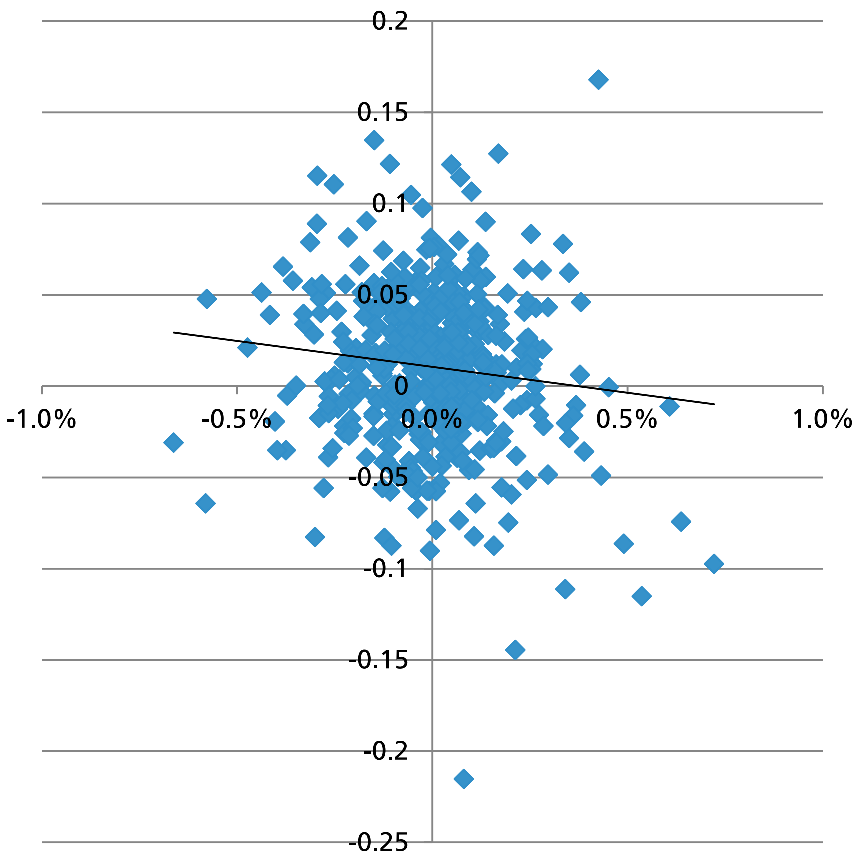
UBS

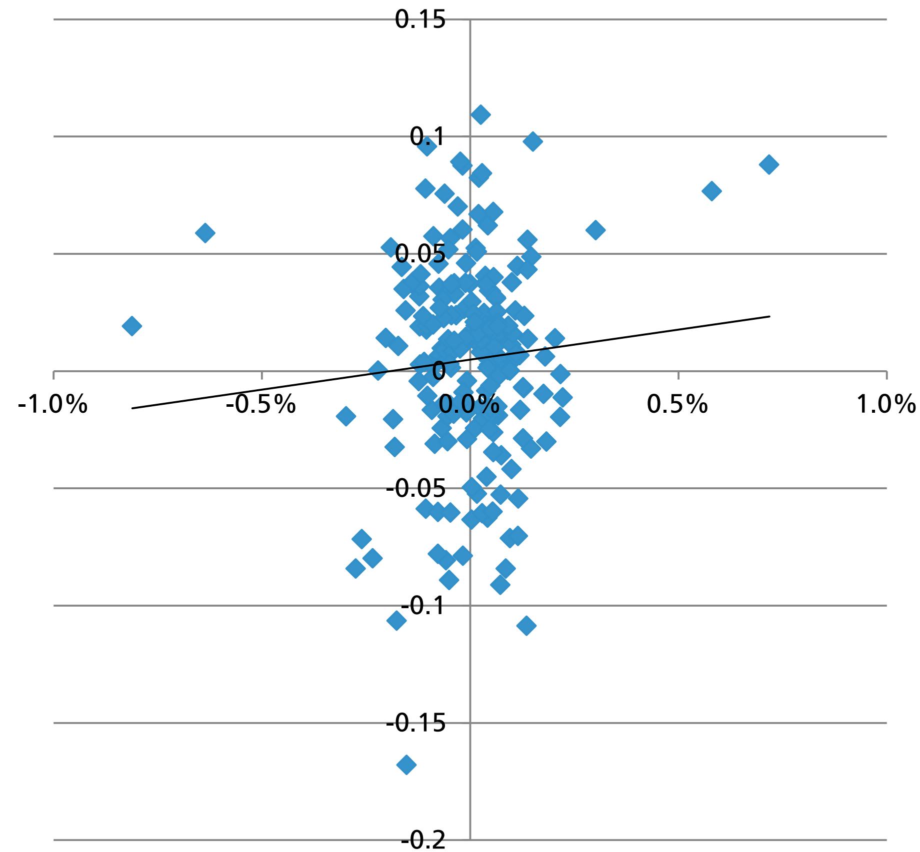
Inflation

- Why should inflation have an effect on the stock-bond correlation?
- (Unexpectedly) Higher inflation has a straightforward effect on bonds – which is negative. Higher inflation raises expected future short rates and (potentially) risk premia.
- For equities the story is more complex. If we consider any DCF model then increasing inflation could have no impact if it affects the top line (cash flows) by the same as the bottom line (discount rates). However the effect could have either sign. For example, too high a level of inflation leads to higher discount rates (and potentially lower future growth from monetary policy).
- However at the moment inflation is very low and any increase has been seen as a positive for growth.

Equity returns and changing inflation

