Alternative investments: return driving actors

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ABSTRACT

In an asset allocation process, correlations are particularly important if one includes 'alternative investments' such as real estate, commodities and hedge funds, which have been proclaimed to provide diversifying benefits within the overall portfolio context. However, by looking at correlations between asset classes alone some diversification benefits may be over or under-stated. More recently, finance literature has focused on alternative asset classes to study their behaviour and to identify the main driving factors. Particularly, these studies have tried to shed light upon the cyclical behaviour of these 'new' assets and their link with overall economic trends.

This paper represents the first comparative study of several asset classes. We analyse the common driving factors of fourteen (both traditional and alternative) assets to provide insights into their likely performance over different economic environments. Firstly, Principle Component Analysis is used to give a better statistical understanding of the structure of the data and the number of likely common factors. Subsequently, a number of different univariate and multivariate regressions are performed using financial and economic variables identified in the literature. We find evidence of common macroeconomic and financial factors

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driving the returns of certain asset classes, with consequences on the reduced diversification benefits of such assets during particular phases of the business cycle.

1. Introduction

The aim of this paper is to investigate the relationship between the different asset classes further, more specifically at whether there are any factors which mutually drive the returns of more than one asset. This is useful for three main reasons; at a basic level it may help us understand how an asset class should perform under certain circumstances for example under different macroeconomic states. Furthermore the techniques can perhaps identify if there are strong common drivers between the assets and thus if any will have low diversifying power in the common overall portfolio. Finally if underlying factors are identified it may be possible to replace certain asset with ones that may have other more favourable characteristics, for example better liquidity.

At a single asset class level there have been numerous studies that focus on the links between the asset class and macroeconomic variables; however, there has been very little research that looks at more than one asset class in these terms simultaneously. Most of the original research was concentrated on stocks and bonds but more recently more work has been performed on other asset classes, particularly real estate, although commodities and hedge funds have been studied in these terms as well.

This study will use several methods to attempt to identify the factors that drive returns across a number of asset classes. In a broad sense it is perhaps possible to divide factor models of the returns on assets into three general types: fundamental, statistical and macroeconomic (Connor 1995). As we are interested in the factors that are driving different asset classes over time, the first type of model, those that use cross sectional asset pricing using fundamental factors, are not applicable to this work. However; the other two general types of model will be used. Firstly, principle component analysis will be used in order to identify on a statistical basis the number of likely driving factors and the degree of their effect. Secondly, regression based methods will be used to identify if macroeconomic variables that have been previously identified in the literature are proven to affect real estate returns. Ex post return regressions will indicate whether a variable will have a statistical significant exposure to macroeconomic factors.

2. Principle Component Analysis of the Asset Class Returns[3]

Firstly principle component analysis was performed on four different sets of asset class data. At a basic level PCA is a mathematical data reduction technique. It is used to transform the original data set into a number of principal components. Each of these will account for a degree of the variation within the original data. One study has already performed PCA on multiple asset class return proxies in the U.K.; Bond et al. (2007). Here the authors find that six common risk factors explain 99% of the variation in the returns of the 8 core asset classes.

Firstly, it was applied to all of the 14 assets being investigated in this section. Then it was applied to the data split into two sub-sets, one comprising of nine sub-assets which may be defined as being traditional assets and another of five 'alternative' assets. Fourthly, the technique was applied to a set of seven sub-asset classes that only included one sub-asset classes in each broad asset class category was included. For example only U.K. equities and government bonds were included rather than all seven equity and fixed income sub-asset classes; this was done order to check that the assets with more sub-asset classes were not biasing the results.

[INSERT EXHIBIT 1 + 2 HERE]

The table and diagram above show when all the 15 sub-asset classes are addressed together that the first principle component explains approximately 40% of the variance of the assets, while the second principle component explains 17% of the variation. The first four components cumulatively explain nearly 80% of the variation, while the first eight explain over 95% of the variation. When the results were split into the two sub-groups of traditional and alternative investments in general the results were quite similar, except in both cases the first principle component explained around 50% of the variability rather than 40%. This may be the result of first factor being over shadowed by other factors when all the assets are present.

[3] For details of PCA see for example Alexander (2008)

3. Macroeconomic factor models- Background and brief literature review

The purpose of this section is to document the different macroeconomic risk exposures that different asset classes have. This area of research is related to the Arbitrage Pricing Theory of Ross (1976) because the factors that are driving asset class returns are also those which can then be found to be 'priced in' to the returns of an individual security. Most of the papers in the area do come from the pricing point of view but a few concentrate on the macro exposures or study both. A brief review of the literature in this area is presented below, it documents which assets are studied; however, it will focus primarily on the macroeconomic variables that the various authors decided to include in their models.

The first major paper to address, using this framework, that macroeconomic variables may be connected to asset performance is Chen, Roll and Ross (1986). In this paper the authors explain the returns of portfolios of equities in the context of several macroeconomic variables and to see if these risks are priced in. They point out that up to this paper there was a complete ignorance of the identity of which underlying variables are likely to influence all assets, although there was theoretical support for their existence. Therefore they state that it is very difficult to determine a complete list of factors. They use the logic that any factor which changes the discount rate will be a valid systematic factor. An article which applies a similar methodology to international equity markets is Ferson and Harvey (1993). The returns of bonds are addressed in a similar framework to these previous articles by Elton et al. (1995). The first paper to apply this approach to real estate as an asset class is Chan et al. (1990); Chen, et al. (1997) also look at the indirect real estate market in the U.S.A. Also addressing real estate are Ling and Naranjo (1997) and the U.K. based study Brooks and Tsolacos (1999). Bailey and Chan (1993) and Erb and Harvey (2006) use macroeconomic factors to help explain commodity returns. A paper that applies a limited multi-factor analysis to hedge fund indices using only a few key macroeconomic variables is Schneeweis et al. (2003). Secondly in Amenc et al. (2003) use a greater number of factors to explain the returns of hedge funds. See the table below for a summary of the factors that were considered by the main papers in this area.

[INSERT EXHIBIT 3 HERE]

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4. Data

4.1 Asset Class Return Data

The tables Exhibit 4 show both the basic statistics and the correlation matrix for the 14 sub-asset classes that are considered in paper. All the returns are calculated as log changes of the total return indices of the assets[4]. Three are three equity sub-asset classes; U.K. Equities (E_UK), Overseas Equities (E_OS) and Emerging Market Equities (E_EM). Also included are four fixed income sub-classes; Gilts (B_GVT), bonds with greater credit link (B_GVT), Index-linked Gilts (B_IL) and Overseas Bonds (B_OS). Both Listed Estate (REL) and Direct Real Estate (RE) are included. Three types of commodities futures indices are studied, two diversified: C_GS and C_RJ and also a gold index (GOLD). A diversified hedge fund index (HF) and an index based on the returns of wine (WINE) are featured as well. Real estate, hedge funds and wine have been desmoothed in order to compensate for their reduced volatility that has resulted from valuation or illiquidity biases[5].

[INSERT EXHIBIT 4 HERE]

As one might expect, the average monthly returns are substantially different across the different asset classes with the maximum one being HFRI at 1.1% a month and the lowest one being the Reuters/ Jefferies CRB index with a figure of 0.30%. Fixed income assets produced low levels of variation in their total returns over time; gilts had a standard deviation of 0.169% this was exceeded by most other assets. One must be careful with regard of the distributions of these assets; all but the gilt index fail the Jarque-Bera test for normality at both 95% and 90% confidence levels, whilst the gilt index only passes at 90%. Many of the indices are leptokurtic, particularly RE and the Reuters/ Jefferies index. On the other hand the FTSE 100 and gilts indices are extremely platykurtic. Most of the indices have varying levels of negative skewness. Below one can also find the correlation matrix for the asset classes.

[INSERT EXHIBIT 5 HERE]

[4] Please contact authors for more details on the asset classes and the proxies used.

[5] These were each desmoothed differently; details are available on request.

4.2 Macroeconomic factors

Macroeconomic factor variables such as ones used in the literature above are found not only to explain asset class performance but as one may expect more generally they are indicators of recent and future economic growth (Chen 1991). Below you can find a description of each macro-economic variable included in this study as well as additional commentary on why it has been included.

Change in Industrial production and other proxies for general economic conditions

Chen et al. (1986) uses both the industrial production month to month growth rate and yearly growth rate both of which are led by one month. In Brooks and Tsolacos (1999) the rate of unemployment tis used to reflect general economic conditions in the UK. In our preliminary regressions we will include both unemployment and industrial production (lead by one month). In both cases these were included in terms of the monthly log changes; the variable for industrial production is denoted as IPRO while unemployment is UNEM.

