Explaining the Funding Ratio

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Summary

In this paper, we investigate which risk factors drive the funding ratios of Dutch pension funds. We analyze policy funding ratios of a large number of Dutch pension funds over the past decade and demonstrate, on the basis of historical data, that the traditional risk factors such as bond yields and equity returns explain a large part of the funding ratio change. It is shown that simple combinations of these main factors explain most of the funding ratio variation, and therefore, simple investment strategies can be sufficient in achieving industry-average results.

Our results also show that matching the pension fund's portfolio perfectly against the liabilities (i.e., hedging away interest rate risk) does not reduce the performance of the funding ratio. In fact, entirely matching the liabilities diminishes the volatility of the funding ratio.

Furthermore, our investigation suggests that pension fund investors should consider being more exposed to investments other than highly rated bonds, as equity and high yield bond exposure significantly enhances the funding ratio performance, especially in the long term. Finally, considering alternative equity-like investments such as real estate and private equity can further improve the coverage ratio and significantly contribute to the asset diversification.

We would like to stress that ours is a high-level investigation, which does not go into fine detail of more complex pension funds' portfolios, but we believe that our results are quite generic and demonstrate clearly our point about simplicity above complexity.

PROBABILITY & PARTNERS

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Introduction

The financial position of Dutch pension funds has been deteriorating in the past few years, due to persistently low interest rates which led to loss of income from fixed income securities as well as to high value of liabilities. Many pension funds attempt to improve their financial situation by investing in complex portfolios, containing, next to traditional bonds and stocks, other assets such as real estate, infrastructure investments, private equity and others.

The funding ratio is the ratio of a pension fund's assets to its liabilities. Controlling this ratio is one of the essential tasks for a pension fund. Many Dutch pension funds recently reported a decline in their funding ratio, meaning that pensions will be cut for millions of retirees in 2020[1].

Although pension funds shifted towards more complex investment portfolios in pursuit of higher returns, this did not lead to a significant improvement of their funding ratio. It is thus interesting to analyze what factors drive changes in the funding ratio. In this white paper, we address exactly this question, i.e., which risk factors cause the funding ratio changes. Our first hypothesis is that the traditional risk factors such as bond yields and equity prices explain a large part of the funding ratio change, while more sophisticated investments contribute only marginally to that. Hence, we suspect that simple combinations of these main factors explain most of the funding ratio variation, and therefore, simple investment portfolios should suffice.

A recent article by (Ennis, 2020) has clearly outlined the same issues: it showed that public pension funds underperformed passive investment by approximately 1.0% a year for the last decade. Alternative investments, which increasingly entered pension funds' portfolios, no longer offer diversification benefits and lead to increasing costs for pension funds, dragging down their performance. Ennis' empirical analysis of US pension funds shows that, in the last decade, a simple combination of US stocks and US bonds statistically explain the large part of risk–return characteristics of large public pension funds' portfolios. The author recommends a greater use of passive investments to decrease costs without loss of performance. These are all the conclusions we also come to in this paper.

Our research is based on numerical, data-driven investigation, where we used a well-known proxies for the investment risk factors, outlined below. We would like to stress that ours is a high-level investigation, which does not go into fine detail of more complex pension funds' portfolios, but we believe that our results are quite generic and demonstrate clearly our point about simplicity above complexity.

Data

The funding ratio data for the period 2014-2020 is obtained from De Nederlandsche Bank (DNB). We use the policy funding ratio, which is the average funding ratio over 12 months. The risk factors which we consider are stocks, interest rates, exchange rates, credit premia, private equity and real estate.