- We see this in these charts: pre-2000 (LHS) inflation increasing was bad for equities; post 2000 it was good. We also see the same effect looking at inflation above and below 2.5%. The charts show the change in annual inflation against next month's S&P 500 return.





Source: UBS. LHS chart data from Jan 1959 to Dec 2000; RHS from Jan 2001 to Jan 2017.

UBS

Modelling unexpected inflation

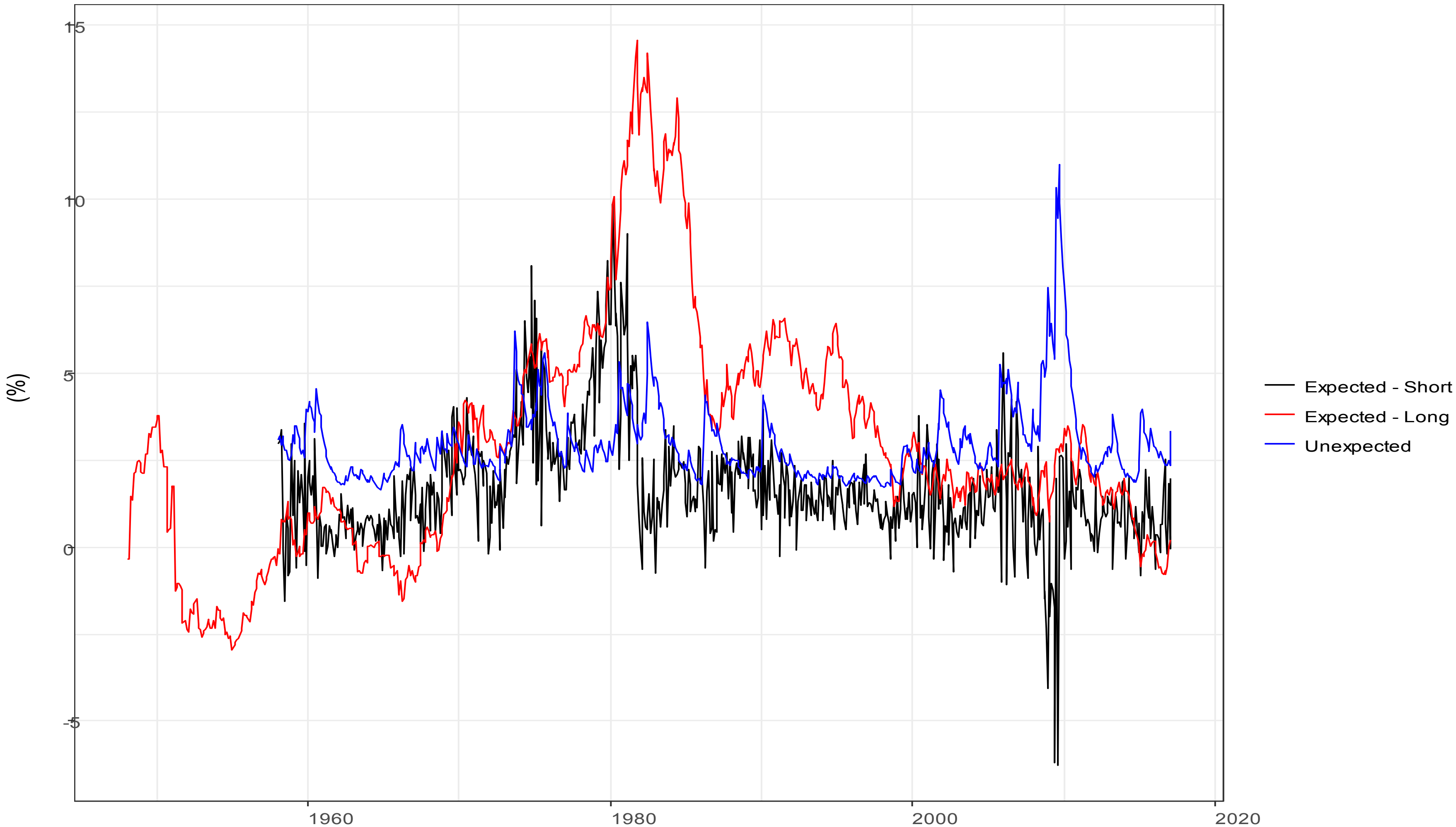
- We need to separate inflation into expected and unexpected components. Andersson et al (2008) use consensus economic forecasts (from Consensus Economics).
- Li (2002) produces two measures of expected inflation – a short term one, built from a Bayesian Vector Autoregression (BVAR) model with inputs of trailing inflation, industrial production and the T-bill rate (using 12 lags); and a long term one defined as the spread between long term bond yields and the trailing 5 year real GDP growth rate.
- Wei (2009) builds a model of inflation based on trailing inflation and the unemployment rate.
- Once we have expected inflation we can calculate real interest rates and unexpected inflation.