Change in expected inflation

In many of the studies above inflation is spilt into different components, both expected and unexpected inflation are included as separate variables. Geske and Roll (1983) suggest that equity performance should be negatively related to expected inflation. Some research, such as Gorton and Rouwenhorst (2006) suggests that commodities may be a better hedge against inflation than equities or bonds. There are several methods suggested to calculate expected inflation as in Chen et al. (1986), we use the Fama and Gibbons (1984) method to create their measure of expected inflation. This is the difference between the T-bill rate and the fitted expected real rate, where the expected rate is equally weighted moving average of the past 12 month's ex post real rates (T-bill minus CPI). This also compared this with a forecast from an ARIMA model and the results were similar. Unlike Chen et al. (1986) we use the first differences in terms of percentage point changes in yield of this variable to attempt to reduce autocorrelation. This variable will be denoted as EX_IN. We also included actual inflation as measured by the percentage change in the consumer price index (CPI) as ACT_IN.

Unexpected or unanticipated inflation (UNEX_IN)

Schwert (1981) suggests that for equities unexpected inflation contains new information on the likely level of future expected inflation. He suggests that an increase in unexpected inflation is likely to cause a transfer of wealth from bond holders to equity holders. In contrast to this, Geake and Roll (1983) conclude that equities are negatively related to both unexpected and expected inflation. Chen, Roll and Ross (1986) and others calculate this by subtracting the realised monthly first difference in the log of the Consumer Price Index less the series of expected inflation as calculated above. We use this approach and use the first differences of the series in percentage points.

Changes in the risk structures of interest rates (RISK)

Chen et al. (1986) define this variable as the returns on a portfolio of Baa and under bonds less the return on long-term government bonds. A measure for term and default is also used in Fama and French (1992) to explain both stock and bond returns. Elton, Gruber, and Blake (1995) suggest that higher default risks should affect corporate bond returns. Ferson and Harvey (1991) note that their results in a pricing model were sensitive to the definition of this variable. Due to this study being U.K. based, the closest proxy available was to use data from the Barclays Capital fixed income index series. The data that was used was from bonds that formed the Barclays Sterling non-Gilt AAA and BBB indices (mostly corporate bonds). There is a problem with using this data; despite some adjustments there was still a duration mismatch between the indices.

Changes in the term structures of interest rates (TERM)

This variable is included in many of the studies in the literature review above. There also has been extensive additional work in in using the term structure of the yield curve to gain insight into asset prices (Keim and Stambaugh 1986, Campbell 1987, Resnick and Shoesmith 2002). Campbell (1987) uses the yield curve to predict the return on equities and finds a similar result; that suggests that risk premia on T-bills tend to move fairly independently with equities whereas taking 20 year bonds into account boasts the predictably. In Chen et al. (1986) they define this as return on long-term government bonds less the period return on one month T-bills (lagged one month). In this study the difference used was that between 10 year government bonds and three month T-bills. The monthly change in percentage point terms of this rate was used.

Oil Prices (OIL)

Chen et al. (1986) point out that it is often argued that the oil price should be included in any list of systematic factors that influence equity returns and pricing. In Amenc et al. (2003) the authors consider the oil price to be related to short term business cycles. We have included the monthly change in the price of Brent Crude (US $).

Short term interest rate factor (SHORT)

Ferson and Harvey (1993) and Roache (2008) include this as they suggest it can be used to capture the state of investment opportunities there it is included in real terms. Again this is included it as monthly changes to avoid problems associated with autocorrelation.

Stock market factor (DIV)

This is used in Elton et al. (1995) as a measure to reflect general economic conditions. However, it is included in many other studies as the proxy for the market portfolio. We have used the monthly change in the dividend yield on companies in the FTSE All-Share index as our stock market factor. Dividend yield is used widely throughout the literature to attempt to predict the returns of different asset classes.

Foreign Exchange factor (FX)

Ferson and Harvey (1993) include currency movements of G-10 countries versus the dollar. Roache (2008) suggest that exchange rate risk may be priced by the stock market and that commodities are argued by some to act as a hedge against a weak U.S. Dollar. Here we have included the change in the logs of the UK GBP Sterling index effective exchange rate index which is an index of the UK Pound's performance versus other currencies on a trade weighted basis.

TED Spread (TED)

Ferson and Harvey (1993) include this factor as they suggest that it may capture fluctuations in credit risk. This indicator was also widely followed during the 2007 financial crises as it represents to some extent the level of risk that is contained in the banking sector. It is calculated as the difference between the three month LIBOR rate and the three month T-bill rate. To reduce autocorrelation it is included in the change in the rate from the previous month in basis point terms.

Change in the VIX Index (VIX)

The VIX Index (the Chicago Board Options Exchange Volatility Index) measures the implicit volatility of options written on the S&P 500 index. This is included in the Amenc et al. (2003) paper as a factor for hedge fund risk exposure. It can also be used as a general proxy for the volatility or risk levels that are likely to seen in the U.S. equity market going forward and in a wider context as a guide to the general level of risk aversion contained within world financial markets. The change in the log of the VIX index is included.

A summary of the explanatory variables is included in Exhibits 5 and 6 below.

[INSERT EXHIBIT 6 + 7 HERE]

5. Methodology

5.1 Background

Firstly univariate regressions were carried out by regressing each asset class on each one of the macroeconomic variables at lags zero to 12. Overall, the independent variables had the most significance at lag zero. Thus the conclusion from this preliminary exercise was that it is worth further investigating the all the variables at lag zero. In the next part of the process models were created using some of the framework laid out in the existing literature. Six models were run using variable combinations identified from the previous work[6]. Using these results and the results from the univarate regressions, two final models were created.

5.2 The Basic Model Econometric Model

Ordinary least squares time-series regressions are run in order to get estimates for the risk parameters. 14 different regressions were run; one for each of the sub-asset classes all of the basic form below.

$$R_{it} = B_{i0} + B_{i1}F_{1t} + \ldots + B_{ik}B_{kt} + e_{it}$$

Where

R_{it} = the realised return on an asset i in month t, t = 1,…,228.

B_{i0} = a constant for asset i.

B_{ij} = the estimated sensitivity (factor beta) of R_{it} to factor j, j =1,…,k (depending upon specific model.

F_{jt} = the measure for systematic factor i in month t and

e_{it} = the residual for asset

In each case the dependent variable is one of the 14 sub-asset classes (R_{it}). While the independent variables (F_{jt}) are macroeconomic factors and the number of these depends on the exact model that is being run but is between four and eight.

5.3 Multicollinearity issues

In Alexander (2008) the possibility that problems due to multicollinearity may arise in fundamental factor models is directly addressed. The presence of multicollinearity does not tend to affect the power of the model in overall term but it does affect individual regression coefficients. These are estimated with reduced precision and the OLS estimator becomes less efficient.

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6 Results available on request.

There is no fully established statistical test for the presence of multicollinearity although it is possible to roughly assess the likelihood of its presence by looking at the correlations between the explanatory variables. In Exhibit 7 above the correlation matrix for the explanatory variables is shown. It is clear that there are a number of correlation coefficients that could perhaps be described to be high; the highest of these is the correlation coefficient between expected inflation and short term interest rates of 0.66. This high correlation does make economic sense as the expected inflation figure is based upon a forecast of short term interest rates. The next highest is that between unexpected inflation and actual inflation (0.65). Two of the other high correlations are between expected inflation and the change in term spreads of -0.52 and expected inflation and the TED spread of -0.54. Expected inflation is also reasonably highly correlated with the foreign exchange factor (has a coefficient of 0.39); perhaps a result of a common interest rate effect. Change in the dividend yield and the change in the VIX index are reasonability high correlated (the coefficient is 0.53) as are the change in unemployment and the change in the short term interest rates (0.40), again these links are ones which one may expect. From this analysis it may be possible to conclude that there may be some multicollinearity issues that will arise especially from the two inflation variables. Many preliminary regressions were performed using replicating ones from the existing literature and also by building up models by adding in factors. By doing this it is possible to discover signs of multicollinearity, there were substantial changes in the estimated regression coefficients when certain explanatory variables were added to some models. The variables that caused notable changes within in the models were (perhaps unsurprisingly) the inflation variables and also the combination of SHORT and TERM. In order to correct for this multicollinearity problem the first decision made was to drop both expected and unexpected inflation from the main model. We are effectively replacing expected and unexpected inflation with actual (realised) inflation thus in theory the amount of information lost should be minimised. Secondly, unexpected inflation appeared to have little predictive power anyway thus removing will have little effect on the model's power; however, it is worth noting that expected inflation did appear to have somewhat more predictive power than actual inflation. Secondly, TERM was included in the final model but SHORT was excluded as its inclusion appeared to influence some of the betas.

5.4 The final models

For the final results, as stated previously; two new models are reported. One of these was deemed to have the best explanatory power across all the asset classes whilst using the best proxies and being as econometrically accurate as possible. This model included seven variables: DIV, FX, OIL, VIX, TERM, ACT_IN and TED. The second was a version of this model that was constrained to having four factors, as in Section 1 the results suggest that only four factors may explain a great deal of the variation of the returns of the asset classes. The four factors that were included are: DIV, SHORT, FX and OIL. Also reported for comparative purposes are the models based upon the factors discussed in the papers; Chen et al. (1986) and Amenc et al. (2003).

