Stockholm School of Economics
Department of Finance

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Return Predictability and Strategic Asset Allocation

A study examining return predictability on the Swedish market and strategic asset allocation of the Swedish buffer pension funds.

Jakob Glasberg*

Jonatan Blomstrand**

Abstract

The purpose of this paper is to examine whether Swedish macro-economic variables can predict domestic excess stock and bond return. The paper examines what effects the short-term rate, maturity yield spread and dividend yield have on the aforementioned returns. We also investigate if the Swedish buffer pension funds (AP1, AP2, AP3 and AP4) incorporate these macro-variables into their strategic asset allocation decisions.

Previous financial literature suggests that certain macro-variables can predict excess returns, but the conclusions vary. Furthermore, fund managers' ability to incorporate information from macro-variables in a way coherent with conventional literature is also debated. The results from this thesis is that a widening yield spread significantly predicts excess stock return positively. We also conclude that the buffer pension funds incorporate return predictive macro-variables (mainly short-term rate) into their strategic asset allocation. However, the funds do not necessarily incorporate the information in coherence with our findings.

Keywords: Return predictability, Strategic asset allocation, Pension fund

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*23534@student.hhs.se **23517@student.hhs.se

INTRODUCTION

Optimal asset allocation theories, with various macro-economic variables as predictors for excess returns is of high importance for pension fund managers. The financial literature on the subject of macro-variables as predictors of returns is exhaustive[1], reaching conclusions about different asset classes' cross-correlations and their implications for asset allocation. The literature does not give a coherent answer to which macro-variables that predict returns on stocks and bonds. In this paper we try to identify the drivers of excess returns on Swedish bonds and equities. More specifically we want to study how the short-term rate, maturity yield spread and dividend yield relate to the aforementioned excess returns. Furthermore, if there are signs that the variables can predict returns; are the Swedish buffer pension funds' strategic asset allocations consistent with our findings?

In order to perform the analysis necessary to investigate the subjects mentioned above we have studied autocorrelation and correlation to examine whether the macro-variables might track similar parts of expected return. The autocorrelation of the return predictive variables also gives information about which parts of expected return the variables track, related to their responsiveness to business cycle variations. A graphical illustration of the macro-variables movements at business cycle peaks and troughs is also used to describe this. Furthermore, we construct a vector autoregression (VAR) to examine how lags in return and return predictive variables can forecast excess returns. A triangle matrix of cross-correlation of residuals from the VAR is made since it gives information about how unexpected return is related to shocks in the variables. Finally, on the return-predictive section of this paper, we perform impulse-response functions (IRFs) to see how return on stocks and bonds are affected by uncorrelated structural shocks of the macro-variables.

To robustly examine if the Swedish buffer pension funds incorporate the variables short-term rate, yield spread and dividend yield into their strategic asset allocation, we use three ordinary least squares (OLS) regressions. In the first regression we use 6 month lags in the return predictive macro-variables as explanatory variables. In the second regression we use average over the previous 6 months and in the third regression we use change of the macro-variables over the previous 6 months as explanatory variables.

Short-term rate (yield on 3-Month T-Bill) is a variable that is included in several models for return predictability. Ang and Bekaert (2007) find that short-term rate predicts excess stock return negatively. The work of Campbell and Viceira (2005) reiterate a significant negative

[1] E.g. Ang and Bekaert (2007), Campbell, Chan and Viceira (2003), Viceira (2007).

correlation between lagged short-term rate and excess stock returns. Campbell, Chan and Viceira (2003) find that lags in short-term rate fail to predict excess bond return on both quarterly and yearly lags. Additionally, Fama and French (1989) identify that the short-term rate rises during business cycle expansionary periods and declines during contractionary periods.

Based on our analysis of autocorrelation and business cycle troughs and peaks, we suggest that the short-term rate explains expected return variations related to more persistent aspects of business conditions. The variable has a more persistent autocorrelation on longer lag lengths compared to yield spread and dividend yield. Neither excess stock nor bond return has a significant relation to 6 month lags in short-term rate in our vector autoregression. In the cross-correlation of residuals of the VAR we find that both unexpected stock and bond return has a negative relation to shocks in short-term rate. In the impulse-response functions, the main effect on excess stock return from a positive impulse on short-term rate is negative. To sum up, we find no clear results regarding the return predictability of short-term rate.

Maturity yield spread (yield on long-term government bonds less short-term rate) is included in several return predictive models. Viceira (2007) studied the predictability of excess bond returns; finding a positive and significant correlation between the lagged yield spread and excess bond returns. Similar results were found by Hoevenaars, Molenaar and Steenkamp (2008), concluding that the yield spread is a strong predictor for bond returns. The coefficients for the regressions in Viceira (2007) seem to increasingly steepen with the time horizon. The implication for investors would in the case of widening yield spreads to increase their allocation to bonds. Campbell, Chan and Viceira (2003) find a positive relation between lags in yield spread and excess stock return, but the coefficient is not significant for neither quarterly nor yearly lags. Fama and French (1989) have shown that the yield spread tends to bottom during business cycle peaks and peak during business cycle troughs, suggesting that yield spread tracks part of expected return related to short-term movements in business conditions. In the same paper it is shown that yield spread has an autocorrelation that is less persistent on longer lags than dividend yield. Thus, suggesting that dividend yield and yield spread track different parts of expected return.

We find that yield spread has high autocorrelation on the first order lag, but the autocorrelation decreases rapidly for longer lags. Moreover, we find a high (negative) correlation between yield spread and dividend yield. In the VAR, lags in yield spread affect both excess stock and bond return positively, but the coefficient for excess bond return is not significant. The relation between unexpected excess stock return and shocks in yield spread is also positive, but the corresponding effect on unexpected excess bond return is negative. In the IRF, the effect on excess bond return is initially negative. This is the macro-variable that has most impact on excess bond return amongst the impulse-response functions. The response of excess stock return from an impulse on yield spread is positive. Thus, our conclusion is that a widening yield spread predicts excess stock return positively, both when looking at "ordinary" changes as well as shocks.

The final return predictive macro-variable of interest in this study is the dividend yield (dividend-price ratio). Early work from Fama and French (1988) shows that dividend yield has a return predicting ability, especially as the time horizon increases. They find a positive correlation between dividend yield and future expected equity returns. Vector autoregressive models performed by Bams, Schotman and Tyagi (2016) as well as Campbell, Chan and Viceira (2003) all find positive significant relationships between lagged dividend yield and expected excess stock return and that unexpected return has a strong negative relation to shocks in dividend yield. Ang and Bekaert (2007) are somewhat more restrictive in their conclusions of dividend yield and stock return predictability; they find a significant positive correlation between the variables solely at a short-term horizon. Campbell, Chan and Viceira (2003) also find that both quarterly and yearly lags in dividend yield are positively related to excess bond returns, but the coefficients are not significant. Fama and French (1989) argue that dividend yield tracks expected return related to more persistent aspects of business conditions and not in response to short-term variations in business conditions.

Our research of dividend yield suggests that it tracks similar parts of expected return as yield spread. Yield spread and dividend yield have the highest (absolute) correlation amongst the macro-variables and similar autocorrelation. Dividend yield tends to peak at business cycle troughs and bottom at business cycle peaks. Thus, our findings suggest that dividend yield tracks variations in expected return in response to short-term variation in business conditions. In the VAR, we find that lags in dividend yield predicts excess stock and bond return positively. However, both correlated and uncorrelated shocks to dividend yield have a substantial negative effect on excess stock return. We suggest that this effect is explained by the denominator of dividend yield, i.e. large share decreases of the stock index constituents. This is based on the strong positive relation between unexpected stock return and lagged shocks in stock return. Regarding excess bond return, we find that shocks in dividend yield is positively related to excess bond return.

To sum up our findings from the return-predictability part of this paper, we suggest that yield spread and dividend yield track similar parts of expected return. We do not find that short-term rate, yield spread or dividend yield predict excess bond return significantly. However, we find a positive relation between yield spread and excess stock return. Dividend yield also predicts excess stock return, but the sign of the coefficient is depending on whether the change is a shock or not.

Our second objective with the paper is to examine whether the strategic asset allocation decisions made by the Swedish buffer pension funds are coherent with the conclusions drawn by our analysis of the macro-variables' return predictability. The Swedish pension system is unique in comparison to its international counterparties; divided into three pillars; (1) the National Public Pension, (2) Occupational Pension and (3) Private Savings[2]. The primary constituent of the National Public Pension is the pay-as-you-go income pension system where the yearly contributions that are paid by the working population (16% of salary) are paid out to the non-working pensioners[3]. The 5 pension buffer funds called AP1, AP2, AP3, AP4 and AP6 manage the buffer capital in the pension system, receiving capital if the net payments are positive and capital is withdrawn and allocated to pension receivers if net payments are negative. We study 4 of these 5 funds (AP6 is excluded from the analysis due to different fund characteristics). AP1-4 have allocation targets for various asset classes that are rebalanced periodically, thus performing strategic asset allocation. The funds have regulatory limitations where they are not allowed to have more exposure than 40 % in foreign exchange risk and need to keep at least 30% of their portfolio in fixed income products[4]. The regulation on foreign exchange makes the funds highly exposed to the Swedish market, although we acknowledge that the currency exposure can partially be mitigated through using various derivatives. Nevertheless, Severinson and Steward (2012) emphasize the funds' bias towards the Swedish markets.

The pension system as a whole has experienced a negative balance recently where its liabilities have exceeded its assets. This activated a balancing mechanism leading to less pension paid to the current retired Swedes[5]. It is therefore of great important that the funds keep track of the return predictable variables on the Swedish market and incorporate it in their strategic asset allocation in order minimize the risk of the balancing mechanism to be activated.