Uncertainty in inflation

- Li (2002) goes on to also calculate the uncertainty of inflation. He uses the level of long term expected inflation as a measure of its uncertainty. This was observed in Okun (1971) – higher inflation leads to higher uncertainty of inflation.
- For short term unexpected inflation he uses the volatility from a GARCH(1, 1) model fitted to the short term unexpected inflation.

Inflation – expected and unexpected

- Chart shows the expected inflation and the volatility of unexpected inflation. Note the scales are adjusted to put the data on one plot.



Source: UBS

UBS

Regression results

- The relationship with expected inflation has changed; historically it was positive; now it's negative – so increasing expected inflation now decreases correlation. It's seen as good for equities.

Pre 2000

Intercept	Ycor	EXPINF_S	EXPINF_L	UNINF_S	UNINF_SIGMA
0.0101	0.372 ***	271.29 *			
0.0005	0.346 ***		0.100 *		
0.3861	0.393 ***			-104.7	
0.3726	0.397 ***				18.31
0.124	0.337 ***		0.114 *		-268.4

Post 2000

Intercept	Ycor	EXPINF_S	EXPINF_L	UNINF_S	UNINF_SIGMA
-0.1873	0.432 ***	17.283			
-0.1331	0.445 ***		-0.023		
-0.1707	0.444 ***			-0.312	
-0.1832	0.444 ***				8.9369
-0.261	0.326 ***		-0.029		24.149

Source: UBS

UBS

Section 2

Return decomposition

Return decomposition

- What drives stock returns? If we consider a discounted cash flow model (of any sort) then a change in the price must be down to either
  - A change in the top line, the cash flows, or
  - A change in the bottom line, the discount rates.
- In order to derive the model we start with an approximation from Campbell and Schiller (1988) where they approximate the log return on a dividend paying asset $r_{t+1} = \log(P_{t+1} + D_{t+1}) - \log(P_t)$ using a Taylor series expansion around the long term mean log dividend-price ratio $\overline{(d_t - p_t)}$ where *P* and *D* are the price and dividend and *p* and *d* are their logs.
- The approximation is

$$r_{t+1} \approx k + \rho p_{t+1} + (1-\rho) d_{t+1} - p_t$$

- where $\rho = {}^{1}/_{(1+\exp(\overline{d_t - p_t}))} \approx 0.96$ and $k = -\log(\rho) - (1-\rho)\log({}^{1}/_{\rho} - 1)$.

Return decomposition (2)

- Campbell (1991) took this idea and provided the following (approximate) decomposition of unexpected returns

$$\begin{aligned} e_{t+1} &= r_{t+1} - E_t r_{t+1} \\ &= (E_{t+1} - E_r) \sum_{j=0}^{\infty} \rho^j \Delta d_{t+1+j} - (E_{t+1} - E_r) \sum_{j=0}^{\infty} \rho^j r_{t+1+j} \\ &= e_{CF,t+1} - e_{DR,t+1} \end{aligned}$$

  where r_{t+1} is the equity return and E_t is the expectation at time t. ρ is the constant from above, and Δd_t is the dividend growth rate. e_t is the unexpected market return, and $e_{CF,t}$ and $e_{DR,t}$ are its cash flow and discount rate news components.

- So unexpected returns are a function of changes in expectation about future dividends ("cash flow news") and changes in future expected returns ("discount rate news").