6. Results

6.1 The overall explanatory power of the models

In Exhibit 8 a comparison of all the initial models is shown as well as the new models, the adjusted R^2 for each different is shown model for each of the sub-asset classes as well as a simple average for all of them. All the models F-statistics are significant at the one percentage level except are of the models when applied to wine and the Chen et al. (1986) model when Model Three applied to gold. Generally the two best models were those using the factors identified in Ferson and Harvey (1993) and in Amenc et al. (2003). These had an overall R^2 of approximately 0.34 which is marginally higher than that of our full model (0.318) the model using the Chen et al. (1986) factors and the Ling and Naranjo (1997) model. At the asset class level most of the models had high explanatory power when related to equities sub-asset classes, whilst all expect the one using factors based on Ferson and Harvey (1993) explained government bonds well. The returns of index linked bonds were not explained particularly well by any of the models, the maximum R^2 here was 0.33 and models that included the change in expected inflation appeared to perform best. Likewise all the models which included the change in the risk structure of interest rates appeared to have a higher explanatory power in regard to the returns of corporate bonds well than those that do not. The models that include them generally produced an R^2 of around 0.60. Overseas bonds are generally not explained very well by any of the models. Listed real estate was generally explained fairly well were as conversely unlisted real estate was the asset class that was explained the worst apart from wine. The two general commodity indices were explained better by some models than others, the inclusion of OIL as a variable certainly increased a model's explanatory power while the inclusion of SHORT may also have increased it. Hedge funds generally have an R^2 in the low to mid-twenties; however this increases to the low thirties in our main model and in Amenc et al. (2003); this may be a result of the inclusion of VIX.

[INSERT EXHIBIT 8 HERE]

Although looking at the above results is an interesting exercise there are important caveats one must consider. As discussed previously there is a multicollinearity problem with including the variable expected inflation. Although this will not cause the overall models to be less reliable it does affect the individual coefficients accuracy, thus we have removed it from our model. Expected inflation does appear to be a better explanatory variable than actual inflation (which was the alternative included in our model) thus the models that include it are likely to gain some increased explanatory power from this variable. The first three models in table Exhibit 8 did use both expected and unexpected inflation. The second problem with these results is that SHORT, which was also not included in our models due to multicollinearity, has explanatory power beyond TERM. Thirdly, we did not include the RISK variable in our models regarding which may also have made some other models on occasion look superior to mine. As previously discussed our proxy for this variable is noisy so it is likely to represent more than one economic effect. In order to be as prudent as possible in terms of creating our final models we thus did not include RISK. If this variable was included as well as the other eight in the model it would it would increase the average R^2 from 0.318 to 0.335. All of other the models in the above table feature RISK except for Ferson and Harvey (1993).

6.1 Equity

In Exhibit 9 below the detailed regression results for all four of the models are shown in represent of each of the three equity sub-asset classes. The first major point to note is that all the regressions are significant at the one percent level of significant and that there is little deviation in terms of the R^2 of the four models for all three of the assets. Also worth noting is that there is perhaps evidence of multicollinearity in Model 4; the changes in the sign of the variable TERM when compared with the other models may be an indicator of this.

[INSERT EXHIBIT 9 HERE]

The four models for U.K. equities all have a great deal of explanatory power with adjusted R^2 values ranging from 81 to 83 percent. All the models have negative coefficients for dividend yield that are significant at the 1% level. This is what one would expect in terms of these coefficients, the dividend yield of the FTSE All-Share should have a large highly significant effect on the total return of the All-Share index. This is because the dividend yield is calculated as the dividend divided by the price, the total return is also made up of the dividend return as well as the capital return so it is also directly a constituent of the total returns. As the price goes up, the denominator of dividend yield goes up driving it lower as equity prices tend to rise much faster than the dividend pay-out ratios this leads to a negative relationship between equities and dividend yield which we see here. The SHORT variable is also significant at the 1% level in Model 4, the sign being positive, this represents the fact that the opportunity cost of capital is increasing and thus the return on equities should also increase. OIL is also significant at the 1% level in each of the four models; it has a positive sign which may be surprising as it is a direct cost to many firms and thus a rise in its price may reduce profitability. However; as the Oil and Gas sector is the second biggest sector in the FTSE All-Share, making up over 17% of the index (FTSE 2010), the benefits to this sector may cancel out the costs to other companies. Chen et al. (1986) also found a positive link with the oil price. In the case of Model Three, industrial production is significant with a positive sign at the 5% level which is economically feasible. In Model One and Model Four which include VIX, this variable is significant at the 1% level with a negative sign in both cases. As VIX can be thought of as an indicator of perceived risk within the financial markets it tends to have a negative relationship with equities. The only other variable that is significant in terms of U.K. equities is actual inflation in Model One (at the 10% level); it has a positive sign which may imply that domestic equities may be a hedge against domestic inflation.

In terms of general overseas equities the four models explanatory power is substantially less than when they are applied to U.K. equities, here the R^2 values range from 43% to 50%. This is to be expected as the change in the FTSE dividend yield will have a larger effect on U.K. equities. DIV is still significant at the 1% level in all four of the models; this supports the thesis that world stock markets are connected. In this case SHORT is no longer significant in Model Three. FX is significant at least the 10% level in the three models that include it; the negative sign here is likely the result of the fact that as Sterling depreciates the returns in these overseas assets will automatically be bigger in Sterling terms. Oil is only significant in two of the models, one at the 10% and the other at the 5% significance level. Again VIX is significant at the 1% level for both models with a negative coefficient. In respect to overseas equities, in Models Three and Four which contain it as a variable, RISK is significant at the 1% level. The coefficients have negative signs suggesting that as the premium gained for holding lesser quality bonds over those with higher credit ratings decreases, the return on overseas equities goes up; this may be a sign of increased risk tolerance. In the 1st model now actual inflation is significant at the 1% level and also TED is significant at 1%. The coefficient for TED has a negative sign, TED can be thought of a measure of stress in the financial system, as this goes down it will encourage more risk taking in the financial markets. Ferson and Harvey (1993) also find in their study that their TED spread variable has a negative sign for most countries.

Finally addressing emerging market equities one can see in most cases the results are the same as with developed market overseas equities. The same coefficients are significant for DIV, VIX and TED. Only Model 4 has a significant coefficient for FX, perhaps implying that currency moves are less responsible for the returns of emerging market equities to the U.K. investor. The major differences are that RISK is no longer significant, and expected inflation and TERM are significant in Model 1 and 4 at the 1% level.

6.3 Fixed Income

The results in respect to the four fixed income sub-classes are shown in Exhibit 10 below. Again all the regressions are significant at the 1% level but in this case there is large deviation in terms of the R^2 of the four models for all each of the sub-asset classes. In addition to this there is a large range of the explanatory power of the models between regarding different assets. Two general points can be made, firstly, both government and U.K. credit exposed bonds are overall better explained by some of the models than index-linked and overseas bonds. Secondly, Models Three and Four which include the RISK variable in most cases have the most explanatory power.

[INSERT EXHIBIT 10 HERE]

In general Gilts are explained by the three larger models reasonably well with approximate R^2 between 0.50 and 0.71. There is a small significant coefficient for DIV which is significant at the 1% level for Models One, Two and Four and significant at the 10% for Model Three. This implies that there is a slight positive performance between stocks and bonds which may be contrary to some previous findings. SHORT is significant at the 1% level in Model 4 and has a large negative coefficient, this is to be expected as when interest rates fall bond prices move upwards. The foreign exchange variable is significant in all three of the models that include it, it has a negative beta, and this may suggest that the pound weakens due to falling interest rates which have a positive for bond prices. OIL has a small significant negative coefficient which is significant in all of the four models; this may be the result of oil prices being inflationary. The coefficient for VIX is small and positive for the two models that include it and is significant at least the 10% level, as investors tend to buy government bonds when they are being risk adverse this effect is intuitive. TERM is significant at the 1% level in all four models. The coefficient is negative which suggests as the yield curve gets steeper that bonds prices fall, this may be the case as the rates on the longer duration bonds may be rising this their prices will be falling. Elton, Gruber, and Blake (1995) state that interest rate changes are the major cause of the changes in bond portfolios. RISK is also highly significant in the two models that feature it, here the sign is positive, this may be expected as when there is less demand for risky bonds there tends to be more demand for government ones. In the main model TED is significant at the 1% level with a positive sign as with VIX as, in this case financial sector, risk is deemed to be higher the demand for Gilts should increase. Surprisingly unexpected inflation is not significant; Elton, Gruber, and Blake (1995) find a negative relationship with this variable. However expected inflation is significant in Model Three at the 1% level and actual inflation is Model One at the 1% level. Both these variable's signs are negative as higher inflationary expectations or higher realised inflation will have a negative impact on bond values (via expected increased interest rates). Cambell and Ammer (1993) make the point that increases in long-run expected inflation tend to drive the bond market down.