Addoum, Van Binsbergen and Brandt (2010) examined whether pension fund managers are able to make asset allocation decisions in a way consistent with the financial literature on

[2] Pensionsmyndigheten (2018). *Pensionens alla delar*.
[3] Pensionsmyndigheten.se (2018). *Pensionsgrundande inkomst*.
[4] AP2 (2018). *Placeringsregler*.
[5] Assets/Liability ratio in 2008 and 2009 was 0.9672 and 0.9570, respectively, according to AP3, (2018). Annual report 2017.

macro-variables. They find that lagged changes in dividend yields are negatively correlated with reallocations to equity, and positively correlated with reallocations to bonds. This implies that fund managers incorporate information from macro-variables in a way inconsistent with most financial literature. Furthermore, Bams, Schotman and Tyagi (2016) also argue that pension funds are unable to incorporate predictive information in their strategic asset allocation.

We find that the Swedish buffer pension funds incorporate return predictive macro-variables into their strategic asset allocation, however not necessarily in line with the findings from the analysis on the macro-variables' return predicting ability. On average, the funds decrease their holdings in stocks when short-term rate, dividend yield and yield spread increases. Based on our findings from the return-predictability analysis, the funds should not decrease their holdings in equities when the yield spread increases. The macro-variables underlying the funds' decision to change their holdings in bonds are the short-term rate and dividend yield (both with significant coefficients in two regressions). On average, the funds increase their holdings of bonds when short-term rate and dividend yield increase.

This paper aims to contribute to the literature by analyzing the predictive power of Swedish macro-variables on excess return of stocks and bonds on the Swedish market. Furthermore, we will cross-check our findings with the Swedish buffer pension funds to examine their compliance with our findings. To the best of our knowledge such a study has not been done with respect to the Swedish market, but is important due to their exposure to Swedish securities. Moreover, the fact that the balancing mechanism has been activated makes this an even more relevant subject since the current retired Swedes has to pay for the pension funds' potential incorrect strategic asset allocation.

The paper proceeds as follow. Section 1 provides an overview of the sample data, the strategy implementation and summary statistics. Section 2 presents the results for the predictive power of Swedish macro-variables through autocorrelation and correlation analysis, plots of the forecasting variables, vector autoregression analysis, impulse-response function as well as the findings for the cross-checking with the AP funds' allocation decisions. Section 3 discusses potential mechanisms and additional evidence for the findings in the previous section. Section 4 concludes. Section 5 provides suggestions for further studies.

1. MEASURING EXCESS RETURN PREDICTABILITY AND PENSION FUND STRATEGIC ASSET ALLOCATION

1.1 DATA

For our analysis we use various sources of financial and macro-economic data. The Swedish macro-economic data is retrieved from the Swedish Riksbank (Sweden's national central bank), Bloomberg and Thomson Reuters Eikon. Aforementioned data was acquired on a monthly frequency for the period 2002-07 until 2018-03.

In order to examine the economic conditions and business cycles in Sweden, domestic data was retrieved from Sweden's National Institute of Economic Research (NIER). Values for the *Economic Tendency Survey*, applied in the paper, is reported on a monthly frequency for the same period as for the macro-economic data.

Furthermore, we want to investigate how the Swedish public buffer funds allocate capital in equities and fixed-income (mainly bonds). Data on the allocation to equities and bonds is obtained from the funds' balance sheets. The data is semi-annual from 2002-06 to 2017-12 and is obtained from the funds' annual and semiannual financial reports[6].

As our data includes three business cycle peaks and troughs, thus 2.5 business cycles, we believe that the data is applicable for the study.

1.1.1 MACRO-ECONOMIC DATA

Based on previous financial literature on strategic asset allocation and macro-economic variables as predictors of excess returns, three different variables were chosen. These variables are; (1) the short-term rate, *r*, (2) the yield spread, *ys*, and (3) the dividend yield, *dy*.

The short-term rate (*r*) is the annualized nominal yield on the Sweden 3-Month T-Bill. Obtained from the Swedish Riksbank, it is the nominal yield for the current month.

The yield spread (*ys*) is the annualized yield on the Sweden 5-Year government bond less the short-term rate (*r*).

The dividend yield (*dy*), is calculated year-on-year on the SAX index. The SAX Index (currently known as OMXS) contains all publicly traded equities on the Stockholm Stock Exchange (Nasdaq OMX). The index is capitalization-weighted and revised semiannually. In

[6] For calculation of change and average over previous 6 months data back to 2002-01 has been obtained. The first observation (2002-06) for dividend yield and average over the previous 6 months is the YoY dividend yield calculated for 2001-07 to 2002-07.

order to avoid the seasonality aspect of dividends, the dividend yield is based annual yields, in line with Fama and French (1989) and Campbell, Chan and Viceira (2003).

Excess stock returns (*esr*) is the monthly return on the SAX Total Return Index less the monthly yield on short-term rate (*r*). The equity total return index is calculated as

$$ETRI_t = ETRI_{t-1} * [\frac{Equity\ Price\ Index_t + D_t}{Equity\ Price\ Index_{t-1}}]$$

where the subscript *t* refers to time, *ETRI* to the equity total return index and *D* the dividends paid out per index point.

Excess bond returns (*ebr*) is the monthly return on the FTSE Sweden Global 3-5YR Total Return Index less the monthly yield on the short-term rate (*r*). The FTSE Global 3-5YR Sweden Total Return Index is based on Sweden government zero-coupon bonds with maturities between 3- and 5-years. The bond total return index is calculated as

$$BTRI_t = BTRI_{t-1} * [\frac{Bond\ Price\ Index_t + C_t}{Bond\ Price\ Index_{t-1}}]$$

where *BTRI* refers to the bond total return index and *C* to the coupons paid out per index point.

1.1.2 BUSINESS CYCLE INDICATOR

The *Economic Tendency Survey* from Sweden's National Institute of Economic Research (NIER) is used as a proxy to quantify Sweden's economic and business conditions. The survey indicator is a report that is carried out on a monthly basis and captures the sentiment in manufacturing, services, construction, retail and consumers.

The indicator has a mean value of 100, with a standard deviation of 10. Values above 110 are, by NIER, interpreted as an indication of an economy that is much stronger than normal, and values below 90 one that is much weaker than normal.

In our analysis, economic peaks and troughs are defined as NIER defines extreme economic conditions. The first month when the business cycle indicator drops below 90, we define a trough in the Swedish economy, and the first month when it increases past 110 a peak.

1.1.3 FINANCIAL AP FUND DATA

From the public buffer pension funds, we have obtained semi-annual data on their allocations to fixed income products (mainly bonds) and stocks. Data is received from the balance sheets in their annual and semiannual reports.

Percentage allocation to equities (*ae*) is the closing balance sheet value of equity holdings divided by total fund capital, calculated as average for the Swedish buffer pension funds AP1, AP2, AP3 and AP4. Percentage allocation to bonds (*ab*) is the closing balance sheet value of bond divided by total fund capital, calculated as average for AP1-4 combined.

As stated by Severinson and Steward (2012), one of the main reasons behind the multiple fund structure of the AP funds was to diversify financial and management risk. Additionally, the assets over liabilities calculation underlying the decision to activate the balancing mechanism is based on the sum of the funds' capital together. With our objective of this paper, the funds' diversification roles and the relevance of the balancing mechanism in mind, it is reasonable to examine them as a unit rather than individual portfolios. We therefore examine the funds' allocation decisions as a whole, calculated as averages.

1.2 IMPLEMENTATION OF EMPIRICAL STRATEGY

The key goal of this paper is to examine whether macro-economic variables can act as predictors of excess return on stocks and bonds in the Swedish market. Furthermore, if there are signs that the variables can predict returns; are the Swedish pension funds' asset allocations consistent with our findings?

The research is made by calculations of correlation, autocorrelation, a vector autoregressive model combined with cross-correlation of residuals and impulse-response functions to robustly examine if these macro-variables predict excess returns on the Swedish market during our sample period. Furthermore, the analysis includes a business cycle-perspective to further examine which part of expected return the return predictive variables track and if there are similarities. Calculations of correlation and autocorrelation combined with the graphical illustration with the business cycle-perspective gives information on how the macro-variables relate to movements in business cycles on different time horizons.

The findings from the analysis of the potential return predictive variables will then be cross-checked on the strategic asset allocation of the Swedish public buffer pension funds. This is done to examine if the funds incorporate these variables in their strategic asset allocation, and if they do, do they allocate properly?

1.2.1 RESTRICTIONS AND IDEAL DATA SET

With the nature of the topic this paper studies, and its geographical restriction to Swedish variables (due to AP funds' Swedish bias) our sample criteria has impacted the sample size, as well as variables possible to analyze. Similar papers that have examined U.S. data have often included credit spread (difference between the yield on high yield corporate bonds and yield on safe government bonds) in their models. However, data on the Swedish corporate bond market for our sample period is very limited, to both time horizon and frequency. Gunnarsdottir and Lindh (2011) argue that the Swedish corporate bond market is underdeveloped, illiquid, poorly transparent in terms of pricing and has highly varying maturities. As we are dealing macro-economic variables it is of high importance that the time horizon of the sample data is long enough to cover several economic cycles in order to be able to produce reliable results. Due to aforementioned reasons, we have not included credit spread as a variable in our analysis.