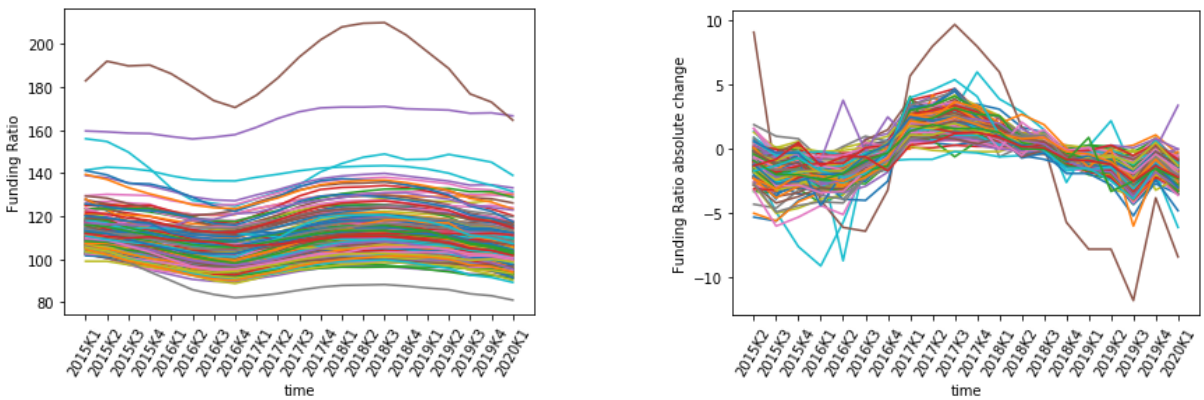
For stocks, the MSCI world index (MSCI) captures the exposure to the stock market. It is a broad global equity index representing 1644 large and mid-cap stocks across 23 developed markets. The Vanguard Real Estate Index Fund (REIT) serves as a proxy for real estate investment

[1] This will happen unless there is a rule revision, see e.g., (Sterling, 2019)

performance. Credit premia in debt markets are captured by investment grade and high yield bond returns. We use iShares' Euro Investment Grade Corporate Bonds UCITS ETF (IG) to capture the exposure to investment-grade bond returns. Similarly, the iShares Euro High Yield Corporate Bond UCITS ETF (HY) captures the exposure to high yield bond returns. Furthermore, the Invesco Global Listed Private Equity ETF (PE) acts as a proxy for private equity investments. All these data series are sourced from Yahoo Finance.

We also use the Euro interest rate swap rates from ECB and the EUR/USD foreign exchange rate (FX) from the Federal Reserve Bank of St. Louis (FRED). With the swap rates, we create the Euro yield curve, which is then used to create a hypothetical bond portfolio with a maximum maturity of 20 years. The maximum maturity of 20-year is selected because the average duration of the liabilities of a pension fund is approximately 20 years. For the actual matching bond portfolio, different maturities are used, depending on the desired bond portfolio maturity.

The Dutch pension funds dataset from DNB contains quarterly observations of policy funding ratios. For some pension funds, funding ratios are missing for several consecutive quarters. The missing values mostly are towards the end of the dataset, indicating a discontinued pension fund. So we excluded pension funds with at least one missing value, and the resulting dataset contains $4,531$ observations on 166 pension funds.



(a) All pension funds' funding ratios

(b) Changes in funding ratios

Figure 2: Funding ratio data

In Figure 2, we observe that the pension funds' funding ratios move together in a comparable pattern (the average funding ratio evolution is shown in Figure 3). This pattern suggests that pension funds have very similar exposures. It also indicates that events in the market affect all pension funds similarly. So our goal is to explain the time variation in funding ratios with the risk factors mentioned above.