Fitting the model

- How do we fit the model? The (usual) approach (from Campbell and Vuolteenaho (2004)) is to model the discount rate news and then calculate the cash flow news as the residual.
- The discount rate r_t is modelled as part of a VAR model
- $z_{t+1} = a + \Gamma z_r + u_{t+1}$
- Where it has become convention to put r_t as the first element in z_t and the other variables are chosen as ones that have some predictive power for r_t. In the 2004 paper they use the term spread, the 10 year PE and the small stock value spread.
- Chen & Zhao (2009) have some criticisms of this approach (saying it is somewhat unstable as any modelling errors get pushed into the cash flow news) but Engsted at al (2010) provide a reasonable defence of the approach.

Fitting the model (2)

- Once we have fitted the VAR model then it follows that

$$-e_{DR,t+1} = -(E_{t+1} - E_r)\sum_{j=0}^{\infty} \rho^j r_{t+1+j}$$
$$= e1'\sum_{j=0}^{\infty} \rho^j \Gamma u_{t+1}$$

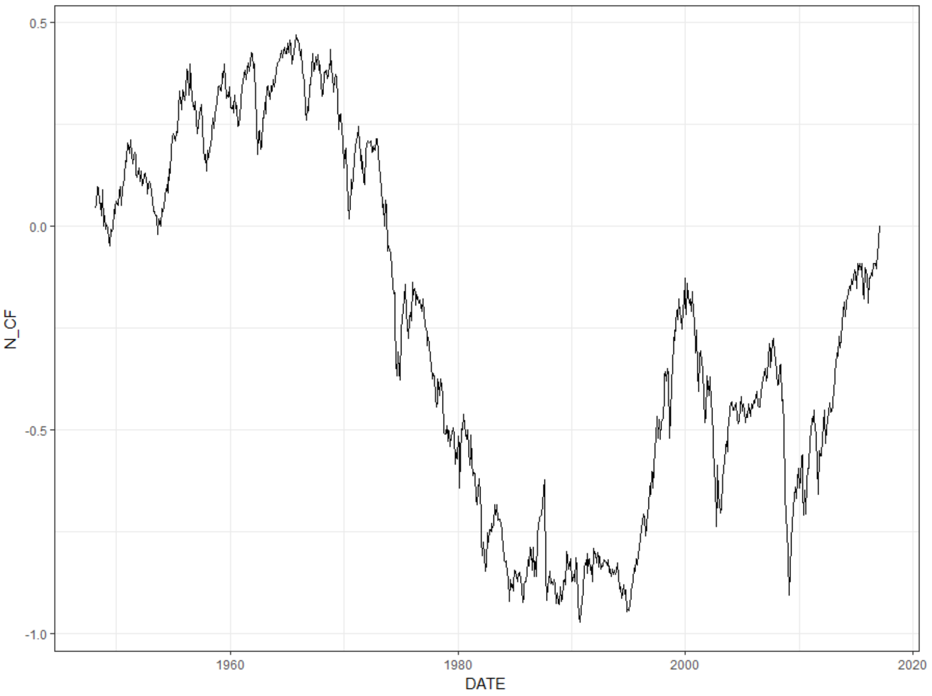
$$= e1'\rho\Gamma(I-\rho\Gamma)^{-1}u_{t+1} = e1'\lambda u_{t+1}$$

- where $\lambda = \rho\Gamma(I-\rho\Gamma)^{-1}$ and ***e1*** is a vector where the first element is 1 and the rest are zero.
- And then the cash flow news is simply $(\mathrm{e}1' + e1'\lambda)u_{t+1}$

UBS

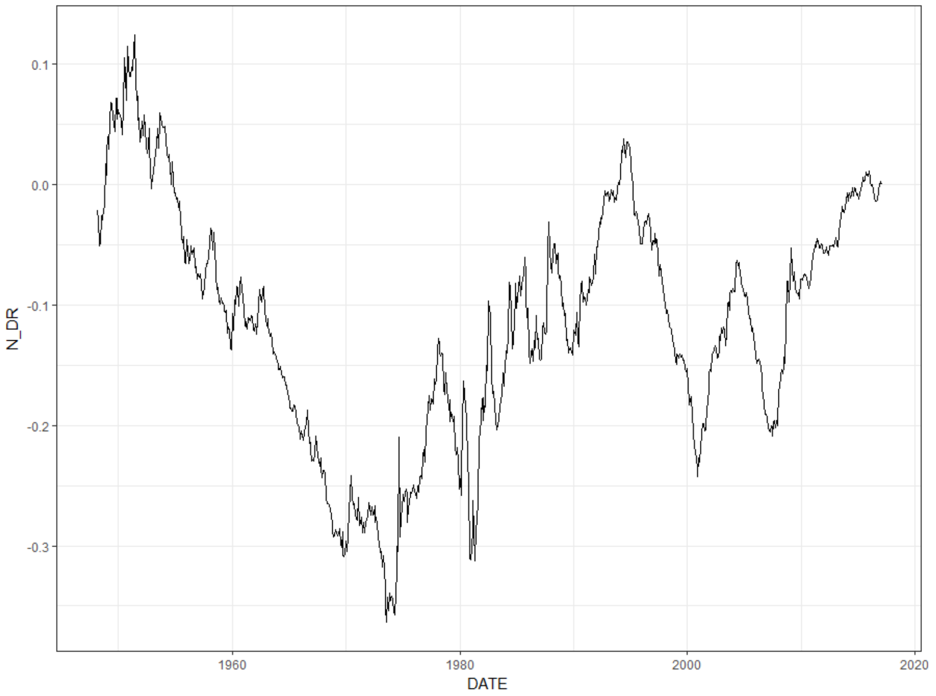
Picture of cash flow and discount rate news