As mentioned above, this paper is restricted to the Swedish market, which influences the sample size of our variables. The geographical restriction that we have chosen has had implications for the sample size since we only have access to data on dividend yield on a major Swedish index for the time period 2002-07:2018-03. Thus, dividend yield on a major Swedish index is the restricting variable for the sample size in the paper. The shorter time horizon for our data sample can be a potential issue as much of the previous, and regarded, financial literature in the field has data for longer time periods in order to capture several business and economic cycles[7]. However, since we were not able to include credit spread into our models, we chose to include the dividend yield instead of looking at only short-term rate and yield spread over a longer time horizon. This selection influenced our sample size but was necessary to execute the analysis.

The semi-annual data on the pension funds' asset allocation also restricts our analysis. With semi-annual data, it is not possible to divide the data set into different periods and still have a sufficient amount of observations. When analyzing the AP funds' strategic asset allocation we look at their balance sheet values, and such analysis brings potential sources of error. The main issue is that the closing balance does not provide information about what has happened during the 6-month period. The funds may have been more or less exposed to stocks or bonds during a particular period than what the closing balance suggests. Moreover, an increase in the balance sheet value of stocks can be a result of active reallocation towards stocks or the fact that the market value of the stocks has increased. An alternative would be to do like Bams, Schotman and Tyagi (2016) and look at the allocation policy stated by the funds and add it to the analysis. However, this data is not available for the funds during our sample period. AP1-4 is also performing tactical asset allocation but to isolate the strategic asset allocation has not been possible with the data available.

[7] Fama and French (1988), Fama and French (1989), Campbell, Chan and Viceira (2003)

An ideal data set would include the above outlined data used for our analysis for a longer time horizon, covering more economic cycles in order to be able to better screen out anomalies in the economy, such as unconventionally loose monetary policies (e.g. the Riksbank's extensive quantitative easing program, expanded in 2015)[8]. Reliable data on credit spread in Sweden would also make the data set more complete. Optimal would also be to have an official indicator of Sweden's business cycle's troughs and peaks, similar to those identified for the US economy by the National Bureau of Economic Research (NBER). Moreover, monthly data on the pension funds' asset allocation would also be preferable since we then would be able to divide the data set in order to examine the funds' strategic asset allocation in different periods. Campbell, Chan and Viceira (2003) find that macro-variables can affect return on stock and bond in different directions depending on whether the change in the macro-variables is assumed to be a shock or not. Then, monthly data would make it possible to draw better conclusions if the funds incorporate information from the return predictive macro-variables correctly by isolating periods without shocks of the macro-variables. This analysis is not possible to do with our sample period and the semi-annual data set on the pension funds' asset allocation. Lastly, the data set would be better suited for this study if data on tactical versus strategic asset allocation of the funds would be available. This would make it possible to erase the asset allocation related to tactical investments and isolate the funds' strategic asset allocation.

1.2.2 AUTOCORRELATION AND CORRELATION ANALYSIS

We start of by examining the autocorrelation of the macro-economic variables *r*, *ys*, *dy*, *esr* and *ebr* in order to gain information about the autocorrelation over different horizons. Fama and French (1989) argue that autocorrelation of return predictive variables gives information about the behavior of expected return. Lag lengths for which they will be analyzed are 1 to 18 months.

Autocorrelation is the correlation of a signal with a delayed copy of itself as a function of delay. Autocorrelation is defined as

$$R(s,t) = \frac{E[(X_t - \mu_t) * (X_s - \mu_s)]}{\sigma_t * \sigma_s}$$

where subscript s and t refer to two different periods of time, R the autocorrelation, X the realized value, μ the mean of the given variable and σ the standard deviation of the given variable.

[8] Riksbanken (2018)

To further examine how the return predictive macro-economic variables explain different parts of expected return, we look into correlation. Fama and French (1989) suggest that variables with similar autocorrelation and that are highly correlated may explain similar parts of expected return. Correlation is defined as

$$\rho_{a,b} = \frac{cov(a,b)}{\sigma_a * \sigma_b}$$

where a and b refer to two different variables, *cov* is the covariance of the given variables and σ the standard deviation of the given variable.

1.2.3 PLOTS OF THE FORECASTING VARIABLES

The historical movements of the macro-economic variables *r*, *ys*, *dy* during our sample period are plotted against business cycle peaks and troughs in order for us to be able to graphically observe how they vary with each other as well as behave by business cycle extremes. According to Fama and French (1989), this can suggest whether a macro-economic variable tracks variation in expected return related to short-term variations or more persistent aspects in business conditions.

As mentioned earlier in the report, *bci* (results from the *Economic Tendency Survey*, from NIER) will be used as a proxy for business conditions. The first month the business cycle indicator reaches a value of 90 or below, a trough is identified, and the first month the indicator reaches a value of 110 or above a peak is identified. Peaks and troughs will be identified as vertical lines; thin and thick, respectively.

The graphical plots are analyzed with the autocorrelation and correlation in mind since it is all related to which components and horizons of return the macro-variables track.

1.2.4 VECTOR AUTOREGRESSION AND IMPULSE-RESPONSE FUNCTIONS

We perform a vector autoregression (VAR) with returns and macro-economic variables to provide insight on how expected returns can be explained by lags in the return predictive variables as well as by lags in itself. This will provide insights on how long-term investors should reallocate their portfolios when asset returns are assumed to be predictable.

To decide which lag length to use in the vector autoregressive model there are various methods that can be utilized. We have examined optimal lag lengths through a likelihood ratio test, final prediction error, Akaike's information criterion, Hannan and Quinn information criterion and Schwarz's Bayesian information criterion. The advantage of using several methods of calculating suggested lag lengths is that we can see whether the outcomes are consistent with each other, in order to confidently choose an applicable lag length. Since the result (presented in *Table 9* in the Appendix) from these tests suggested different lag lengths (1, 5 or 10) and the objective of this paper to examine the pension funds strategic asset allocation (where we have semi-annual data), we use a lag length of 6 months.

This results in the following vector autoregressive model:

$$\begin{bmatrix} r_t \\ ys_t \\ dy_t \\ esr_t \\ ebr_t \end{bmatrix} = \alpha_0 + A_1 \begin{bmatrix} r_{t-6} \\ ys_{t-6} \\ dy_{t-6} \\ esr_{t-6} \\ ebr_{t-6} \end{bmatrix} + \begin{bmatrix} \varepsilon_{\mathbf{1},\boldsymbol{t}} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \\ \varepsilon_{5,t} \end{bmatrix}$$

where α_0 is a vector of intercept terms, and A_1 is a 5*5 matrix of slope coefficients. The error terms, ε, are shocks to the variables, which for now are allowed to be cross-correlated.

We investigate the correlations of the error terms in order to see whether shocks in the VAR are correlated across equations. The cross-correlation of residuals of interest are those that show how unexpected return of stocks and bonds is explained by shocks to the variables in the model. Since our sample period includes times of negative short-term rate, we cannot logarithm the variables like other previous financial studies have done in their vector autoregressive models[9].

To follow up on the VAR and robustly analyze the effect of shocks to the return predictive variables on excess stock and bond return, we construct impulse-response functions (IRFs). The IRFs illustrate how the variables react to shocks on itself and other endogenous variables. The functions are based on a VAR with lags from 1 to 6 periods since we want to illustrate the responses for every period and not just every 6 periods. The reason we build this model is since the cross-correlation of residuals only show accumulated magnitude and not how the response and its significance varies over time. The (orthogonalized) impulse-response functions simulate underlying structural shocks that are, by definition, uncorrelated across equations. The model follows the structure of (1) short-term rate, (2) yield spread, (3) dividend yield, (4) excess stock return and (5) excess bond return. The model is set up in a way that variables are affected by shocks in variables placed earlier in the model but remain unaffected by shocks later in the model (see Section 7.2 in Appendix for mathematical explanation on cross-correlation of residuals and IRFs).

[9] As previously done by Campbell, Chan and Viceira (2003) as well as Bams, Schotman and Tyagi (2016)

1.2.5 COMPARISON WITH ASSET ALLOCATION OF PENSION FUNDS

To robustly examine whether the Swedish buffer pension funds AP1-4 incorporate return predictive variables into their strategic asset allocation, we perform three regressions for allocation to equities and bonds. One regression with 6 month lagged macro-variables, one with previous 6-month averages of the macro-variables and one regression with percentage change over the previous 6 months of the macro-variables as explanatory variable of allocation to equities and bonds. We calculate variance inflation factors to check for multicollinearity and use White-corrected standard errors to control for heteroscedasticity.

The first regression, with 6 month lags of the explanatory variables, is expressed as

$$w_t^j = \alpha + \beta_1 * r_{t-1} + \beta_2 * ys_{t-1} + \beta_3 * dy_{t-1} + \varepsilon_t$$

where the super-script *j* refers to equities as well as bonds. The calculation is based on semi-annual data, thus the subscript *t-1* is a lag of 6 months.