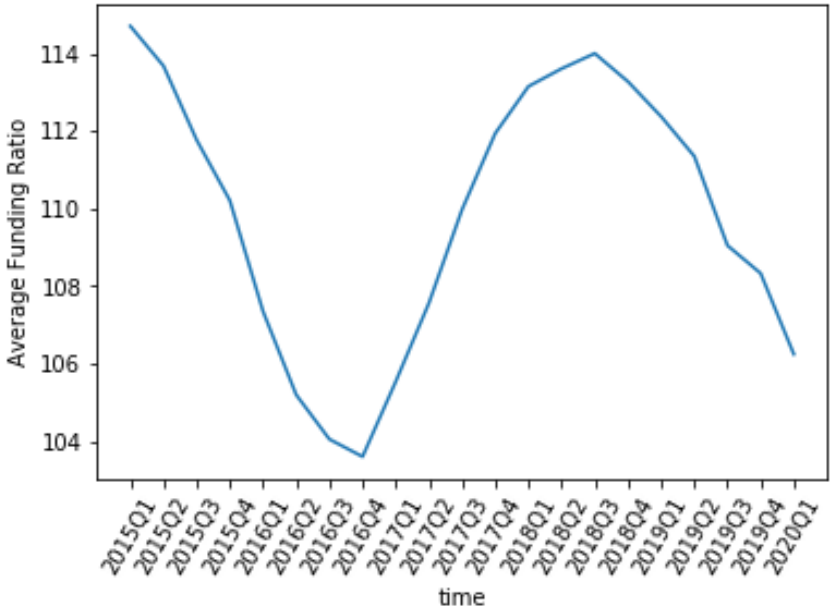


Figure 3: The average policy funding ratio of the 166 pension funds

Prices of various asset classes are denominated in dollars or in Euro. We convert all dollar-denominated prices into euro using the average Euro/Dollar rate over the past 12 months. Next, we obtain the quarterly percentage price changes of the asset classes. Figures 5 and 6 in the Appendix illustrate the evolution of the risk factors.

Below we show the correlations between the risk factors. Some possible collinearities are visible, such as high correlations between the stock market and private equity or between Euro bonds and Investment grade bonds.

	MSCI	FX	PE	REIT	IG	HY	bond
MSCI	1.0	0.51	0.85	0.32	0.39	0.45	0.11
FX	0.51	1.0	0.33	0.81	0.14	-0.24	0.41
PE	0.85	0.33	1.0	0.28	0.30	0.69	-0.08
REIT	0.32	0.81	0.28	1.0	0.32	0.00	0.58
IG	0.39	0.14	0.30	0.32	1.0	0.57	0.71
HY	0.45	-0.24	0.69	0.00	0.57	1.0	0.01
bond	0.11	0.41	-0.08	0.58	0.71	0.01	1.0

Table 1: Correlation matrix of all the factors

The policy funding ratio is the average of the monthly funding ratios over the last twelve months. On the other hand, the asset price data consists of daily prices for each risk factor. Hence, for each risk factor we use the last entry for the month. Next, the prices are consolidated using twelve-month rolling average, which provides a good association between the risk factors and the policy funding ratio. A portfolio of bonds is composed by rolling over into a newly issues bonds every quarter.

Fixed effects model

Our aim is to understand which factors drive the policy funding ratio changes. The dataset on the policy funding ratios of Dutch pension funds is the so-called *panel data*: observations on a number of pension funds, each observed at several points in time. So we naturally consider a panel regression model for analysing these data. Two types of panel regression can be applied: fixed effects or random effects panel regression. The random effects model assumes that the independent (explanatory) variables are uncorrelated with the unobserved individual heterogeneity. The fixed effects model assumes that the specific individual effect is correlated with the independent variables. In our research, we find the fixed effects model more realistic; moreover, as we do not know whether individual effects are correlated to the explanatory variables, it is more prudent to proceed with the fixed effects model.

The fixed effects model is formulated as

$$y_{i,t} = \alpha_i + \beta x_{i,t} + \varepsilon_{i,t}, \tag{1}$$

where $y_{i,t}$ is the dependent variable (here the change in funding ratio), $x_{i,t}$ is the vector of the independent variables, α_i is the unobserved time-invariant individual effect for the entity i (in our case, for ith pension fund), β is the vector of the unknown regression coefficients and $\varepsilon_{i,t}$ are the error terms. In our case, the fixed effect regression is given as

$$\Delta FR_{t,i} = \alpha_i + \beta_1 R_{MSCI,t} + \beta_2 R_{FX,t} + \beta_3 R_{PE,t} + \beta_4 R_{REIT,t} + \beta_5 R_{HY,t} + \beta_6 R_{IG,t} + \beta_7 R_{Bond,t} + \varepsilon_{t,i}, \tag{2}$$

where $\Delta FR_{t,i}$ is quarterly change in the funding ratio at the quarter t for pension fund i and the explanatory variables are the quarterly returns on the corresponding indices.