Cash flow news



Source: UBS

Discount rate news



Source: UBS

Relationship with inflation over time

- Historically (pre 2000) the correlation of inflation with discount rate news and cash flow news was negative (-0.40 and –0.19 respectively).
- Since 2000 the correlation with discount rate news has remained negative but smaller (-0.16) and the correlation with cash flow news has turned positive (0.07) – so again backing up the idea that increasing inflation is now seen as a positive thing

Conclusions

- Since 2000 stock-bond correlations have been negative, in contrast to the previous 200 years.
- The main driving force behind this change seems to be the influence of inflation on equity returns – higher inflation is now apparently good news for equities.
- The flight to quality effect seems to have grown larger – the correlation falls more when the VIX increases.

Valuation Method and Risk Statement

Our quantitative models rely on reported financial statement information, consensus values and stock prices. Errors in these numbers are sometimes impossible to prevent (e.g. when an item is misstated by a company). Also, the models employ historical data to estimate the efficacy of stock selection strategies and the relationships among strategies, which may change in the future. Additionally, unusual company-specific events could overwhelm the systematic influence of the strategies used to rank and score stocks.

Analyst Certification

Each research analyst primarily responsible for the content of this research report, in whole or in part, certifies that with respect to each security or issuer that the analyst covered in this report: (1) all of the views expressed accurately reflect his or her personal views about those securities or issuers and were prepared in an independent manner, including with respect to UBS, and (2) no part of his or her compensation was, is, or will be, directly or indirectly, related to the specific recommendations or views expressed by that research analyst in the research report.

Required Disclosures

This document has been prepared by UBS Limited, an affiliate of UBS AG. UBS AG, its subsidiaries, branches and affiliates are referred to herein as UBS.

For information on the ways in which UBS manages conflicts and maintains independence of its research product; historical performance information; and certain additional disclosures concerning UBS research recommendations, please visit www.ubs.com/disclosures. The figures contained in performance charts refer to the past; past performance is not a reliable indicator of future results. Additional information will be made available upon request. UBS Securities Co. Limited is licensed to conduct securities investment consultancy businesses by the China Securities Regulatory Commission. UBS acts or may act as principal in the debt securities (or in related derivatives) that may be the subject of this report. This recommendation was finalized on: 27 March 2017 05:37 AM GMT

UBS Investment Research: Global Equity Rating Definitions

12-Month Rating	**Definition**	**Coverage**[1]	**IB Services**[2]
Buy	FSR is > 6% above the MRA.	45%	29%
Neutral	FSR is between -6% and 6% of the MRA.	39%	27%
Sell	FSR is > 6% below the MRA.	15%	16%
Short-Term Rating	**Definition**	**Coverage**[3]	**IB Services**[4]
Buy	Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%

Source: UBS. Rating allocations are as of 31 December 2016.
1:Percentage of companies under coverage globally within the 12-month rating category.
2:Percentage of companies within the 12-month rating category for which investment banking (IB) services were provided within the past 12 months.
3:Percentage of companies under coverage globally within the Short-Term rating category.
4:Percentage of companies within the Short-Term rating category for which investment banking (IB) services were provided within the past 12 months.

KEY DEFINITIONS: Forecast Stock Return (FSR) is defined as expected percentage price appreciation plus gross dividend yield over the next 12 months. **Market Return Assumption (MRA)** is defined as the one-year local market interest rate plus 5% (a proxy for, and not a forecast of, the equity risk premium). **Under Review (UR)** Stocks may be flagged as UR by the analyst, indicating that the stock's price target and/or rating are subject to possible change in the near term, usually in response to an event that may affect the investment case or valuation. **Short-Term Ratings** reflect the expected near-term (up to three months) performance of the stock and do not reflect any change in the fundamental view or investment case. **Equity Price Targets** have an investment horizon of 12 months.