When using 6 month lags for the explanatory variables there is a risk of including values that are not representative for the whole previous period of 6 months. In other words, a particular value of short-term rate, yield spread or dividend yield used in our first regression may differ significantly from the other values during the previous 6-month period. In order to control for this, in our second regression we use averages over the previous 6 months as explanatory variable for the pension funds' asset allocation. We end up in the following regression:

$$w_t^j = \alpha + \beta_1 * r_{t,t-6}^{avg} + \beta_2 * ys_{t,t-6}^{avg} + \beta_3 * dy_{t,t-6}^{avg} + \varepsilon_t$$

where the averages of the return-predictive variables for the semi-annual regression above is calculated on monthly data as

$$a_{t,t-6}^{avg} = \frac{1}{6} \sum_{i=t-6}^{6} a_i$$

In the third and last regression where we examine how the pension funds incorporate information from the return predictive variables into their strategic asset allocation we use change in the macro-economic variables as explanatory variables. This is done in order to analyze whether the funds reallocate based on changes in the return predictive variables and not just look at the level of short-term rate, yield spread and dividend yield. The regression model is

$$w_t^j = \alpha + \beta_1 * \Delta r_{t,t-1} + \beta_2 * \Delta ys_{t,t-1} + \beta_3 * \Delta dy_{t,t-1} + \varepsilon_t$$

where the change is calculated on semi-annual data as below:

$$\Delta a_{t,t-1} = \frac{a_t - a_{t-1}}{a_{t-1}}$$

There are a couple of reasons for why we use lags of the return predictive variables in our analysis of the pension funds' strategic asset allocation. First of all, our data on AP fund asset class allocations are semi-annual, and the implication is that even though the macro-economic variable and asset allocation observations occur simultaneously, we cannot know with certainty whether the funds' portfolio managers had access to the macro-data when making their portfolio decisions. Further on it is reasonable to assume that, due to nature of pension funds as long-term investors with relatively stringent allocation policies, their response to macro-economic changes will be delayed.

1.3 SUMMARY STATISTICS

1.3.1 VARIABLES FOR RETURN PREDICTABILITY ANALYSIS

Table 1: Summary Statistics Return Predictability

Summary statistics for monthly observations on the short-term rate (*r*), yield spread (*ys*), dividend yield (*dy*), 1-Month excess returns on equity (*esr*), 1-month excess return on bonds (*ebr*) and the business cycle indicator (*bci*). Data is expressed in percent (except for *bci*).

Variables	Obs.	Mean	S.D.	Min	Max
r	189	1.39	1.51	-0.81	4.53
ys	189	0.81	0.69	-0.77	2.53
dy	189	3.21	0.80	2.08	6.31
esr	189	0.87	5.11	-18.26	21.66
ebr	189	0.21	0.73	-1.69	2.52
bci	189	100.34	10.35	66.80	116.50

Notes: r is the annualized yield on the Sweden 3-Month T-Bill. *ys* is the difference between annualized yield on the Sweden 5-Year government bond and the annualized yield on the Sweden 3-Month T-Bill. *dy* is the ratio of dividends on the SAX index for year *t* to the value of the index at the end of the year. *esr* is the monthly return on the SAX Total Return Index less the monthly return on the Sweden 3-Month T-Bill. *ebr* is the monthly return on the FTSE Sweden Global 3-5YR Total Return Index less the monthly yield on the Sweden 3-Month T-Bill. *bci* is the values from the Swedish Economic Tendency Survey.

Prior to continuing to the results of our various regression we will present our summary statistics. *Table 1* pertains to our first question to study; how short-term rate, yield spread and dividend yield predict excess stock and bond return. *Table 1* shows our summary statistics for the monthly observations of variables during the period 2002-07:2018-03.

Average annualized short-term rate on the Sweden 3-Month T-Bill, *r*, for the period is 1.39% with a standard deviation of 1.51%. The yield spread has a mean of 0.81%, with the lowest standard deviation of all the variables; 0.69%. The final potential explanatory variable, dividend yield, is on average 3.21% and exhibits a standard deviation of 0.80%. Monthly excess equity return measured on the SAX index has a mean of 0.87%, almost four times as high as the mean monthly excess return on AAA government bonds (0.21%). Excess return on the equity index shows, unsurprisingly, the highest standard deviation (5.11%), seven times higher than then excess bond returns (0.73%). As the equity risk premium is higher than the bond risk premium, the differing standard deviations are intuitively sound. Finally, the values from the business cycle indicator have a mean of 100.34 with a standard deviation of 10.35%, consistent with the survey definition given by Sweden's National Institute of Economic Research.

1.3.2 VARIABLES FOR PENSION FUND STRATEGIC ASSET ALLOCATION

Table 2: Summary Statistics Asset Allocation

Summary statistics for semi-annual observations on the short-term rate (*r*), yield spread (*ys*), dividend yield (*dy*), AP fund allocation to equity (*ae*) and AP fund allocation to bonds (*ab*). Data is expressed in percent.

Variables	Obs	Mean	S.D.	Min	Max
r	32	1.40	1.53	-0.77	4.30
ys	32	0.88	0.65	-0.36	2.29
dy	32	3.23	0.79	2.18	5.91
ae	32	59.66	2.69	55.49	64.21
ab	32	38.85	2.20	34.91	44.14

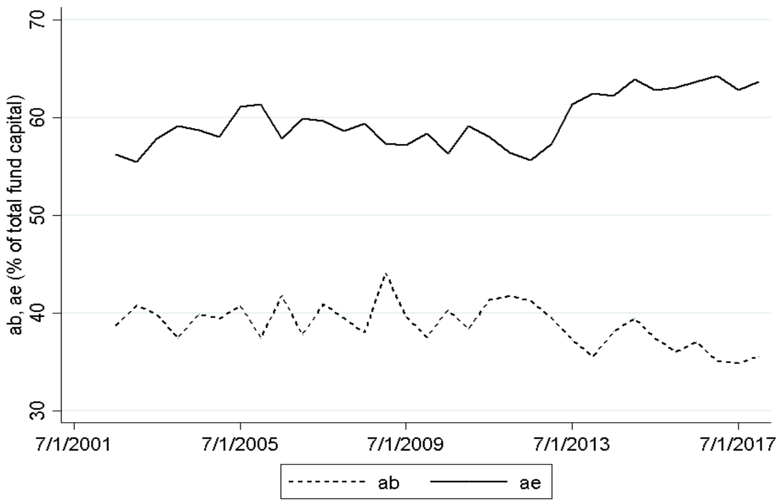
Notes: r is the annualized yield on the Sweden 3-Month T-Bill. *ys* is the difference between annualized yield on the Sweden 5-Year government bond and the annualized yield on the Sweden 3-Month T-Bill. *dy* is the ratio of dividends on the SAX index for year *t* to the value of the index at the end of the year. *ae* is the AP funds' average percentage allocation to equities. *ab* is the AP funds' average percentage allocation to bonds.

Table 2 relates to our second question of interest in this paper; if and how the AP funds incorporate the potential drivers of returns in their strategic asset allocation decisions. Summary statistics in *Table 2* present semi-annual data for the period 2002-06:2017-12 and show similar results for *r*, *ys* and *dy* as in *Table 1*. They differ slightly because of fewer observations, caused by a somewhat shorter sample period and lower frequency. The mean for the average allocation to equities is 59.66% and the mean for average allocation to bonds is 38.85% with standard deviations of 2.69% and 2.20%, respectively. Considering the fact that the AP funds have clear regulation when it comes to their holdings of bonds (required to hold a minimum of 30% of portfolio in bonds), it is not too surprisingly to see that the minimum allocation to bonds observed in our sample is 34.91%.

In *Figure 1* we can see the historical equity and bond allocations during the period 2002-06 until 2017-12. Graphically we can observe a peak in bond allocation during the 2008-09 crisis, as well as a trough in equity allocations; presumably during the height of the Eurozone debt crisis. The allocation levels observed are relatively stable, but during the last years we see a general slight increase in equity allocation, implying a slight decrease in bond allocation. This could be a result of the persistently decreasing interest rates (for the period 2012-01:2017-12), and in theory decreasing bond yields, urging the buffer funds to search for yield in equities instead. Bams, Schotman and Tyagi (2016) emphasize that this is consistent with literature on strategic asset allocation, where fixed-income becomes a less attractive asset class when interest rates are low due to lower expected returns.

Figure 1: Pension Fund Asset Allocation

Average AP fund portfolio weighting for equities (*ae*) and bonds (*ab*) for the time period 2002:2017.



2. RESULTS

2.1 FINDINGS FROM AUTOCORRELATION AND CORRELATION ANALYSIS

Table 3: Autocorrelation

Autocorrelation table for monthly observations on the short-term rate (*r*), yield spread (*ys*), dividend yield (*dy*) and on 1-month excess stock return (*esr*) and excess bond return (*ebr*).

			Autocorrelations										
Variables	Mean	S.D.	1	2	3	4	6	8	10	12	14	16	18
2002-2018													
r	1.39	1.51	0.98	0.95	0.92	0.88	0.80	0.72	0.64	0.56	0.49	0.42	0.36
ys	0.81	0.69	0.95	0.89	0.82	0.74	0.59	0.45	0.30	0.14	0.01	-0.11	-0.18
dy	3.21	0.80	0.95	0.88	0.80	0.72	0.52	0.39	0.27	0.18	0.08	0.00	-0.07
esr	0.87	5.11	0.08	-0.03	0.15	0.01	0.01	0.05	-0.11	0.06	0.04	-0.05	-0.14
ebr	0.21	0.73	0.17	0.14	0.12	-0.02	-0.08	-0.12	-0.03	0.00	0.01	-0.02	0.03

Notes: r is the annualized yield on the Sweden 3-Month T-Bill. *ys* is the difference between annualized yield on the Sweden 5-Year government bond and the annualized yield on the Sweden 3-Month T-Bill. *dy* is the ratio of dividends on the SAX index for year *t* to the value of the index at the end of the year. *esr* is the monthly return on the SAX Total Return Index less the monthly return on the Sweden 3-Month T-Bill. *ebr* is the monthly return on the FTSE Sweden Global 3-5YR Total Return Index less the monthly yield on the Sweden 3-Month T-Bill.

Table 3 describes the autocorrelation for the return predictive variables as well as for excess stock and bond return for lag lengths from 1 to 18 months. The autocorrelation of the return predictive macro-economic variables give us a hint on how the variables affect different components of excess return. The autocorrelation for the predictive macro-variables are highest for the first order lag and then decrease for longer lags.