This model will be estimated on the basis of historical data to determine which risk factors are essential in explaining the policy funding ratio's average change[2]. We apply stepwise backward regression to determine which risk factors are essential in determining the funding ratio change. The method disposes of risk factors, one by one, that are not vital for the model (i.e., on the basis of their p-value, indicating the likelihood that the coefficient for that factor is not significantly different from zero).

First, we apply the fixed-effects model with the change in the policy funding ratio as the dependent variable and the percentage change of each risk factor *individually* as the independent variable. The results of this analysis are shown in Table 2.

	MSCI	FX	PE	REIT	IG	HY	bond
Coefficient (β)	27.27	-43.76	28.32	-28.51	-27.70	124.43	-40.19
	(1.38)	(1.42)	(1.11)	(0.951)	(3.52)	(3.28)	(1.62)
R^2	0.07	0.23	0.18	0.24	0.01	0.30	0.29

Table 2: Parameter estimates and the R-squared for each of the factors

The table above shows that most factors have a link with the change in the policy funding ratio. As expected, the bond price increase leads to the decrease of the funding ratio. In contrast, as

[2]Recall that we used the policy funding ratio as it is available in the database of the Dutch Central Bank and the data on actual funding ratio data is not available.

high yield investment value increases, the policy funding ratio increases as well, which is the consequence of a more equity-like character of high yield ETF.

Next, we regress the changes in the policy funding ratio on all the risk factors. The resulting panel regression estimates are shown in the table below.

	Coefficient	Std. Err.	t-value
MSCI	56.06	2.37	23.62***
FX	-32.06	2.67	-12.00***
PE	-11.53	1.51	-7.66***
REIT	-8.29	1.15	-7.24***
IG	-116.60	7.00	-16.65***
HY	124.94	5.49	22.78***
bond	-9.34	1.92	-4.86***
R^2	0.72		
adj. R^2	0.72		

Table 3: Parameter estimates for all the risk factors
(*, ** and *** means significant at 10%, 5% and 1%, respectively)

In table 3, we find that combining all the factors explains approximately three quarters of the variation in the funding ratio, with all the estimated parameters being significant.

As mentioned above, some variables are correlated, resulting in some multicollinearity in our regression.

We would like to preserve the regression's explanatory power while removing some of the correlated variables. Table 5 shows the results of this sequential procedure.

step	Omitted variable	R^2	$adj.R^2$	Explaining Factors
1	None	0.72	0.72	Bond, MSCI, FX, REIT, IG, PE, HY
2	Bond	0.71	0.71	MSCI, FX, REIT, IG, PE, HY
3	PE	0.71	0.71	MSCI, FX, REIT, IG, HY
4	REIT	0.71	0.71	MSCI, FX, IG, HY
6	IG	0.59	0.59	MSCI, FX, HY
7	HY	0.58	0.58	MSCI, FX
8	MSCI	0.23	0.23	FX

Table 4: Backwards stepwise regression results

Note that Bond investment gets dropped by the stepwise procedure first. This is because bond portfolio has the lowest volatility of all the factors, while being correlated to e.g., Investment Grade bond portfolio. Hence, it contributes less to explaining the variability in the funding ratio. However, it might be less intuitive to remove the bond portfolio from investigation. So we also tested the sequential variable removal procedure where we required the bond portfolio to stay in the model, and manually removed other factors in a prescribed order. The results are shown in the following table.

step	Omitted variable	R^2	$adj.R^2$	Explaining Factors
1	None	0.72	0.72	Bond, MSCI, FX, REIT, IG, PE, HY
2	HY	0.70	0.70	Bond, MSCI, FX, REIT, IG, PE
3	PE	0.69	0.69	Bond, MSCI, FX, REIT, IG
4	IG	0.69	0.68	Bond, MSCI, FX, REIT
6	REIT	0.68	0.68	Bond, MSCI, FX
7	FX	0.40	0.40	Bond, MSCI
8	MSCI	0.29	0.29	Bond

Table 5: Regression results while selecting our variables manually

Table 5 shows that after removing some of the variables we still get a high R^2 and $adj.R^2$. This result indicates that, with only a few variables, we can explain the majority of the variation in the funding ratio - the conjecture we postulated at the beginning of the paper.