Out of the four fixed income assets, the models overall had the second least explanatory power in respect to index-linked bonds, generally overseas bonds were the most difficult to explain. For the most part the results for index-linked Gilts were largely similar to normal Gilts: DIV, TERM, FX and TED had much the same results. SHORT was now only significant at the 10% level. RISK was no longer significant in any of the models which may be surprising. Realised inflation was not found to have a significant affect upon the returns of index-linked bonds; this is unanticipated since these securities' prices are adjusted to take account of inflation there should be a positive relationship. However; there are two reasons why no link may have been established, firstly; the inflation figures we have used for realised inflation are based on the CPI (RPI is used in the index-linked calculation). Secondly, there the way that the inflation adjustment is applied to the prices if index-linked gilts mean that there is either a three or an eight month lag in the inflation protection. Expected inflation; however, was significant at the 1% level, it has a smaller coefficient than normal Gilts but it is still negative. This negative sign is difficult to explain, even given the problems discussed above. In Reschreiter, (2003) a negative link is suggested of inflation linked bonds and unexpected inflation, although, this is easier to justify than with unexpected inflation.

Following on from these results for inflation-linked bonds, the results for bonds with higher credit risk are very alike although the models had much higher R^2. The only real different in the significance level of the betas relates to SHORT and FX. Unlike both types of Gilts there is no longer a significant relationship with FX except at the 5% level in Model Four. Only different are that RISK and ACT_IN are significant; although these results are comparable to those produced in relation to normal Gilts.

The results for overseas bonds are in many ways the most different from the other fixed incomes sub-classes. Firstly DIV is no longer significant for any of the models. IPRO has a large negative beta (1% level); this is hard to interpret due to the international nature of the returns. The variable SHORT does have a significant negative coefficient, while OIL is not significant. FX is highly significant with large negative coefficient values, as with foreign equities. The coefficient for EX_IN is comparable to those for the other three asset classes. While TERM is highly significant for Models Three and Four and not significant for Models One and Two, this may be a result of effects of multicollinearity. Perhaps a surprising result is that whilst still significant at 5% for both models; RISK now has a negative sign. This may suggest that this may be an asset class which be less highly rated and thus an increase in the risk premium may hurt the price.

6.4 Real Estate

The results from the two real estate sub-classes are shown in Exhibit 11. All four models have F-statistics that are significant at the 1% level for both sub-asset classes, except the application of Model Three to listed real estate (significant at the 5% level). Each of the four models also has a very similar R^2 in regard to listed real estate (between 0.29 and 0.33). The R^2 for direct real estate were very low ranging from 0.028 to 0.085, demonstrating that none of the models have much explanatory power.

[INSERT EXHIBIT 11 HERE]

Like with the results of diversified U.K. equities, listed real estate has a large negative beta for DIV which was significant at the 1% level in all four of the models. This follows from the fact that these are a type of equity and thus will be subject to more general equity market movements. Also significant at the 1% level in Model Four is SHORT; again this reflects that the investment opportunity cost is increasing. However, it is interesting that both TERM and RISK are not significant as these firms tend to use leverage. There is a positive beta for IPRO that is significant at the 1% level; perhaps as generally increasing production will lead to a demand for buildings. OIL was significant at a minimum of the 5% level of significance in all four models, this result is unexpected. TERM is significant in three out of the four models that feature it, thus implying that real estate tends to do well in times where credit risk is perceived to be low. Chan et al. (1990) found that changes in term structure were important in explaining listed real estate returns although there are also contradictory results. In Model Three expected inflation is highly significant with a negative beta, this may contradict some research that both equities and real estate protect against inflation (including Chen et al 1997) or alternatively that there is no significant link either way (Chan et al. 1990).

The results for direct estate were not as one way expect due to the fact that they had very low explanatory power. It is very possible that this may be a result of the unsmoothing process and this will be investigated later in this article. The only significant betas at a maximum of the 5% level are TED (Model One), EX_IN (Model Three) and OIL, in three out of four models. TED has a large negative coefficient and thus it may suggest that real estate performs well during an environment of stable banking markets. EX_IN has a positive beta which may imply that real estate may perform better in inflationary periods. In their study Brooks and Tsolacos (1999) use listed real estate returns net of stock market influences (thus a proxy of the direct market), they find no main macroeconomic variables have any significant explanatory power for this index.

6.5 Commodities

All the four models have F-statistics that are positive at the 1% level for both of the diversified commodity indices. Our main model has slightly more explanatory power (R^2 of 0.26) for the GSCI than for the Reuters Jefferies index (R^2 of 0.24). This general relationship is the same for the other three models as well.

[INSERT EXHIBIT 12 HERE]

The GSCI index shows negative significant coefficients (two out of four at the 5% level plus one at 10%) with DIV. This may suggest that as companies do well that they may increase the demand for and thus price of, commodities. This finding is unlike Bailey and Chan (1993) which finds no connection with a general stock market index. SHORT is also significant in Model Four. As these indices are made up of fully collateralised futures, there will be an element of a return from interest. FX is significant at the one percent level for two of the three models that include it; in addition the other is significant at 5%. The beta here is negative and this is likely because all commodities are priced in terms of U.S. Dollars. In Erb and Harvey (2006) the authors also find a significant beta with respect to a foreign exchange factor as does Roache (2008). OIL is significant at the one percent level in all of the models. The fact that oil futures make up a large part of this index, it is logical that there will be a large positive beta with the change in the spot price of oil. In the two models that include it, there is a negative coefficient (one is significant at the 1% level) with RISK suggesting that commodities may perform better in when there is less expectation of risk in the bond market. Likewise there is a negative coefficient with TED. Although the beta with expected inflation is not significant both, unexpected inflation and actual inflation have positive significant coefficients; expected at the 5% level and actual at the 1% level. Gorton and Rouwenhorst (2006) find a basic positive relationship between commodity futures and all three types of inflation included in this study.

The results for the Thomson Reuters/Jefferies CRB index are alike those for the CSCI; the betas for DIV, RISK and TED are similar but significant at a stronger level while FX's significance level is the same. SHORT is no longer significant which is an unexpected result. The betas for OIL are also highly significant but lower than those with the GSCI; this is because the CRB is a more balanced index whilst the GCSI is more energy focused. Again unexpected inflation is significant at the 5% level but in this case actual inflation is slightly less significant (at the 5% level). Like with the GSCI above no significant results are found with the TERM variable this finding is supported by that in Bailey and Chan (1993).

Addressing the results for gold it is apparent that for models One, Two and Four the regression results are significant at the 1% level, although the F-statistic is not significant using the Chen et al. (1986) factors. This may suggest that FX is a major explanatory factor for gold. The R^2 are low, the best being 0.14 in Amenc et al. (2003). The coefficient for SHORT is significant with negative betas; this suggests that as short term fall gold becomes more valuable; this could be a link between higher gold prices in deflationary environments. All the betas are significant for the FX factor at the 1% level; again this is because gold is priced in U.S. Dollar terms. In Model One there is a large negative, highly significant beta in regard to TED this may suggest that gold may be desired during times of financial crises. Likewise in Model Four there is a significant negative beta with RISK. None of the inflation variables are significant which may challenge some opinions that gold is a good hedge against inflation.

6.6 Hedge Funds

The results for hedge funds are shown in Exhibit 13; all four models have F-statistics that are positive at the 1% level. Model One has an R^2 of 0.33 while Model Four has one of 0.30; the four factor model also has reasonable explanatory power at 0.27. DIV is significant in all the models at the 1% level with negative betas, as many hedge funds hold long equity positions this is understandable. Also significant with negative betas in all the models at the 1% level, is FX. This result will be due to the vast amount of hedge fund positions being in U.S. and other foreign currency terms. In the two models that feature it VIX is significant at least the 5% level of significance with negative betas. Thus as volatility increases hedge funds perform less well, this is intuitive as this is a diversified index; however, it is likely that some individual funds or strategies will perform better if volatility increases. In Schneeweis, Kazemi and Martin (2003), the authors find that all the hedge fund sub-indices a negative coefficient with VIX, except convertible bond arbitrage. TED has a negative coefficient (with is significant at the 1% level), thus this also suggests that hedge funds returns tend to decrease it times of financial risk. There is also a negative relationship with RISK which is also true in Schneeweis, Kazemi and Martin (2003). There is also a positive, significant beta with actual inflation which is perhaps is unintuitive although only at the 10% level.

[INSERT EXHIBIT 13 HERE]

6.7 Wine

Looking at Exhibit 13 it is clear that the returns of wine are not explained by any of models. Each of the models has an F-statistic which is not significant at the 10% or higher level. Thus the returns on wine appear to be driven by factors that are not included in any of these models.

6.8 Unadjusted Indices

In Exhibit 14 below the results of using the factor models on the original versions of the indices that were included as desmoothed versions above are shown. It is useful to compare these with the adjusted versions in order to see how the desmoothing process has affected the regression results.