The short-term rate experiences a smaller decrease of autocorrelation on longer lag lengths than yield spread and dividend yield. Thus, the short-term rate is more highly correlated to its own historical values on longer lags than yield spread and dividend yield. Fama and French (1989) argue that this suggests that the yield spread and dividend yield track components of return that are autocorrelated but with a tendency towards mean reversion.

The autocorrelation and correlation in our sample shows that dividend yield and yield spread seem to predict similar components of return, but in opposite direction. The fact that the autocorrelation of these variables decrease rapidly for longer lags suggests that they track components of return related to short-term variations in business conditions. As shown in *Table 4*, yield spread and dividend yield also have the highest (absolute) correlation amongst the return predictive variables in our sample, which strengthens the previous suggestion. This is in contrast to previous literature on U.S. data with longer sample periods that suggests yield spread and dividend yield track different components of return, i.e. components on different time horizons. Fama and French (1989) find that yield spread predicts components of excess return in response to short-term variations in business conditions whilst dividend yield tracks variation related to more persistent aspects of business conditions. In our data, short-term rate has a more stable autocorrelation and is less correlated with the other return predictive variables, suggesting that short-term rate tracks expected return variations related to more long-term aspects of business conditions.

Table 4: Correlation

Correlation table for monthly observations on the short-term rate (*r*), yield spread (*ys*), dividend yield (*dy*) and on 1-month excess stock return (*esr*) and excess bond return (*ebr*).

	r_t	ys_t	dy_t	esr_t	ebr_t
r_t	1.00				
ys_t	-0.14	1.00			
dy_t	-0.14	-0.47	1.00		
esr_t	-0.19	0.25	-0.26	1.00	
ebr_t	0.06	-0.18	0.23	-0.37	1.00

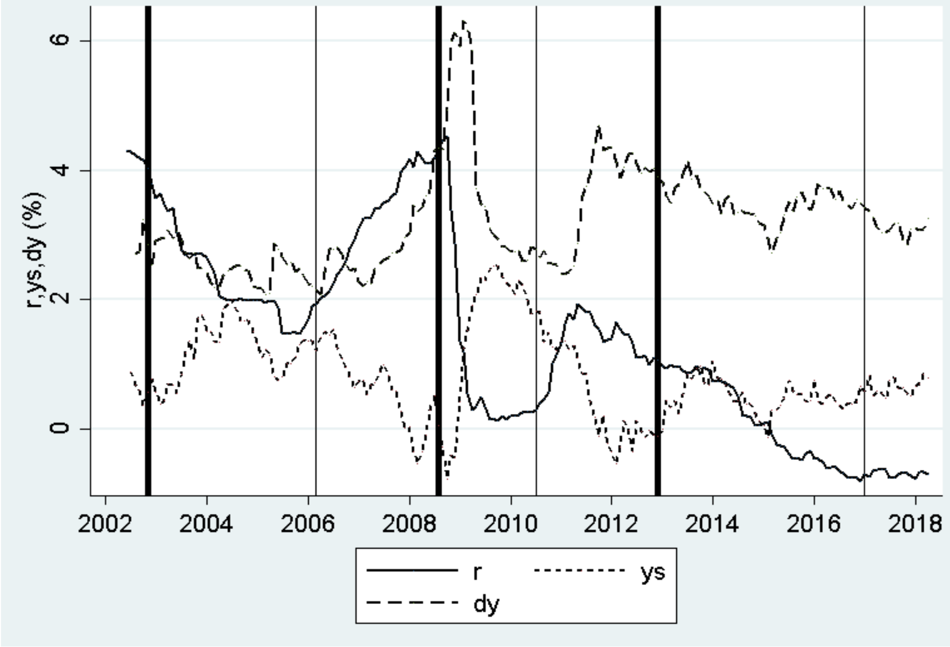
Notes: r is the annualized yield on the Sweden 3-Month T-Bill. *ys* is the difference between annualized yield on the Sweden 5-Year government bond and the annualized yield on the Sweden 3-Month T-Bill. *dy* is the ratio of dividends on the SAX index for year *t* to the value of the index at the end of the year. *esr* is the monthly return on the SAX Total Return Index less the monthly return on the Sweden 3-Month T-Bill. *ebr* is the monthly return on the FTSE Sweden Global 3-5YR Total Return Index less the monthly yield on the Sweden 3-Month T-Bill.

2.2 FINDINGS FROM PLOTS OF THE FORECASTING VARIABLES

When analyzing and interpreting the following plots of the forecasting variables it is important to have the results from the analysis of autocorrelation and correlation in mind as they should have implications for the graphics of the plots. The autocorrelation analysis suggests that short-term rate forecasts return variations related to more persistent aspects of business conditions than yield spread and dividend yield that track similar less persistent components of expected return. The high correlation (in absolute terms) between yield spread and dividend yield strengthens the suggestion that yield spread and dividend yield track similar parts of expected return.

Figure 2: Macro-variables and Business Cycle Peaks and Troughs

The short-term rate, *r*, yield spread, *ys*, dividend yield, *dy*, plotted against each other for the time period 2002-7:2018-3. Thick and thin lines represent business cycle troughs and peaks, respectively.



2002-10 (T), 2006-02 (P), 2008-07 (T), 2010-06 (P), 2012-11 (T), 2016-12 (P)

Notes: r is the annualized yield on the Sweden 3-Month T-Bill. *ys* is the difference between annualized yield on the Sweden 5-Year government bond and the annualized yield on the Sweden 3-Month T-Bill. *dy* is the ratio of dividends on the SAX index for year t to the value of the index at the end of the year.

In *Figure 2* above, the three predictive variables short-term rate, yield spread and dividend yield are shown with respect to the business cycle troughs and peaks, based on data and definitions from NIER. There are three troughs and three peaks during our sample period; thick vertical lines represent business cycle troughs and thin vertical lines represent business cycle peaks.

The reason for analyzing this graphically is, as in Fama and French (1989), to gain information about how the return predictive variables track parts of return related to more or less persistent aspects of business conditions.

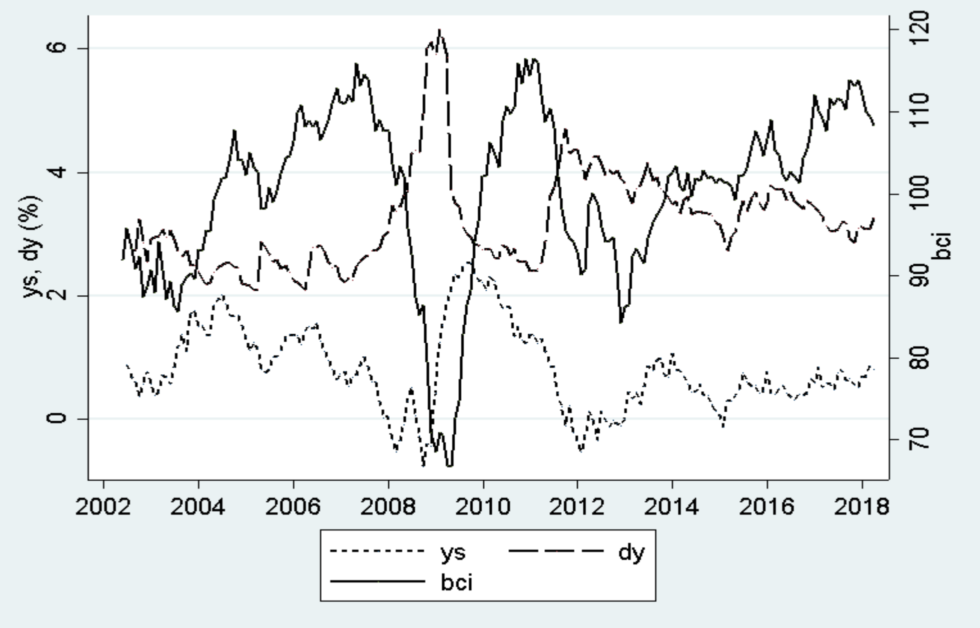
The short-term rate, *r*, seems to show some business cycle variations, but its movements seem to go beyond the cycles identified by NIER. For the period 2002-07:2011-12, *r* varies relatively coherent with the peaks and troughs. Pre-2012 the short-term rate declines during contractionary periods and rises during expansionary conditions. Post-2011 it has a steady linear negative slope despite the business cycle experiencing both a trough and a peak. The fact that the autocorrelation of short-term rate is more persistent on longer lags than the other macro-variables strengthens this. This suggests that short-term rate predict parts of stock and bond returns related to more persistent aspects of business conditions.

Looking at the yield spread, its variation is more related to measured business cycles extremes, where it takes its lowest value during our sample period at the 2008-09 crisis and its highest value post crisis close to the following business cycle peak. In general, yield spread tends to be high close to business cycle peaks and low close to business cycle troughs. The pattern is not as clear after 2013 as before 2013. A possible explanation to this could be the unconventional monetary policy, enacted by the Riksbank through low interest rates and quantitative easing. Fama and French (1989) find a similar anomaly during the period 1933:1951 where the bill rate (short-term rate) in U.S. was close to zero. The fact that yield spread has high autocorrelation for first order lag but decreasing rapidly for longer lag lengths is in line with this finding that it varies with short-term variations in business conditions and is not as dependent on its own historical values.