EXCEPTIONS AND SPECIAL CASES: UK and European Investment Fund ratings and definitions are: Buy: Positive on factors such as structure, management, performance record, discount; **Neutral:** Neutral on factors such as structure, management, performance record, discount; **Sell:** Negative on factors such as structure, management, performance record, discount. **Core Banding Exceptions (CBE):** Exceptions to the standard +/-6% bands may be granted by the Investment Review Committee (IRC). Factors considered by the IRC include the stock's volatility and the credit spread of the respective company's debt. As a result, stocks deemed to be very high or low risk may be subject to higher or lower bands as they relate to the rating. When such exceptions apply, they will be identified in the Company Disclosures table in the relevant research piece.

Research analysts contributing to this report who are employed by any non-US affiliate of UBS Securities LLC are not registered/qualified as research analysts with FINRA. Such analysts may not be associated persons of UBS Securities LLC and therefore are not subject to the FINRA restrictions on communications with a subject company, public appearances, and trading securities held by a research analyst account. The name of each affiliate and analyst employed by that affiliate contributing to this report, if any, follows.

UBS Limited: David Jessop, Nick Baltas, Claire Jones, Josie Gerken, Desi Ivanova, Paul Winter

Unless otherwise indicated, please refer to the Valuation and Risk sections within the body of this report. For a complete set of disclosure statements associated with the companies discussed in this report, including information on valuation and risk, please contact UBS Securities LLC, 1285 Avenue of Americas, New York, NY 10019, USA, Attention: Investment Research.

Compendium Disclosure

For a complete set of disclosure statements associated with the companies discussed in this report, including information on valuation and risk, please contact:

UBS Securities LLC,
1285 Avenue of Americas,
New York, NY 10019, USA.

Attention: Publishing Administration

Global Disclaimer

Global Disclaimer (continued)