[INSERT EXHIBIT 14 HERE]

Real Estate (Unadjusted Index)

When the factor models were applied to the desmoothed real estate index all four models had even little explanatory power. The best model was Model One with an R^2 of 0.09. Overall only the adjusted returns for wine were explained by the four models to an even less extent. The results for the unadjusted indices; however, are different to these. Firstly the first three models have slightly higher explanatory power; all with R^2 in the region of 0.15. Model Four; however, has a much higher R^2 of 0.41. Considering Models One, Two and Three the variables that are generally significant are: DIV, TERM and FX. These results suggest that a negative relationship with DIV and TERM and a positive one with FX are some of the factors driving the returns. All of these are feasible relationships with the stock market factor a proxy for firm health and a flattening yield curve good for financing opportunities. The result using the adjusted series found the FX variable and expected inflation to be significant; none of these betas are significant when the models are applied to the original unadjusted index data. This may prove that in this case the desmoothing techniques that were used on the real estate data in order to correct for the understated volatility has also changed the econometric structure of the returns. The desmoothing technique used for the hedge fund data was the most severe and it also changed the mean of the returns so perhaps this is unsurprising. What is most interesting is Model 4; here the very large R^2 is being driven by SHORT. This is likely to be the result of another problem, which is that since the original index returns are highly autocorrelated and SHORT is the most autocorrelated explanatory variable the large R^2 values may be a result of this autocorrelation. Thus the regression results may be biased anyway in the case. Secondly, in model Four there is the peculiar result that TERM is significant but with a positive beat whilst Models One, Two and Three have negative betas. This is likely to be a result a multicollinearity effect as SHORT is included although with TERM.

Hedge Funds (Unadjusted Index)

Desmoothing the hedge fund index has some effect on the results of the regressions. In this case the R^2 values are higher when the models are applied to the desmoothed index rather than the unadjusted one, for example the R^2 for Model One was 0.32 using the desmoothed data, while it was 0.27 using the original index data. Here the increased volatility structure of the returns may help price discovery and thus increase the model's power. One of the only coefficients to vastly change their significance levels from using adjusted to original index data are using the original data is RISK. This is now significant at a minimum of the 5% level in the two models where it is a variable, were as it was not significant using the desmoothed series. It is possible that this result may have been a consequence of the fact that there the original series is autocorrelated and thus this result does not appear in when the desmoothed data is analysed. VIX is no longer significant using the original data whereas it significant in both models that include it at the 1% level using the desmoothed data. This suggests that by desmoothed the data and thus adding volatility to it, there is now a connection to the VIX index which is a measure of equity market volatility.

Wine (Unadjusted Index)

When the models are applied to the unadjusted wine index there is little difference between the results.

7. Conclusion

The purpose of this study was to attempt to build up a better understanding of how a wide range of asset classes react to changes in macroeconomic factors in respect to returns to a U.K. based investor. After a long process a seven factor model and a four factor model were designed in order to best explain the asset class returns whilst being as econometrically correct as possible. The seven factor model had a simple average R^2 of 0.32 over the 14 asset classes. This value varied considerably from asset to asset. Some of the more traditional sub-asset classes had were explained reasonably well, for example U.K. equities (R^2 is 0.83), developed market overseas equities (0.50) and U.K. government bonds (0.50). Emerging market equities (0.37), Index-Linked (0.29) and overseas bonds (0.23) were explained less well. Listed real estate had an R^2 of 0.29 but directly held real estate returns were very poorly explained by the models both in original and desmoothed terms. Out of the 'alternative assets'; hedge funds had the highest level of explanatory power at 0.33, commodities were fairly low, while gold was the second lowest at 0.13. The returns of wine were not explained at all by the models, this result should be investigated further in the future. Direct real estate, gold and wine appear not to be driven by traditional economic variables at least not in a linear way. These may thus have portfolio diversifying benefits, although further investigation is required

Generally dividend yield and the change in terms spreads were the factors that had the most influence on the assets; however, these were not significant for all sub-asset classes. The change in the oil price and a foreign exchange factor were the next influence and these four factors made up the reduced models. Some of the other variables were important in explaining a particular asset classes' returns. Most of the individual coefficient results were supported by the existing literature or had economic logic but some warrant further investigation.

An important point that was highlighted is that the choice of desmoothing method appears as if it can considerably affect the results of factor analysis work. This is worth noting for future work.

This information can be used to better understand what asset classes are likely to do during different economic environments. It gives a better understanding to the relationship in the asset correlation matrix. For example the correlation of 0.44 between overseas bonds and overseas equities is at least partly driven by the fact they are independently driven by the foreign exchange factor (as one may have hypothesised).

8. Further Work

In addition to be points raised above in term of specific results that may warrant further investigation, this work with be improved by using a more complex method. Firstly, investigating how the regression coefficients change over time may be worthwhile. Secondly, initial Granger Causality tests suggest that there may be justification for the application of a vector autoregression (VAR) technique to this data set.

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Exhibits

Exhibit 1- Principle Component Analysis of All Asset Classes

Value	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10	PC 11	PC 12	PC 13	PC 14
Eigenvalue	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% of variation	39.46	17.18	12.18	9.73	6.96	5.08	2.87	2.08	1.78	0.99	0.78	0.51	0.32	0.07
Cumulative %	39.46	56.64	68.82	78.55	85.51	90.59	93.46	95.54	97.32	98.31	99.09	99.61	99.92	99.99
Eigenvectors:														
E_UK	0.24	0.38	-0.04	-0.03	0.13	-0.06	0.23	-0.10	-0.63	0.11	-0.25	-0.48	0.10	-0.04
E_OS	0.38	0.15	-0.15	0.12	0.00	-0.14	0.56	-0.31	0.04	-0.09	0.49	0.29	-0.19	-0.03
E_EM	0.52	0.24	-0.27	0.37	0.25	0.12	-0.53	0.19	0.17	-0.07	0.16	-0.12	0.01	0.00
B_GVT	0.01	0.04	0.00	-0.02	-0.10	-0.13	0.03	0.49	-0.14	-0.03	-0.03	0.11	-0.41	-0.72
B_IL	0.04	0.05	0.04	-0.05	-0.09	-0.04	0.09	0.49	-0.26	-0.21	0.24	0.30	0.69	0.05
B_CRT	0.03	0.07	0.02	-0.03	-0.05	-0.06	0.05	0.44	-0.20	-0.07	-0.06	0.11	-0.52	0.68
B_OS	0.15	-0.19	-0.09	0.02	-0.34	-0.20	0.33	0.31	0.43	0.02	0.05	-0.61	0.10	0.06
REL	0.23	0.55	0.28	-0.52	-0.40	-0.10	-0.22	-0.10	0.24	0.02	-0.04	0.08	0.01	0.01
RE	0.05	0.10	0.19	0.03	-0.12	0.92	0.25	0.12	0.06	0.09	0.05	-0.05	-0.05	-0.05
C_GS	0.41	-0.41	0.37	-0.41	0.43	-0.03	-0.03	0.10	-0.02	0.35	0.18	-0.02	-0.02	0.00
C_RJ	0.33	-0.27	0.10	-0.14	0.03	0.10	0.04	-0.12	0.00	-0.79	-0.36	-0.01	-0.03	-0.04
GOLD	0.28	-0.41	-0.15	0.06	-0.64	0.08	-0.27	-0.18	-0.40	0.17	0.10	0.04	-0.04	0.01
HF	0.31	-0.03	-0.16	0.16	-0.02	-0.04	0.21	0.08	0.19	0.37	-0.66	0.42	0.15	0.02
WINE	0.06	0.03	0.77	0.60	-0.11	-0.18	-0.01	-0.04	-0.03	0.00	-0.02	-0.02	0.01	0.00

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Exhibit 2- Principle Components Explaining Variances of All Asset Classes

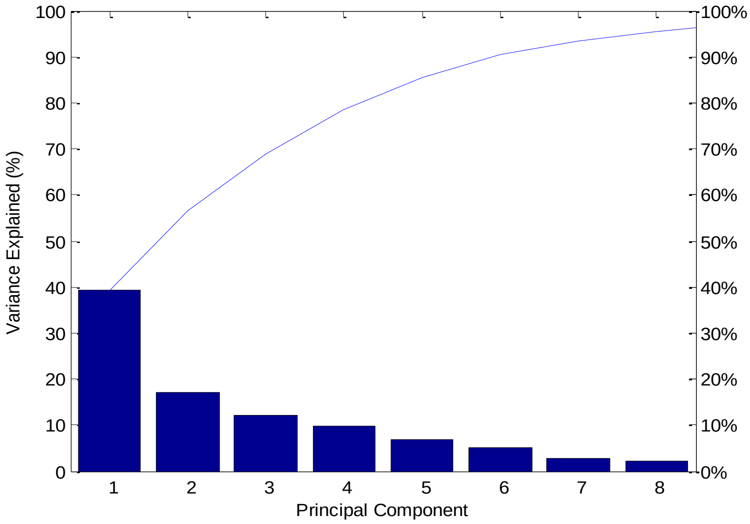

Exhibit 3- Summary of the macroeconomic factors used in the most relevant literature