Dividend yield, *dy*, peaks at business cycle troughs and bottoms at business cycle peaks. As *Figure 2* shows, the dividend yield has its highest value during the 2008-09 crisis and its lowest value at the business cycle peak before this crisis. This indicates that the dividend yield forecasts high returns when business conditions are particularly weak and low returns when business conditions are particularly strong. The dividend yield is highly correlated with yield spread and has the similar behavior with high autocorrelation at the first order lag but with less persistent autocorrelation on longer lags. This suggest that dividend yield also tracks parts of stock and bond return related to short-term variations in business conditions, in contrast to short-term rate.

Figure 3: Yield Spread, Dividend Yield and Business Cycle Indicator

The yield spread, *ys*, dividend yield, *dy*, and the business cycle indicator, *bci*, plotted against each other for the time period 2002-07:2018-03.



Notes: ys is the difference between annualized yield on the Sweden 5-Year government bond and the annualized yield on the Sweden 3-Month T-Bill. *dy* is the ratio of dividends on the SAX index for year t to the value of the index at the end of the year. *bci* is the values from the Economic Tendency Survey, carried out by NIER.

Figure 3 above, shows the correlated macro-variables yield spread and dividend yield and how they relate to fluctuations in the business conditions, where *bci* is the proxy. In the same figure we see that yield spread and dividend yield reaches its highest value during the culmination of the 2008-09 financial crisis, almost simultaneously as the business cycle indicator reach its lowest value.

As outlined previously in the autocorrelation analysis the two studied variables have a more rapid decrease in autocorrelation on longer lag lengths. This can be observed graphically as we see that fluctuations in *bci* occur relatively simultaneously as those for *ys* and *dy*. This strengthens our previous suggestion that yield spread and dividend yield predict changes in stock return closely related to the short-term business cycle variations.

Kessel (1965) documented the fact that yields on longer term Treasury bonds rise less than short-term rates during business expansions and fall less during contractions, implying that *ys* should move inversely *bci*, which is also observable in the figure, although only apparent in the period 2002-07:2012-12.

Fama (1988) argues that business cycle-variation in short-term rates have a mean-reverting tendency, implying variations in long-term rates to be less extreme than variations in short-term rates. When combined with Kessel's (1965) observation of short-term rates rising during expansionary periods we should see (1) an increasing *r* for the period 2013 until 2018 and (2) a widening yield spread, consistent with prior observations for the time period. In F*igure 3* it is also observable that neither Fama's nor Kessel's conclusions can be seen. In *Figure* 2 we see that post-2011, when we identify both a business cycle trough and peak, the short-term rate continues to decline, and post-2015 we do not see a widening yield spread, but a rather linear and non-sloping development. All in all, the patterns for the macro-variables seen pre-2012 seem to cease to exist. Possible reasons for these inconsistencies with financial literature for the periods outlined above could be the economic uncertainty following the Eurozone debt crisis, culminating in 2012, and the unconventionally loose monetary policy enacted by the Swedish Riksbank that followed. It is also important to note that one cannot draw too sound conclusions based on graphical analysis, it is best to be used as a tool in combination with more technical analysis, as we have from the autocorrelation and correlation.

2.3 FINDINGS FROM VECTOR AUTOREGRESSION ANALYSIS

2.3.1 MAIN VAR FINDINGS

As mentioned earlier in the strategy implementation, prior to the vector autoregression analysis, we run several tests in order to determine optimal lag lengths. As shown in *Table 9* in the Appendix, we find that for our sample the likelihood ratio test suggests a lag length of 10 periods, final prediction error and Akaike's information criterion a lag length of 5 periods and Hannan and Quinn as well as Schwartz's information criterion a lag length of 1 period. Obviously we see inconsistencies in the results for suggested lag lengths. As the objective of the paper is to cross-check our findings with the Swedish buffer pension funds (and the fact that the tests do not give consistent suggested lag length), we choose a lag length appropriate with the frequencies of the observations in our data set on the pension funds. As the data on the pension funds' asset allocation has a semi-annual frequency, we choose to conduct the VAR estimations with a lag length of 6 months. Our tests indicate optimal lag lengths between 1 and 10 months, thus the lag length is in this interval and is therefore assumed to be reasonable.

Table 5 presents our results from the VAR and cross-correlation of residuals. In the top (*Table 5a*), we present the VAR parameter estimation results with a lag length of 6 months. The last row reports the R^2 and the *p*-value of the F-test of the joint significance. In *Table 5b* we present a matrix with the results from the cross-correlations of residuals, calculated on the error terms from the VAR. It should be mentioned that it is difficult to predict return on stocks and bonds. Fama and French (1989) emphasize that R^2 typically is less than 0.1 for monthly returns. Campbell, Chan and Viceira (2003) emphasize that predicting stock return is difficult and have R^2 below 0.1 in their VAR.

Table 5: Vector Autoregression

5a: VAR parameter estimation results for monthly observations on the short-term rate (*r*), yield spread (*ys*), dividend yield (*dy*) and on 1-month excess stock return (*esr*) and bond return (*ebr*). *z*-score in parentheses for the coefficients and *p*-value in parentheses for R^2.

	r_t	ys_t	dy_t	esr_t	ebr_t
r_{t-6}	0.827	0.074	0.073	-0.108	0.048
	(27.13)	(2.81)	(2.34)	(-0.44)	(1.25)
ys_{t-6}	0.083	0.795	-0.499	1.124	0.119
	(1.18)	(12.98)	(-6.93)	(1.98)	(1.33)
dy_{t-6}	-0.447	0.342	0.368	1.229	0.050
	(-7.15)	(6.30)	(5.78)	(2.45)	(0.64)
esr_{t-6}	-0.001	0.024	-0.011	0.058	-0.004
	(-0.13)	(2.96)	(-1.16)	(0.79)	(-0.33)
ebr_{t-6}	-0.130	0.177	-0.204	0.905	-0.088
	(-2.09)	(3.30)	(-3.23)	(1.82)	(-1.12)
R^2	0.847	0.506	0.492	0.066	0.023
	(0.00)	(0.00)	(0.00)	(0.02)	(0.52)

5b: Cross-Correlation of Residuals

	r_t	ys_t	dy_t	esr_t	ebr_t
r_{t-6}	0.32	-0.11	-0.10	-0.26	-0.06
ys_{t-6}		0.24	-0.10	0.46	-0.12
dy_{t-6}			0.33	-1.07	0.16
esr_{t-6}				20.60	-1.09
ebr_{t-6}					0.52

Notes: *r* is the annualized yield on the Sweden 3-Month T-Bill. *ys* is the difference between annualized yield on the Sweden 5-Year government bond and the annualized yield on the Sweden 3-Month T-Bill. *dy* is the ratio of dividends on the SAX index for year *t* to the value of the index at the end of the year. *esr* is the monthly return on the SAX Total Return Index less the monthly return on the Sweden 3-Month T-Bill. *ebr* is the monthly return on the FTSE Sweden Global 3-5YR Total Return Index less the monthly yield on the Sweden 3-Month T-Bill.

With the lags applied in our three macro-economic variables it is observable that they fail to significantly predict excess bond returns in the VAR. Short-term rates, *r*, yield spreads, *ys*, and dividend yields, *dy*, show z-score of (1.25), (1.33) and (0.64), respectively. Furthermore, the *p*-value of the F-test of the joint significance in the equation for excess bond return (0.52) is above the threshold of 0.05 that is often used to define significance. Neither do the cross-correlation of residuals (that indicate how unexpected return is affected by shocks in the return predictive variables) indicate strong impactful effects on excess bond return from shocks in the macro-economic variables. However, it is observed in the same column in *Table 5b* that unexpected excess bond return is highly negatively correlated to lagged shocks in excess stock return (-1.09). The negative correlation is consistent with the flight-to-quality theory. The dynamics of the theory is that as the equity market experiences a negative price shock, investors will turn to a risk-off sentiment and allocate more capital towards the bond market, considered safer. As bond demand increases, their share prices increase, and thereon the total return increases. Baur and Lucy (2006) found the market movements in their research, after the Asian and Russian crisis in 1997 to be in line with flight-to-quality.

Lagged short-term rate predict excess stock return negatively, but the effect is not significant at this lag order. Unexpected excess stock return is negatively related to lagged shocks in short-term rate. However, the effect on unexpected return from shocks to short-term rate is smaller than the effect of shocks to both yield spread and dividend yield.

We find a significant positive relation between excess stock return and 6 months lagged yield spread. Looking at the cross-correlation of residuals, unexpected excess stock return is positively correlated with shocks to the yield spread. Thus, both expected and unexpected stock return is positively correlated with lags in yield spread. Domain and Reichenstein (1998) state that a widely adopted but unproven old hypothesis to why the yield spread predicts excess return on stock is based on Fama and French (1989), who suggest that the spread tracks a maturity risk premium in expected returns that is similar for all long-term assets. The hypothesis is that the spread compensates for exposure to discount rate shocks that affect long-term assets like stocks and bonds, in roughly the same way.