Replicating Portfolios

Combining our considered risk factors, we create several replicating hypothetical portfolios, to illustrate that we can produce similar funding ratios as those observed in real life. We consider a fictional pension fund that starts with a funding ratio equal to the average funding ratio (114.715%) and whose funding ratio follows the average pattern. We consider seven standard portfolios (ranging from two very simple bond portfolios to more complex portfolios containing all risk factors in various proportions). More precisely, Portfolio 1 is the "perfect hedge" portfoli: this portfolio matches the liabilities. Portfolio 2 is the 50% hedge: 50% of the liabilities are matched and the other 50% is put into cash. Portfolio 3 has the perfect hedge but also invests significantly in MSCI. Portfolio 4 hedges 50% of liabilities and invests the other 50% into MSCI. Portfolio 5 is similar to portfolio 4 but it invests into MSCI and other indices such as real estate and high yield credit. Portfolio 6 uses the same construction as portfolio 5 but adds diversification in the liability-matching part. Portfolio 7 is portfolio 6 with the foreign exchange hedge added. Portfolio 8 is the most diversified portfolio: it has 75% diversified hedge and a highly diversified return portfolio. Figure 7 in Appendix displays the exact portfolio compositions.

The liability side of our hypothetical pension fund is assumed to behave similarly to the 20-year maturity bond portfolio. We also added potential costs, by reducing the bond portfolio return by ten basis points and equity and FX returns by five basis points (ETF returns for HY, IG, PE, and REIT already account for investment costs). Rebalancing is done at the end of each quarter.

With these assumptions at hand, we obtain the funding ratios for our fictional pension fund if it invests to one of the eight possible portfolios. These are shown, together with the average (over all 166 pension funds) funding ratio in Figure 4.

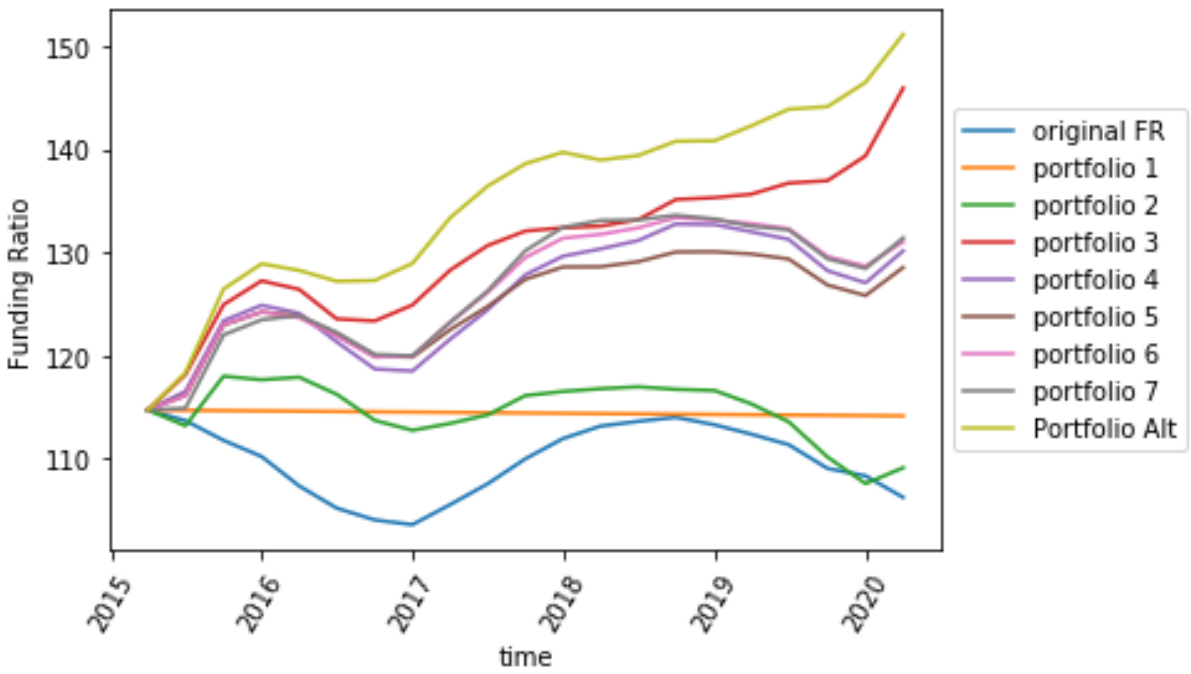


Figure 4: All eight fictional pension fund's funding ratio's compared to the original serie