Reference	Asset Class	Geo.	Explanatory Variables included																
			Δ in industrial production or similar	Consumption	Rate of unemployment	Δ in unexpected inflation	Δ in expected inflation	Expected inflation	Δ in risk premia of interest rates	Δ in term structure of interest rates	Yield on 3 month T-bills	TED spread	Oil Prices	Stock market Factor (inc. div. yield)	index of aggregate bond returns	mortgage sec.relative govt. bonds	Δ in the VIX index	A foreign exchange measure	Market volume
Chen et al. (1986)	Equities	US	×	×		×	×		×	×			×	×					
Ferson and Harvey (1993)	Equities	Global	×			×	×				×	×	×	×					
Elton et al. (1995)	Fixed Income	US	×			×			×	×				×	×	×			
Chan et al. (1990)	Indirect RE	US	×			×	×		×	×				×					
Chen et al. (1997)	Indirect RE	US				×	×		×	×				×					
Ling and Naranjo (1997)	In./ direct RE	US	×	×		×	×	×	×	×	×			×					
Brooks and Tsolacos (1999)	Indirect RE	UK			×	×				×				×					
Bailey and Chan (1993)	Commodities	US	×			×	×		×	×				×					
Roache (2008)	Commodities	US					×				×			×				×	
Schneeweis et al. (2003)	Hedge Funds	US							×	×				×			×		
Amenc et al. (2003)	Hedge Funds	US							×	×	×		×	×			×	×	×

Exhibit 4- Summary statistics of the sub-asset classes

	E_UK	E_OS	E_EM	B_GVT	B_IL	B_CRT	B_OS	REL	RE	C_GS	C_RJ	GOLD	HF	WINE
Mean	*0.007*	*0.006*	*0.018*	*0.007*	*0.006*	*0.007*	*0.006*	*0.004*	*0.008*	*0.003*	*0.003*	*0.005*	*0.010*	*0.011*
Standard Dev.	*0.042*	*0.044*	*0.064*	*0.016*	*0.019*	*0.015*	*0.019*	*0.061*	*0.040*	*0.062*	*0.038*	*0.043*	*0.028*	*0.058*
Kurtosis	*1.111*	*2.734*	*3.617*	*0.744*	*4.348*	*1.134*	*0.437*	*2.512*	*6.756*	*3.420*	*9.613*	*2.531*	*2.432*	*11.680*
Skew	*-0.753*	*-1.073*	*-1.039*	*-0.133*	*0.162*	*-0.395*	*0.090*	*-0.524*	*-0.575*	*-0.748*	*-1.404*	*-0.003*	*-0.718*	*1.204*
Autocorr. 1	0.11	0.13	0.26	0.08	0.04	0.12	0.13	0.23	0.06	0.22	0.22	-0.13	-0.02	-0.12
Autocorr. 2	-0.07	-0.01	0.23	-0.10	-0.27	-0.07	-0.08	0.00	-0.10	0.06	0.18	-0.04	0.07	0.10
Autocorr. 3	0.00	0.11	0.15	0.10	0.01	0.09	0.00	0.08	0.20	0.15	0.16	0.02	-0.01	0.19
Autocorr. 4	0.18	0.09	0.08	0.03	0.10	0.10	-0.08	0.22	-0.10	0.06	0.14	-0.01	0.06	-0.02
Autocorr. 5	0.02	0.04	0.02	-0.02	0.08	0.02	-0.13	0.11	-0.04	0.04	-0.05	0.00	-0.04	0.12
Autocorr. 6	-0.04	-0.07	-0.06	-0.09	-0.11	-0.03	-0.06	-0.10	0.16	0.03	-0.07	-0.01	0.03	0.04
Autocorr. 9	0.03	-0.02	0.09	0.01	0.03	-0.03	0.13	0.01	-0.03	-0.08	-0.17	-0.06	0.07	0.01
Autocorr. 12	0.06	0.07	0.03	-0.01	-0.03	-0.05	-0.12	0.03	0.22	-0.17	-0.22	0.08	-0.06	-0.04

Exhibit 5- Correlation matrix of the sub-asset classes

	E_UK	*E_OS*	*E_EM*	*CASH*	*B_GVT*	*B_IL*	*B_CRT*	*B_OS*	*REL*	*RE*	*C_GS*	*C_RJ*	*GOLD*	*HF*	*WINE*
E_UK	1														
E_OS	0.70	1.00													
E_EM	0.64	0.76	1.00												
CASH	0.02	0.02	0.09	1.00											
B_GVT	0.16	0.03	0.04	0.20	1.00										
B_IL	0.30	0.20	0.14	0.04	0.66	1.00									
B_CRT	0.38	0.15	0.17	0.14	0.86	0.67	1.00								
B_OS	-0.05	0.44	0.23	0.10	0.27	0.21	0.12	1.00							
REL	0.59	0.36	0.28	-0.10	0.23	0.33	0.36	0.01	1.00						
RE	0.13	0.06	0.11	-0.13	-0.15	0.11	0.06	-0.12	0.20	1.00					
C_GS	0.16	0.36	0.32	-0.01	-0.07	0.14	0.02	0.32	0.14	0.04	1.00				
C_RJ	0.21	0.53	0.47	-0.04	-0.09	0.14	0.00	0.49	0.14	0.12	0.82	1.00			
GOLD	-0.04	0.35	0.32	-0.10	0.03	0.10	-0.05	0.65	-0.03	0.02	0.39	0.62	1.00		
HF	0.49	0.80	0.78	0.11	0.08	0.13	0.13	0.57	0.15	0.06	0.44	0.61	0.53	1.00	
WINE	0.02	0.05	0.06	-0.08	0.01	0.08	0.07	-0.01	0.08	0.17	0.12	0.08	-0.01	0.04	1.00

Exhibit 6- Summary statistics of the macroeconomic factors used

	DIV	*IPRO*	*UNEM*	*SHORT*	*FX*	*OIL*	*VIX*	*TERM*	*TED*	*RISK*	*EX_IN*	*ACT_IN*	*UNEX_IN*
Mean	*-0.002*	*0.000*	*-0.001*	*-0.015*	*-0.001*	*0.005*	*-0.001*	*0.000*	*-0.001*	*0.000*	*0.000*	*0.002*	*0.000*
Standard Dev.	*0.049*	*0.009*	*0.031*	*0.076*	*0.016*	*0.082*	*0.166*	*0.003*	*0.250*	*0.024*	*0.003*	*0.008*	*0.012*
Autocorr. 1	0.11	-0.14	0.52	0.56	0.26	0.25	-0.13	0.21	-0.08	-0.37	0.32	0.04	-0.47
Autocorr. 2	-0.11	0.00	0.09	0.42	0.00	0.12	-0.13	0.11	-0.30	-0.20	0.11	0.07	0.07
Autocorr. 3	-0.01	0.16	-0.05	0.37	0.10	0.03	-0.10	0.19	-0.03	0.08	0.12	-0.05	-0.02
Autocorr. 4	0.20	-0.01	0.03	0.21	0.12	-0.05	-0.01	0.07	0.12	0.01	0.12	-0.07	0.02
Autocorr. 5	0.00	0.07	0.26	0.11	-0.10	-0.05	0.05	-0.05	-0.11	0.02	-0.02	-0.11	-0.09
Autocorr. 6	-0.01	0.06	0.47	0.07	-0.14	-0.12	-0.07	0.06	-0.02	-0.03	-0.15	0.05	0.06
Autocorr. 9	0.04	0.07	-0.21	0.03	0.07	-0.06	0.01	-0.12	-0.03	-0.10	-0.09	0.01	0.03
Autocorr. 12	0.06	-0.03	0.71	-0.08	0.05	-0.03	0.05	0.00	-0.06	-0.13	-0.19	-0.25	-0.20

Exhibit 7- Correlation matrix of the macroeconomic factors used

	DIV	*IPRO*	*UNEM*	*SHORT*	*FX*	*OIL*	*VIX*	*TERM*	*TED*	*RISK*	*EX_IN*	*ACT_IN*	*UNEX_IN*
DIV	1.00												
IPRO	-0.07	1.00											
UNEM	-0.04	-0.18	1.00										
SHORT	0.12	0.29	-0.40	1.00									
FX	0.09	0.12	-0.15	0.36	1.00								
OIL	-0.03	0.12	-0.02	0.23	0.15	1.00							
VIX	0.53	-0.06	-0.03	-0.02	0.01	-0.12	1.00						
TERM	0.04	-0.13	0.14	-0.53	-0.24	-0.10	0.04	1.00					
TED	0.04	0.01	-0.05	-0.22	0.13	-0.14	0.15	0.22	1.00				
RISK	-0.27	-0.06	0.09	-0.19	-0.02	0.07	-0.13	-0.27	0.23	1.00			
EX_IN	0.13	0.12	-0.12	0.66	0.39	0.23	-0.09	-0.52	-0.54	-0.20	1.00		
ACT_IN	0.06	0.05	-0.21	0.18	-0.02	0.03	0.02	-0.02	-0.04	-0.13	0.10	1.00	
UNEX_IN	-0.07	0.00	-0.02	-0.20	-0.17	0.01	0.06	0.13	0.07	0.06	-0.27	0.65	1.00