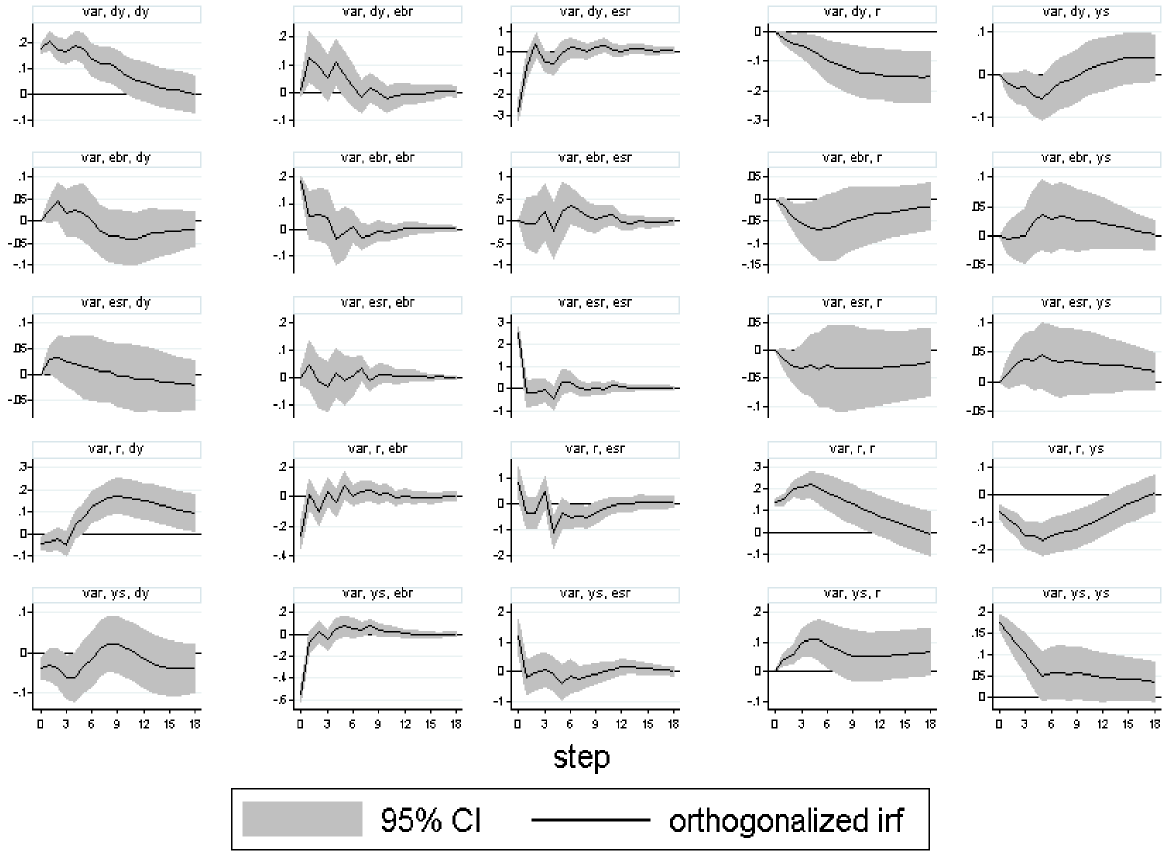
Looking at dividend yield's return predictive power, lagged dividend yield predicts expected stock return positively and the effect is significant. Similar VARs performed by Bams, Schotman and Tyagi (2016) and Campbell, Chan and Viceira (2003) find the same result. However, unexpected stock return and lagged shocks in dividend yield is highly negatively correlated, as shown in the cross-correlation of residuals matrix (*Table 5b*). Thus, the effect of changes in dividend yield on stock return is ambiguous, where the effect on excess stock return depends on if the dividend yield is assumed to experience a shock or not. Furthermore, our findings suggest that the effect on excess stock return from shocks to dividend yield is explained by the denominator of dividend yield, i.e. the stock index itself. Dividend yield peaks during the 2008-09 crisis, and unexpected excess stock return is strongly positively related to lagged shocks in excess stock return (20.60). This implies that the negative relationship between unexpected stock return and shocks to dividend yield is most possibly a result of the positive correlation between unexpected stock return and shocks of stock return rather than a shock in dividends itself.

To sum up our findings from the VAR, the model fails to predict expected excess bond return but yield spread and dividend yield predicts excess stock return significantly. Yield spread predicts stock return positively both when looking at shocks and "ordinary" changes in yield spread. Lags in dividend yield is positively related to expected stock return but shocks in dividend yield is negatively related to unexpected stock return. Thus, yield spread is the best predictor for excess stock return to base strategic asset allocation decisions on. A more nuanced illustration of how returns are affected by (structural) uncorrelated shocks follows in the findings from the impulse-response functions.

2.3.2 FINDINGS FROM IMPULSE-RESPONSE FUNCTIONS

Figure 4: Graphs from the Impulse-Response Functions

Graphical results from orthogonalized impulse-response functions with a 95% confidence interval. One impulse variable in each row and one response variable in each column.



Notes: *r* is the annualized yield on the Sweden 3-Month T-Bill. *ys* is the difference between annualized yield on the Sweden 5-Year government bond and the annualized yield on the Sweden 3-Month T-Bill. *dy* is the ratio of dividends on the SAX index for year t to the value of the index at the end of the year. *esr* is the monthly return on the SAX Total Return Index less the monthly return on the Sweden 3-Month T-Bill. *ebr* is the monthly return on the FTSE Sweden Global 3-5YR Total Return Index less the monthly yield on the Sweden 3-Month T-Bill.

In *Figure 4*, graphs of the results from the orthogonalized impulse-response functions are presented. The vertical axis represent percentage points (pp) and the horizontal axis shows units of time (months). The reason we build this model is since the cross-correlation of residuals (*Table 5b*) only show accumulated magnitude and not how the response and its significance varies over time. The figure is structured with one impulse variable on each row and one response variable in each column. The impulse is a one standard deviation increase. Moreover, in *Table 6* we present the result from the IRFs together with minimum and maximum levels in the 95% confidence interval numerically.

The effect from a positive shock of one standard deviation on the short-term rate is persistent as it stays significantly elevated for 11 months. The response of excess bond return is an initial decrease of 0.26 pp but any significant effect after the initial response is not observable. Increased short-term rate affects excess stock return both positively and negatively. The initial effect is a significant increase of 0.81 pp but followed by significant decreases of -1.12 pp, -0.51 pp, -0.46 pp and -0.53 pp during the first 8 months. Thus, the main effect on excess stock return from an impulse on short-term rate is negative and occurs after 4 to 8 months.

An impulse on yield spread causes it to stay significantly elevated for 4 months. The initial response of excess bond return is a significant decrease of 0.55 pp and a significant increase of 0.08 pp after 8 months. The response of excess stock return is opposite to the one of excess bond. Excess stock return experiences an initial increase of 1.21 pp as a response of a one standard deviation increase of yield spread.

When dividend yield experiences a positive shock of one standard deviation, it stays significantly elevated for 9 periods. The significant response of excess bond return is 0.13 pp, 0.09 pp and 0.11 pp for period 1, 2 and 4. The initial response of excess stock return is a dramatic significant decrease of 2.79 pp followed by a significant decrease of 0.68 pp. After 6 months, the response of excess stock return is positive with a significant increase of 0.36 pp for period 10.

These results match our previous suggestion that yield spread and dividend yield track parts of excess stock return related to short-term variations in business cycles. When these variables are shocked, the main effect on excess stock and bond return is immediate. In contrast, the response of excess stock return from a shock in short-term rate has its main effect between periods 4 and 8. Thus, the response of excess stock return from a shock to short-term rate is different than for yield spread and dividend yield, where the main effect occurs immediately.

Table 6: Impulse-Response Functions

Numerical results from orthogonalized impulse-response functions for monthly observations on the short-term rate (*r*), yield spread (*ys*), dividend yield (*dy*) and on one-month excess stock returns (*esr*) and bond return (*ebr*)

			Lag length									
Impulse	Response		0	2	4	6	8	10	12	14	16	18
r	*esr*	OIRF	0.81	-0.34	-1.12	-0.51	-0.53	-0.17	-0.03	0.08	0.05	0.08
		Lower	0.24	-0.92	-1.70	-0.96	-0.95	-0.50	-0.31	-0.17	-0.17	-0.13
		Upper	1.39	0.24	-0.54	-0.07	-0.11	0.16	0.25	0.32	0.27	0.28
	ebr	OIRF	-0.26	-0.10	-0.04	0.01	0.04	0.03	0.01	0.00	0.00	0.00
		Lower	-0.35	-0.20	-0.13	-0.06	-0.02	-0.03	-0.04	-0.04	-0.03	-0.03
		Upper	-0.17	-0.01	0.05	0.08	0.11	0.09	0.05	0.03	0.03	0.03
ys	*esr*	OIRF	1.21	-0.01	-0.10	-0.12	-0.14	0.00	0.16	0.14	0.07	0.01
		Lower	0.65	-0.59	-0.67	-0.68	-0.52	-0.31	-0.08	-0.06	-0.09	-0.12
		Upper	1.76	0.57	0.48	0.44	0.24	0.32	0.41	0.34	0.23	0.15
	ebr	OIRF	-0.55	0.03	0.06	0.06	0.08	0.03	0.01	0.00	-0.01	0.00
		Lower	-0.61	-0.07	-0.04	-0.03	0.02	-0.02	-0.03	-0.04	-0.03	-0.01
		Upper	-0.49	0.12	0.15	0.15	0.13	0.07	0.05	0.03	0.02	0.02
dy	*esr*	OIRF	-2.79	0.37	-0.55	0.25	0.05	0.36	0.07	0.19	0.07	0.11
		Lower	-3.25	-0.16	-1.06	-0.23	-0.31	0.05	-0.18	-0.03	-0.12	-0.04
		Upper	-2.33	0.90	-0.05	0.72	0.42	0.67	0.33	0.41	0.26	0.27
	ebr	OIRF	0.01	0.09	0.11	0.02	0.02	-0.02	0.00	-0.01	0.00	0.00
		Lower	-0.01	0.01	0.03	-0.05	-0.04	-0.07	-0.04	-0.03	-0.02	-0.01
		Upper	0.04	0.18	0.19	0.10	0.07	0.02	0.03	0.02	0.03	0.02

Notes: r is the annualized yield on the Sweden 3-Month T-Bill. *ys* is the difference between annualized yield on the the Sweden 5-Year government bond and the annualized yield on the Sweden 3-Month T-Bill. *dy* is the ratio of dividends on the SAX index for year *t* to the value of the index at the end of the year. *esr* is the monthly return on the SAX Total Return Index less the monthly return on the Sweden 3-Month T-Bill. *ebr* is the monthly return on the FTSE Sweden Global 3-5YR Total Return Index less the monthly yield on the Sweden 3-Month T-Bill.