When we look at the funding ratios of the eight portfolios, we see some clear distinctions. Portfolio 1 is far too simple and it does not follow the average funding ratio. When we expose our portfolio 50% to interest rate risk (portfolio 2), we see a pattern similar to the original coverage ratio. Portfolios 4, 5, 6 and 7 show a similar - but better - pattern to the average funding ratio. Portfolios 3 and 8 (alternative portfolio) have even better and more stable growth of the funding ratio, due to their high exposure to stocks and other equity-like markets. Alternative portfolio performs particularly well: we match the liabilities for 75% but we also invest heavily in other assets such as stocks, real estate and private equity (whose shares are typically a lot smaller in real life pension fund investments). The performance of this portfolio is remarkably good, demonstrating the potential of strong asset diversification.

Concluding remarks and recommendations

A few simple risk factors - such as an equity index and bond returns - can explain a large part of variation in policy funding ratios of Dutch pension funds. This means that simple investment strategies can be sufficient in achieving industry-average results.

With simple replicating portfolios, an average fund's funding ratio can be easily mimicked and hence, similar financial results can be obtained. It is possible that, for many pension funds, their investment portfolios might be too complicated, as similar returns can be achieved with very simple portfolios.

Based on our research, we can propose some recommendations. First, our analysis shows that portfolios can be simplified while achieving the same performance. By simplifying the portfolio, administrative costs and management fees would decrease significantly.

Our analysis indicate that matching the portfolio perfectly against the liabilities (i.e., hedging

away interest rate risk) does not reduce the performance of the funding ratio. In fact, matching liabilities entirely diminishes the volatility of the funding ratio. This result suggests it can be beneficial to decrease the "nakedness" of interest rate risk for a pension fund. Furthermore, pension fund investors should consider being more exposed to investments other than highly rated bonds, as e.g., equity exposure significantly enhances the funding ratio performance, especially in the long term. Finally, considering alternative equity-like investments such as real estate and private equity (as well as high yield credit), as in the alternative portfolio, can further improve the coverage ratio and significantly contribute to the asset diversification.

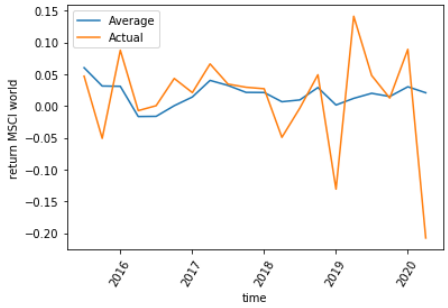
References

Ennis, R. M. (2020). Institutional investment strategy and manager choice: A critique. *Journal of Portfolio Management*.

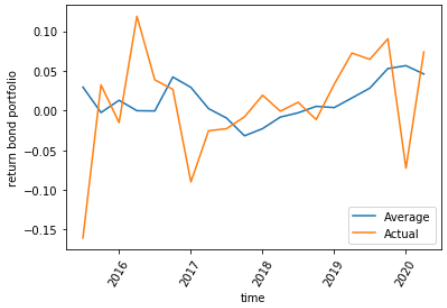
Sterling, T. (2019, September). Coverage ratio at big dutch pension funds falls below 90%, cuts loom. *Reuters Financials*.