Exhibit 8- Adjusted R-squared values for all of the models run initially based on factors identified in the papers stated

Article	Chen et al. (1986)	Ferson and Harvey (1993)	Ling and Naranjo (1997)	Brooks and Tsolacos (1999)	Schneeweis et al. (2003)	Amenc et al. (2003)	Elliott Marcato 1	Elliott Marcato 2
Focus	In./ direct RE	In./ direct RE	In./ direct RE	Real Estate	Hedge Funds	Hedge Funds	All Assets	All Assets
E_UK	0.819	0.832	0.823	0.807	0.828	0.838	0.829	0.816
E_OS	0.456	0.456	0.459	0.435	0.457	0.503	0.499	0.432
E_EM	0.339	0.33	0.337	0.316	0.340	0.351	0.371	0.317
B_GVT	0.713	0.151	0.765	0.150	0.589	0.644	0.497	0.342
B_IL	0.330	0.090	0.321	0.081	0.236	0.288	0.287	0.260
B_CRT	0.610	0.170	0.626	0.182	0.481	0.569	0.410	0.343
B_OS	0.118	0.350	0.175	0.038	0.096	0.305	0.227	0.217
REL	0.331	0.080	0.346	0.269	0.305	0.311	0.292	0.291
RE	0.057	0.261	0.042	0.054	0.024	0.037	0.085	0.028
C_GS	0.225	0.236	0.061	0.037	0.044	0.255	0.258	0.222
C_RJ	0.154	0.236	0.079	0.057	0.044	0.202	0.239	0.153
GOLD	0.016	0.127	0.068	0.008	0.032	0.138	0.134	0.092
HF	0.217	0.266	0.224	0.207	0.232	0.301	0.325	0.272
WINE	0.019	-0.081	0.014	0.010	-0.004	0.012	-0.007	0.003
Average	0.314	0.250	0.310	0.189	0.265	0.340	0.318	0.271

All regressions are significant at a minimum of the 5% level, except all the models applied to WINE and three applied to GOLD.

Exhibit 9- Results of the regressions for the equity sub-classes

Asset Class	R-squared	F stat	C	DIV	IPRO	SHORT	FX	OIL	VIX	TERM	RISK	EX_IN	UNEX_IN	ACT_IN	TED
E_UK															
1/ Full	0.8292	158.4659***	0.0048***	-0.7176***	-	-	-0.0505	0.0631***	-0.0301***	-0.7256*	-	-	-	0.3659***	0.0049
2/ 4 Factor	0.8163	253.2273***	0.0052***	-0.7667***	-	-	-0.0362	0.0686***	-	-0.6654	-	-	-	-	-
3/ Chen et al.	0.8187	147.4657***	0.0053***	-0.7641***	0.3040**	-	-	0.0620***	-	-0.4395	0.0046	0.2633	0.1186	-	-
4/ Amenc et al.	0.8381	168.8303***	0.0063***	-0.7261***	-	0.0915***	-0.1221	0.0486***	-0.0269***	0.6059	0.0813	-	-	-	-
E_OS															
1/ Full	0.4995	33.3592***	0.0033***	-0.5465***	-	-	-0.2667*	0.0357*	-0.0538***	0.5107	-	-	-	0.7894***	-0.0317***
2/ 4 Factor	0.4320	44.1613***	0.0043***	-0.6343***	-	-	-0.3813**	0.0638**	-	-0.2673	-	-	-	-	-
3/ Chen et al.	0.4559	28.1724***	0.0045*	-0.7045***	-0.0357	-	-	0.0498*	-	-0.1394	-0.3911***	1.1802	0.2418	-	-
4/ Amenc et al.	0.5034	33.8757***	0.0053**	-0.5905***	-	0.0563	-0.4892***	0.0485*	-0.0583***	-0.4211	-0.3856***	-	-	-	-
E_EM															
1/ Full	0.3708	20.1139***	0.0148***	-0.6105***	-	-	-0.3091	0.0490	-0.0813***	2.8310**	-	-	-	0.5827	-0.0412***
2/ 4 Factor	0.3171	27.3537***	0.0154***	-0.7497***	-	-	-0.4478	0.0865	-	1.8472	-	-	-	-	-
3/ Chen et al.	0.3387	17.6077**	0.0150***	-0.7887***	0.6597	-	-	0.0309	-	5.0584***	0.0515	5.0458***	0.4790	-	-
4/ Amenc et al.	0.3508	18.5252***	0.0164***	-0.6197***	-	0.0559	-0.5324**	0.0613	-0.0893***	2.2504	-0.1393	-	-	-	-

R^2 values are adjusted for degrees of freedom. The asterisks indicates whether the coefficient is significant at the 10% (*), 5% (**) or 1% (***) levels respectfully

Exhibit 10- Results of the regressions for the fixed income sub-classes

Asset Class	R-squared	F stat	C	DIV	IPRO	SHORT	FX	OIL	VIX	TERM	RISK	EX_IN	UNEX_IN	ACT_IN	TED
B_GVT															
1/ Full	0.4969	33.0321***	0.0075***	-0.0766***	-	-	-0.3134***	-0.0280***	0.0101*	-3.2342***	-	-	-	-0.2772***	0.0230***
2/ 4 Factor	0.3418	30.4697***	0.0071***	-0.0609***	-	-	-0.2316***	-0.0412***	-	-2.7102***	-	-	-	-	-
3/ Chen et al.	0.7131	81.6095***	0.0078***	-0.0216*	-0.0765	-	-	-0.0225***	-	-4.0514***	0.1096***	-3.5990***	-0.0412	-	-
4/ Amenc et al.	0.6443	59.7311***	0.0059***	-0.0424***	-	-0.1083***	-0.1054**	-0.0252***	0.0120***	-3.6594***	0.1501***	-	-	-	-
B_IL															
1/ Full	0.2870	14.0556***	0.0063***	-0.1062***	-	-	-0.3698***	0.0152	0.0103	-2.8702***	-	-	-	-0.0720	0.0124***
2/ 4 Factor	0.2603	20.9751***	0.0062***	-0.0883***	-	-	-0.3278***	0.0073	-	-2.5901***	-	-	-	-	-
3/ Chen et al.	0.3299	16.9674***	0.0069***	-0.0714	0.0052	-	-	0.0184	-	-3.6749***	-0.0023	-2.8516***	0.0367	-	-
4/ Amenc et al.	0.2884	14.1433***	0.0058***	-0.0937***	-	-0.0325*	-0.2852***	0.0135	0.0120	-2.8101***	0.0765	-	-	-	-
B_CRT															
1/ Full	0.4097	23.5066***	0.0073***	-0.1263***	-	-	-0.1737	-0.0018	0.0047	-2.6247***	-	-	-	-0.2078**	0.0152***
2/ 4 Factor	0.3430	30.6210***	0.0070***	-0.1198***	-	-	-0.1188**	-0.0102	-	-2.2773***	-	-	-	-	-
3/ Chen et al.	0.6101	51.7526***	0.0074***	-0.0783**	-0.0244	-	-	-0.0007	-	-2.8153***	0.1956***	-2.0894***	0.0138	-	-
4/ Amenc et al.	0.5693	43.8612***	0.0063***	-0.0898***	-	-0.0599***	-0.0333	-0.0035	0.0056	-2.4892***	0.2246***	-	-	-	-
B_OS															
1/ Full	0.2271	10.5285***	0.0057***	-0.0328	-	-	-0.9408***	-0.0347	0.0287**	-0.6198	-	-	-	0.1568	-0.0113
2/ 4 Factor	0.2173	16.7538***	0.0061***	0.0194	-	-	-0.9865***	-0.0354	-	-0.8594	-	-	-	-	-
3/ Chen et al.	0.1176	5.3238***	0.0074***	-0.0291	-0.7188***	-	-	-0.0256	-	-2.5498***	-0.3596***	-3.4701***	0.2739	-	-
4/ Amenc et al.	0.3051	15.2405***	0.0044**	-0.0402	-	-0.1511***	-0.8743***	-0.0037	0.0234*	-3.4647***	-0.3694***	-	-	-	-

R^2 values are adjusted for degrees of freedom. The asterisks indicates whether the coefficient is significant at the 10% (*), 5% (**) or 1% (***) levels respectfully