United Kingdom and the rest of Europe: Except as otherwise specified herein, this material is distributed by UBS Limited to persons who are eligible counterparties or professional clients. UBS Limited is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. **France:** Prepared by UBS Limited and distributed by UBS Limited and UBS Securities France S.A. UBS Securities France S.A. is regulated by the ACPR (Autorité de Contrôle Prudentiel et de Résolution) and the Autorité des Marchés Financiers (AMF). Where an analyst of UBS Securities France S.A. has contributed to this document, the document is also deemed to have been prepared by UBS Securities France S.A. **Germany:** Prepared by UBS Limited and distributed by UBS Limited and UBS Europe SE. UBS Europe SE is regulated by the Bundesanstalt fur Finanzdienstleistungsaufsicht (BaFin). **Spain:** Prepared by UBS Limited and distributed by UBS Limited and UBS Securities España SV, SA. UBS Securities España SV, SA is regulated by the Comisión Nacional del Mercado de Valores (CNMV). **Turkey:** Distributed by UBS Limited. No information in this document is provided for the purpose of offering, marketing and sale by any means of any capital market instruments and services in the Republic of Turkey. Therefore, this document may not be considered as an offer made or to be made to residents of the Republic of Turkey. UBS AG is not licensed by the Turkish Capital Market Board under the provisions of the Capital Market Law (Law No. 6362). Accordingly, neither this document nor any other offering material related to the instruments/services may be utilized in connection with providing any capital market services to persons within the Republic of Turkey without the prior approval of the Capital Market Board. However, according to article 15 (d) (ii) of the Decree No. 32, there is no restriction on the purchase or sale of the securities abroad by residents of the Republic of Turkey. **Poland:** Distributed by UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce regulated by the Polish Financial Supervision Authority. Where an analyst of UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce has contributed to this document, the document is also deemed to have been prepared by UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce. **Russia:** Prepared and distributed by UBS Bank (OOO). **Switzerland:** Distributed by UBS AG to persons who are institutional investors only. UBS AG is regulated by the Swiss Financial Market Supervisory Authority (FINMA). **Italy:** Prepared by UBS Limited and distributed by UBS Limited and UBS Limited, Italy Branch. Where an analyst of UBS Limited, Italy Branch has contributed to this document, the document is also deemed to have been prepared by UBS Limited, Italy Branch. **South Africa:** Distributed by UBS South Africa (Pty) Limited (Registration No. 1995/011140/07), an authorised user of the JSE and an authorised Financial Services Provider (FSP 7328). **Israel:** This material is distributed by UBS Limited. UBS Limited is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. UBS Securities Israel Ltd is a licensed Investment Marketer that is supervised by the Israel Securities Authority (ISA). UBS Limited and its affiliates incorporated outside Israel are not licensed under the Israeli Advisory Law. UBS Limited is not covered by insurance as required from a licensee under the Israeli Advisory Law. UBS may engage among others in issuance of Financial Assets or in distribution of Financial Assets of other issuers for fees or other benefits. UBS Limited and its affiliates may prefer various Financial Assets to which they have or may have Affiliation (as such term is defined under the Israeli Advisory Law). Nothing in this Material should be considered as investment advice under the Israeli Advisory Law. This Material is being issued only to and/or is directed only at persons who are Eligible Clients within the meaning of the Israeli Advisory Law, and this material must not be relied on or acted upon by any other persons. **Saudi Arabia:** This document has been issued by UBS AG (and/or any of its subsidiaries, branches or affiliates), a public company limited by shares, incorporated in Switzerland with its registered offices at Aeschenvorstadt 1, CH-4051 Basel and Bahnhofstrasse 45, CH-8001 Zurich. This publication has been approved by UBS Saudi Arabia (a subsidiary of UBS AG), a Saudi closed joint stock company incorporated in the Kingdom of Saudi Arabia under commercial register number 1010257812 having its registered office at Tatweer Towers, P.O. Box 75724, Riyadh 11588, Kingdom of Saudi Arabia. UBS Saudi Arabia is authorized and regulated by the Capital Market Authority to conduct securities business under license number 08113-37. **Dubai:** The information distributed by UBS AG Dubai Branch is intended for Professional Clients only and is not for further distribution within the United Arab Emirates. **United States:** Distributed to US persons by either UBS Securities LLC or by UBS Financial Services Inc., subsidiaries of UBS AG; or by a group, subsidiary or affiliate of UBS AG that is not registered as a US broker-dealer (a **'non-US affiliate'**) to major US institutional investors only. UBS Securities LLC or UBS Financial Services Inc. accepts responsibility for the content of a document prepared by another non-US affiliate when distributed to US persons by UBS Securities LLC or UBS Financial Services Inc. All transactions by a US person in the securities mentioned in this document must be effected through UBS Securities LLC or UBS Financial Services Inc., and not through a non-US affiliate. UBS Securities LLC is not acting as a municipal advisor to any municipal entity or obligated person within the meaning of Section 15B of the Securities Exchange Act (the "Municipal Advisor Rule"), and the opinions or views contained herein are not intended to be, and do not constitute, advice within the meaning of the Municipal Advisor Rule. **Canada:** Distributed by UBS Securities Canada Inc., a registered investment dealer in Canada and a Member-Canadian Investor Protection Fund, or by another affiliate of UBS AG that is registered to conduct business in Canada or is otherwise exempt from registration. **Mexico:** This report has been distributed and prepared by UBS Casa de Bolsa, S.A. de C.V., UBS Grupo Financiero, an entity that is part of UBS Grupo Financiero, S.A. de C.V. and is an affiliate of UBS AG. This document is intended for distribution to institutional or sophisticated investors only. Research reports only reflect the views of the analysts responsible for the reports. Analysts do not receive any compensation from persons or entities different from UBS Casa de Bolsa, S.A. de C.V., UBS Grupo Financiero, or different from entities belonging to the same financial group or business group of such. For Spanish translations of applicable