Appendix

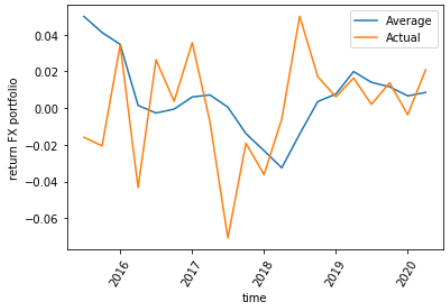
Indices' returns



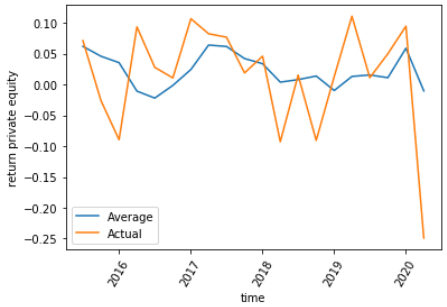
(a) MSCI World % change



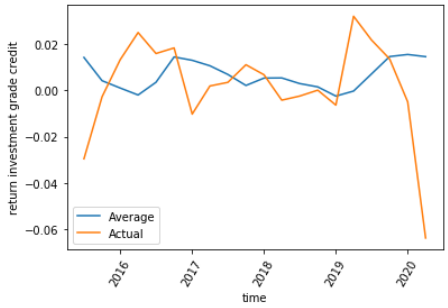
(b) bond portfolio % change



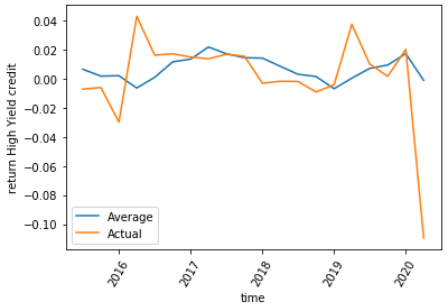
(c) Euro/Dollar FX % change



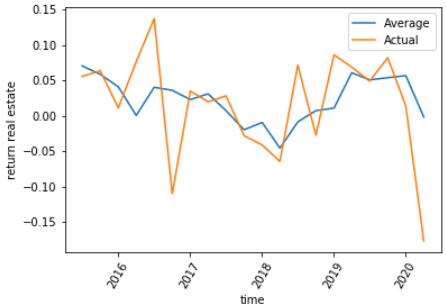
(d) Private Equity % change



(e) Investment Grade credit % change



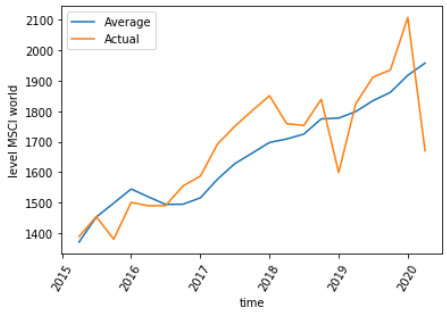
(f) High Yield credit % change



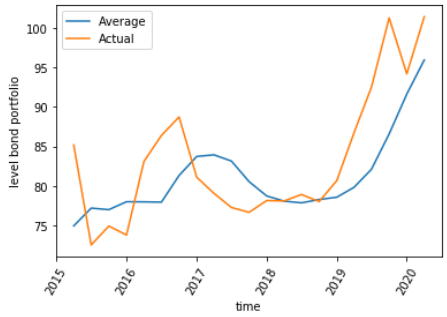
(g) Real Estate % change

Figure 5: Factors % change data

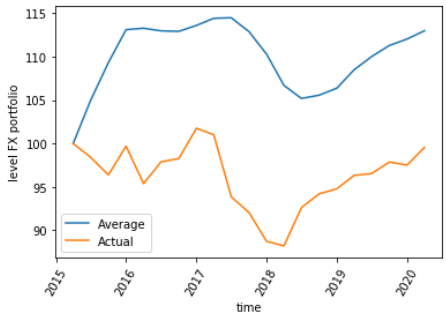
Historical indices



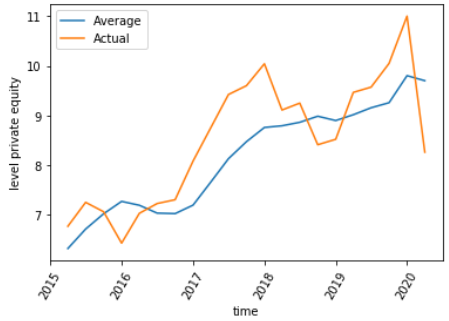
(a) MSCI World



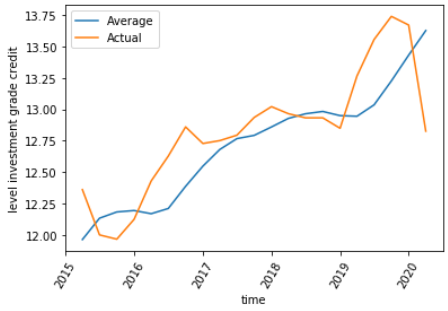
(b) bond portfolio



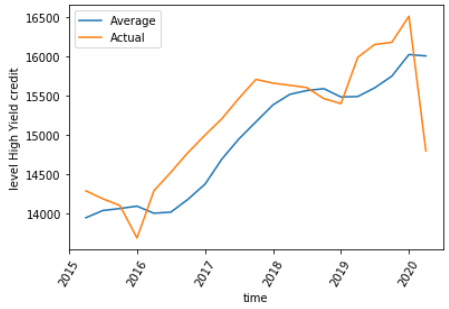
(c) Euro/Dollar FX



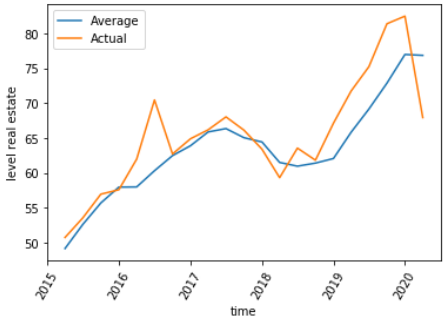
(d) Private Equity



(e) Investment Grade credit



(f) High Yield credit



(g) Real Estate

Figure 6: Factors level data

Portfolios

EUR	Asset	Duration
1140	Bonds	20
0	IG	0
0	Cash	0
1140		20
0	MSCI	
0	REIT	
0	HY	
0	FX Hedge - short ($)	
0	FX Hedge - long (EUR)	
0		

(a) Portfolio 1

EUR	Asset	Duration