Exhibit 11- Results of the regressions for the real estate sub-classes

Asset Class	R-squared	F stat	C	DIV	IPRO	SHORT	FX	OIL	VIX	TERM	RISK	EX_IN	UNEX_IN	ACT_IN	TED
REL															
1/ Full	0.2916	14.3463***	0.0020	-0.6659***	-	-	-0.2204	0.0957**	0.0139	-3.0685**	-	-	-	0.5129	0.0163
2/ 4 Factor	0.2909	24.2826***	0.0028	-0.6349***	-	-	-0.1770	0.0872**	-	-2.7477**	-	-	-	-	-
3/ Chen et al.	0.3309	17.0366***	0.0036	-0.6150***	1.3928***	-	-	0.0861**	-	-3.7996***	-0.1381	-2.6154*	0.1728	-	-
4/ Amenc et al.	0.3106	15.6071***	0.0047	-0.6965***	-	0.1777***	-0.3399	0.0653***	0.0222	-0.4697	0.0918	-	-	-	-
RE															
1/ Full	0.0854	4.0292***	0.0069***	-0.0438	-	-	0.3075*	0.0713**	0.0021	0.8198	-	-	-	0.2522	-0.0434***
2/ 4 Factor	0.0281	2.6400**	0.0073***	-0.0389	-	-	0.1551	0.0909***	-	-0.1367	-	-	-	-	-
3/ Chen et al.	0.0569	2.9578***	0.0067**	-0.0598	0.2065	-	-	0.0692**	-	1.2573	-0.0149	3.2740***	0.2579	-	-
4/ Amenc et al.	0.0367	2.2370***	0.0082***	-0.0530	-	0.0823*	0.0646	0.0788**	-0.0059	0.6812	-0.0696	-	-	-	-

R^2 values are adjusted for degrees of freedom. The asterisks indicates whether the coefficient is significant at the 10% (*), 5% (**) or 1% (***) levels respectfully

Exhibit 12- Results of the regressions for the commodity sub-classes

Asset Class	R-squared	F stat	C	DIV	IPRO	SHORT	FX	OIL	VIX	TERM	RISK	EX_IN	UNEX_IN	ACT_IN	TED
C_GS															
1/ Full	0.2580	12.2758***	-0.0014	-0.1686*	-	-	-0.5987**	0.3568***	0.0236	-0.2419	-	-	-	1.3532***	-0.0341**
2/ 4 Factor	0.2219	17.1816***	0.0008	-0.1127	-	-	-0.7440***	0.3712***	-	-1.0700	-	-	-	-	-
3/ Chen et al.	0.2254	10.4364***	0.0017	-0.1797**	0.0320	-	-	0.3638***	-	-2.2530	-0.5270***	-1.2496	0.7223**	-	-
4/ Amenc et al.	0.2545	12.0732***	0.0023	-0.2189**	-	0.1395**	-0.9179***	0.3603***	0.0204	-0.1958	-0.3420*	-	-	-	-
C_RJ															
1/ Full	0.2393	11.2034***	0.0002	-0.1538**	-	-	-0.4903***	0.1528***	0.0085	0.7300	-	-	-	0.8135**	-0.0506***
2/ 4 Factor	0.1532	11.2665***	0.0015	-0.1316**	-	-	-0.6787***	0.1760***	-	-0.4204	-	-	-	-	-
3/ Chen et al.	0.1539	6.8975***	0.0021	-0.2014***	-0.1356	-	-	0.1605***	-	-0.6523	-0.4203***	0.3136	0.6026**	-	-
4/ Amenc et al.	0.2018	9.1961***	0.0024	-0.1918***	-	0.0773	-0.7960***	0.1698***	-0.0002	-0.3061	-0.3604***	-	-	-	-
GOLD															
1/ Full	0.1338	6.0108***	0.0036	-0.0542	-	-	-0.9161***	-0.0039	0.0270	1.6520	-	-	-	0.3298	-0.0511***
2/ 4 Factor	0.0920	6.7528***	0.0042	-0.0047	-	-	-1.0999***	0.0140	-	0.5384	-	-	-	-	-
3/ Chen et al.	0.0162	1.5355	0.0054	-0.0701	-0.3162	-	-	0.0046	-	-0.1841	-0.3981**	-1.7823	0.4439	-	-
4/ Amenc et al.	0.1378	6.1814***	0.0023	-0.0586	-	-0.1842***	-0.9753***	0.0502	0.0119	-2.8168**	-0.5361***	-	-	-	-

R^2 values are adjusted for degrees of freedom. The asterisks indicates whether the coefficient is significant at the 10% (*), 5% (**) or 1% (***) levels respectfully

Exhibit 13- Results of the regressions for hedge funds and wine

Asset Class	R-squared	F stat	C	DIV	IPRO	SHORT	FX	OIL	VIX	TERM	RISK	EX_IN	UNEX_IN	ACT_IN	TED
HF															
1/ Full	0.3248	16.5989***	0.0083***	-0.2847***	-	-	-0.5576***	0.0040	-0.0365**	1.3359*	-	-	-	0.4679*	-0.0268***
2/ 4 Factor	0.2725	22.2521***	0.0088***	-0.3452***	-	-	-0.6521***	0.0252	-	0.6983	-	-	-	-	-
3/ Chen et al.	0.2168	9.9766***	0.0093***	-0.3868***	-0.2170	-	-	0.0112	-	0.9252	-0.1821*	0.0975	0.3394*	-	-
4/ Amenc et al.	0.3010	14.9662***	0.0088***	-0.2912***	-	-0.0289	-0.6543***	0.0231	-0.0430***	-0.0978	-0.2185**	-	-	-	-
WINE															
1/ Full	-0.0069	0.7773	0.0107***	0.0229	-	-	0.1336	0.0606	-0.0030	-1.4287	-	-	-	0.3471	-0.0076
2/ 4 Factor	0.0029	1.1672	0.0112***	0.0212	-	-	0.1014	0.0658	-	-1.6225	-	-	-	-	-
3/ Chen et al.	0.0185	1.6114	0.0106**	0.0624	0.1865	-	-	0.0408	-	0.5250	0.4377**	2.8648*	0.3185	-	-
4/ Amenc et al.	0.0120	1.3941	0.0120***	0.0651	-	0.0844	0.0626	0.0471	-0.0047	0.2697	0.4070**	-	-	-	-

R^2 values are adjusted for degrees of freedom. The asterisks indicates whether the coefficient is significant at the 10% (*), 5% (**) or 1% (***) levels respectfully

Exhibit 14- Results of the regressions for the unadjusted versions of the real estate, hedge funds and wine proxies

	R-squared	F stat	C	DIV	IPRO	SHORT	FX	OIL	VIX	TERM	RISK	EX_IN	UNEX_IN	ACT_IN	TED
RE_S															
1/ Full	0.1534	6.8744***	0.0061***	-0.0418***	-	-	0.2096***	0.0173	0.0062	-0.5916**	-	-	-	0.1342	-0.0025
2/ 4 Factor	0.1484	10.8899***	0.0063***	-0.0294***	-	-	0.1974***	0.0175**	-	-0.6532***	-	-	-	-	-
3/ Chen et al.	0.1698	7.6306***	0.0061***	-0.0312**	0.3057***	-	-	0.0139	-	-0.4757*	-0.0352	0.7935**	0.0270	-	-
4/ Amenc et al.	0.4116	23.6858***	0.0074***	-0.0601***	-	0.1046***	0.0984**	0.0039	0.0084*	0.6420**	0.0320	-	-	-	-
HF_S															
1/ Full	0.2724	13.1437***	0.0084***	-0.2359***	-	-	-0.4634***	0.0019	-0.0063	1.6226**	-	-	-	0.4589**	-0.0307***
2/ 4 Factor	0.2177	16.7921***	0.0091***	-0.2430***	-	-	-0.5755***	0.0183	-	0.9192	-	-	-	-	-
3/ Chen et al.	0.1766	7.9565***	0.0096***	-0.2908***	-0.3351	-	-	0.0081	-	0.9125	-0.2361**	0.1011	0.3238*	-	-
4/ Amenc et al.	0.2379	11.1204***	0.0091***	-0.2493***		-0.0154	-0.5909***	0.0212	-0.0131	0.1824	-0.2558***	-	-	-	-
WINE_S															
1/ Full	0.0217	1.7205	0.0109***	0.0387	-	-	0.1779	0.0431	0.0024	-1.1383	-	-	-	0.1552	-0.0094
2/ 4 Factor	0.0289	2.6893**	0.0111***	0.0443	-	-	0.1426	0.0473*	-	-1.3526*	-	-	-	-	-
3/ Chen et al.	0.0266	1.8857*	0.0107***	0.0589	0.0627	-	-	0.0377	-	-0.4228	0.1695	1.5122	0.0829	-	-
4/ Amenc et al.	0.0325	2.0905**	0.0118***	0.0526	-	0.0642	0.0986	0.0359	0.0009	-0.2111	0.1756*	-	-	-	-

R^2 values are adjusted for degrees of freedom. The asterisks indicates whether the coefficient is significant at the 10% (*), 5% (**) or 1% (***) levels respectfully