disclosures, please see www.ubs.com/disclosures. **Brazil:** Except as otherwise specified herein, this material is prepared by UBS Brasil CCTVM S.A. to persons who are eligible investors residing in Brazil, which are considered to be: (i) financial institutions, (ii) insurance firms and investment capital companies, (iii) supplementary pension entities, (iv) entities that hold financial investments higher than R$300,000.00 and that confirm the status of qualified investors in written, (v) investment funds, (vi) securities portfolio managers and securities consultants duly authorized by Comissão de Valores Mobiliários (CVM), regarding their own investments, and (vii) social security systems created by the Federal Government, States, and Municipalities. **Hong Kong:** Distributed by UBS Securities Asia Limited and/or UBS AG, Hong Kong Branch. **Singapore:** Distributed by UBS Securities Pte. Ltd. [MCI (P) 007/09/2016 and Co. Reg. No.: 198500648C] or UBS AG, Singapore Branch. Please contact UBS Securities Pte. Ltd., an exempt financial adviser under the Singapore Financial Advisers Act (Cap. 110); or UBS AG, Singapore Branch, an exempt financial adviser under the Singapore Financial Advisers Act (Cap. 110) and a wholesale bank licensed under the Singapore Banking Act (Cap. 19) regulated by the Monetary Authority of Singapore, in respect of any matters arising from, or in connection with, the analysis or document. The recipients of this document represent and warrant that they are accredited and institutional investors as defined in the Securities and Futures Act (Cap. 289). **Japan:** Distributed by UBS Securities Japan Co., Ltd. to professional investors (except as otherwise permitted). Where this document has been prepared by UBS Securities Japan Co., Ltd., UBS Securities Japan Co., Ltd. is the author, publisher and distributor of the document. Distributed by UBS AG, Tokyo Branch to Professional Investors (except as otherwise permitted) in relation to foreign exchange and other banking businesses when relevant. **Australia:** Clients of UBS AG: Distributed by UBS AG (ABN 47 088 129 613 and holder of Australian Financial Services License No. 231087). Clients of UBS Securities Australia Ltd: Distributed by UBS Securities Australia Ltd (ABN 62 008 586 481 and holder of Australian Financial Services License No. 231098). This Document contains general information and/or general advice only and does not constitute personal financial product advice. As such, the Information in this document has been prepared without taking into account any investor's objectives, financial situation or needs, and investors should, before acting on the Information, consider the appropriateness of the Information, having regard to their objectives, financial situation and needs. If the Information contained in this document relates to the acquisition, or potential acquisition of a particular financial product by a 'Retail' client as defined by section 761G of the Corporations Act 2001 where a Product Disclosure Statement would be required, the retail client should obtain and consider the Product Disclosure Statement relating to the product before making any decision about whether to acquire the product. The UBS Securities Australia Limited Financial Services Guide is available at: www.ubs.com/ecs-research-fsg. **New Zealand:** Distributed by UBS New Zealand Ltd. UBS New Zealand Ltd is not a registered bank in New Zealand. You are being provided with this UBS publication or material because you have indicated to UBS that you are a "wholesale client" within the meaning of section 5C of the Financial Advisers Act 2008 of New Zealand (Permitted Client). This publication or material is not intended for clients who are not Permitted Clients (non-permitted Clients). If you are a non-permitted Client you must not rely on this publication or material. If despite this warning you nevertheless rely on this publication or material, you hereby (i) acknowledge that you may not rely on the content of this publication or material and that any recommendations or opinions in such this publication or material are not made or provided to you, and (ii) to the maximum extent permitted by law (a) indemnify UBS and its associates or related entities (and their respective Directors, officers, agents and Advisors) (each a 'Relevant Person') for any loss, damage, liability or claim any of them may incur or suffer as a result of, or in connection with, your unauthorised reliance on this publication or material and (b) waive any rights or remedies you may have against any Relevant Person for (or in respect of) any loss, damage, liability or claim you may incur or suffer as a result of, or in connection with, your unauthorised reliance on this publication or material. **Korea:** Distributed in Korea by UBS Securities Pte. Ltd., Seoul Branch. This document may have been edited or contributed to from time to time by affiliates of UBS Securities Pte. Ltd., Seoul Branch. **Malaysia:** This material is authorized to be distributed in Malaysia by UBS Securities Malaysia Sdn. Bhd (Capital Markets Services License No.: CMSL/A0063/2007). This material is intended for professional/institutional clients only and not for distribution to any retail clients. **India:** Distributed by UBS Securities India Private Ltd. (Corporate Identity Number U67120MH1996PTC097299) 2/F, 2 North Avenue, Maker Maxity, Bandra Kurla Complex, Bandra (East), Mumbai (India) 400051. Phone: +912261556000. It provides brokerage services bearing SEBI Registration Numbers: NSE (Capital Market Segment): INB230951431, NSE (F&O Segment) INF230951431, NSE (Currency Derivatives Segment) INE230951431, BSE (Capital Market Segment) INB010951437; merchant banking services bearing SEBI Registration Number: INM000010809 and Research Analyst services bearing SEBI Registration Number: INH000001204. UBS AG, its affiliates or subsidiaries may have debt holdings or positions in the subject Indian company/companies. Within the past 12 months, UBS AG, its affiliates or subsidiaries may have received compensation for non-investment banking securities-related services and/or non-securities services from the subject Indian company/companies. The subject company/companies may have been a client/clients of UBS AG, its affiliates or subsidiaries during the 12 months preceding the date of distribution of the research report with respect to investment banking and/or non-investment banking securities-related services and/or non-securities services. With regard to information on associates, please refer to the Annual Report at: http://www.ubs.com/global/en/about_ubs/investor_relations/annualreporting.html

The disclosures contained in research documents produced by UBS Limited shall be governed by and construed in accordance with English law.

UBS

Contact Information

UBS Limited
1 Finsbury Avenue
London

Tel: +44-207-567 8000

www.ubs.com