570	Bonds	10
0	IG	0
570	Cash	0
1140		10
0	MSCI	
0	REIT	
0	HY	
0	FX Hedge - short ($)	
0	FX Hedge - long (EUR)	
0		

(b) Portfolio 2

EUR	Asset	Duration
1140	Bonds	20
0	IG	0
-570	Cash	0
570		20
570	MSCI	
0	REIT	
0	HY	
0	FX Hedge - short ($)	
0	FX Hedge - long (EUR)	
570		

(c) Portfolio 3

EUR	Asset	Duration
570	Bonds	10
0	IG	0
0	Cash	0
570		10
570	MSCI	
0	REIT	
0	HY	
0	FX Hedge - short ($)	
0	FX Hedge - long (EUR)	
570		

(d) Portfolio 4

EUR	Asset	Duration
570	Bonds	10
0	IG	0
0	Cash	0
570		10
342	MSCI	
114	REIT	
114	HY	
0	FX Hedge - short ($)	
0	FX Hedge - long (EUR)	
570		

(e) Portfolio 5

EUR	Asset	Duration
499	Bonds	8.75
285	IG	1.25
-214	Cash	0
570		10
342	MSCI	
114	REIT	
114	HY	
0	FX Hedge - short ($)	
0	FX Hedge - long (EUR)	
570		

(f) Portfolio 6

EUR	Asset	Duration
499	Bonds	8.75
285	IG	1.25
-214	Cash	0
570		10
342	MSCI	
285	REIT	
285	HY	
-285	FX Hedge - short ($)	
285	FX Hedge - long (EUR)	
570		

(g) Portfolio 7

EUR	Asset	Duration
784	Bonds	13.75
285	IG	1.25
-499	Cash	0
570		15.00
342	MSCI	
285	REIT	
285	HY	
-342	Cash	
-285	FX Hedge - short ($)	
285	FX Hedge - long (EUR)	
570		

(h) Alternative Portfolio

Figure 7: replicating portfolios