2.4. FINDINGS FOR AP FUND STRATEGIC ASSET ALLOCATION

Table 7: Regressions of Allocation to Bonds

Slopes, (*z-score*), and R^2 from regressions on bond allocations on *r*, *ys* and *dy*; 2002-06:2017-12

	Bond Allocation		
Variables	6M Lag	Previous 6M Avg.	6M Delta
r	0.983***	0.895***	0.121
	(4.51)	(4.07)	(0.57)
ys	0.737	0.573	0.013
	(1.33)	(1.24)	(1.00)
dy	0.430	1.007**	5.307**
	(0.96)	(2.18)	(2.47)
Constant	35.362***	33.810***	38.771***
	(19.49)	(19.54)	(102.26)
Observation	31	32	31
R-squared	0.413	0.384	0.235

6M Lag regression: $w_t^j = \alpha + \beta_1 * r_{t-1} + \beta_2 * ys_{t-1} + \beta_3 * dy_{t-1} + \varepsilon_t$
Previous 6M Avg.: $w_t^j = \alpha + \beta_1 * r_{t,t-6}^{avg} + \beta_2 * ys_{t,t-6}^{avg} + \beta_3 * dy_{t,t-6}^{avg} + \varepsilon_t$
6M Delta: $w_t^j = \alpha + \beta_1 * \Delta r_{t,t-1} + \beta_2 * \Delta ys_{t,t-1} + \beta_3 * \Delta dy_{t,t-1} + \varepsilon_t$
Notes: The regressions are made with White-corrected standard errors to control for heteroskedasticity. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively.

The regressions in *Table 7* show how the average holdings in bonds (as percent of total fund capital) for AP1-4 are explained by 6-month lag, previous 6-month average and change over the previous 6 months in short-term rate, yield spread and dividend yield. The first column from the left lists the variables and the second, third and fourth columns list the slopes for the respective explanatory variables, amount of observations and explanatory values. The regressions are made with White-corrected standard errors to control for heteroscedasticity. No explanatory variable has a variance inflation factor above 1.5. *Table 10* in Appendix shows results for the variance inflation factors for each regression.

For the regression in the second column, 6 month lags, the short-term rate is the only explanatory variable that significantly drives the funds' allocation of bonds. This result is not too surprising as conventional financial theory states that as short-term rate increase, bond share prices decrease due to the discount effect, thus the yield and thereon bond attractiveness increases (disregarding inflation). Lags in yield spread and dividend yield are also positively related to the funds' holding in bonds, but the coefficients are not significant.

In the third column, previous 6 months average for the macro-variables is regressed against holdings in bonds as percentage of total fund capital. The sign and significance of the coefficient for short-term rate is the same as when looking at 6 months lags for the return predictive variables. Dividend yield is significant in this regression, where the funds on average increase their holdings in bonds when the dividend yield increases. Thus, previous 6-month average of dividend yield is positively related to allocation to bonds. The coefficient for yield spread is not significant.

The fourth, and final column shows how allocation to bonds for the funds is explained by change during the previous 6 months for the return predictive variables. Change in short-term rate and yield spread is positively related to allocation to bonds for the funds, but the coefficients are not significant. Changes in dividend yield significantly explains allocations to bonds, where the funds increase their holdings in bonds if the change of dividend yield is positive.

Table 8: Regressions of Allocation to Equities

Slopes, (*z*-score), and R^2 from regressions on equity on *r*, *ys* and *dy*; 2002-06:2017-12

	Equity Allocation		
Variables	6M Lag	Previous 6M Avg.	6M Delta
r	-1.264***	-1.295***	-0.435**
	(-7.30)	(-8.08)	(-2.07)
ys	-1.833***	-1.985***	-0.017***
	(-2.79)	(-3.48)	(-2.90)
dy	-1.344***	-1.590***	-2.014
	(-3.42)	(-3.67)	(-1.04)
Constant	67.597***	68.327***	59.725***
	(46.95)	(46.55)	(116.95)
Observation	31	32	31
R-squared	0.531	0.580	0.063

6M Lag regression: $w_t^j = \alpha + \beta_1 * r_{t-1} + \beta_2 * ys_{t-1} + \beta_3 * dy_{t-1} + \varepsilon_t$
Previous 6M Avg.: $w_t^j = \alpha + \beta_1 * r_{t,t-6}^{avg} + \beta_2 * ys_{t,t-6}^{avg} + \beta_3 * dy_{t,t-6}^{avg} + \varepsilon_t$
6M Delta: $w_t^j = \alpha + \beta_1 * \Delta r_{t,t-1} + \beta_2 * \Delta ys_{t,t-1} + \beta_3 * \Delta dy_{t,t-1} + \varepsilon_t$
Notes: The regressions are made with White-corrected standard errors to control for heteroskedasticity. *, **, and *** represent significance at the 10%, 5%, and 1% level, respectively.

The regressions in *Table 8* show how the average holdings in equities (as percent of total fund capital) for AP1-4 are explained by 6-month lag, previous 6-month average and change during the previous 6 months of short-term rate, yield spread and dividend yield. The regressions are made with White-corrected standard errors to control for heteroscedasticity. No explanatory variable has a variance inflation factor above 1.5, as shown in *Table 10* in the Appendix.

The coefficients for 6-month lags of the return predictive macro-variables are all significantly negative. The slopes are -1.264, -1.833 and -1.344 for *r*, *ys* and *dy*, respectively. Thus, the Swedish buffer pension funds' holdings in equities is negatively related to 6-month lags in short-term rate, yield spread and dividend yield increases. The magnitude is largest for yield spread.

The regression in the third column examines the equity allocation explained by previous 6-month average of the macro-variables. In other words, previous 6-month average for the macro-variables is regressed against holdings in equities as percentage of total fund capital. The sign and significance of the coefficients are the same as when looking at 6 months lags for the return predictive variables. Although it is observable that the slope values for the coefficients are somewhat more negative, compared to those of the 6-month lag regression.

The fourth, and final column, shows how allocation to equities for the funds is explained by change during the previous 6 months for the return predictive variable. Changes in the short-term rate and yield spread have significant coefficients. Changes in dividend yield do not explain allocations to equities significantly.

We find that the buffer pension funds incorporate return predictive macro-variables into their strategic asset allocation. On average, the funds decrease their holdings in equities when short-term rate, dividend yield and yield spread increases. The coefficients are significant in all three regressions expect for the dividend yield in the regression with changes in the return predictive variables as explanatory variable. Thus, the results are most robust for short-term rate and yield spread which have negative significant coefficient in all three of our regressions. The macro-variables underlying the funds' decision to change their holdings in bonds are short-term rate and dividend yield where both have significant coefficients in two out of the three regressions. Yield spread is not significant in any of the three regressions for allocation to bonds. We therefore cannot find evidence that the funds incorporate predictive information from yield spread into their strategic asset allocation when it comes to bond allocation.

It is difficult to give an absolute answer to whether the funds are incorporating the return predictive variables correctly into their strategic asset allocation. One reason for this is that our findings of how the macro-variables affect return on stocks and bonds sometimes differ depending on if the change in the macro-variable is defined as a shock or not. Unfortunately, isolating periods of stable conditions is not possible due to our data set, as explained in Section 1.2.1. Moreover, there are several potential sources of errors when using book values for analysis of asset allocation.

However, based on our findings from the return predictive part of this paper, we can conclude that the funds should not decrease their allocation to equities when the yield spread increases (and vice versa). Both expected and unexpected excess stock return is positively related to change and shocks in yield spread. Yield spread has a significant negative relation to allocation to equities at the 1% level in all three of our regressions of the funds allocation to equities. Thus, according to our findings, the pension funds do not incorporate the information from yield spread correctly into their strategic asset allocation.

Our findings suggest that the funds, on average, seem to mainly incorporate short-term rate into their strategic asset allocation decisions. This is based on the fact that the coefficient is significant in 5 out of our 6 regressions (4 of them are significant at the 1% level). On average, the funds increase their holdings in bonds and decrease their holdings in equities when the short-term rate increases (and vice versa). This behaviour is in line with the search for yield phenomena but not fully supported by our findings. In the VAR, we did not find any significance between 6-month lags in short-term rate and excess stock or bond return. Thus, our findings do not support the short-term rate as what looks to be the main return predictive macro-variable used by the funds in their strategic asset allocation decisions.

3. MECHANISMS AND ADDITIONAL EVIDENCE

3.1 FINDINGS FROM AUTOCORRELATION AND GRAPHICAL PLOTS

As outlined in the autocorrelation and correlation analysis (Section 2.1 and Section 2.2) we suggest that dividend yield and yield spreads seem to track similar components of return, but in opposite directions. The variables have high negative correlation and similar autocorrelation over the different lag lengths. The graphical plots showed their relatively consistent negative fluctuation for the period 2002:2012, but post-2012 the previous cyclical pattern for *ys* ceases, and post-2014 the variable remains relatively stable. The same tendency is observed in the short-term rate, *r*, that post-2011 no longer varies with the business cycles but rather pursues a linear, negative slope.

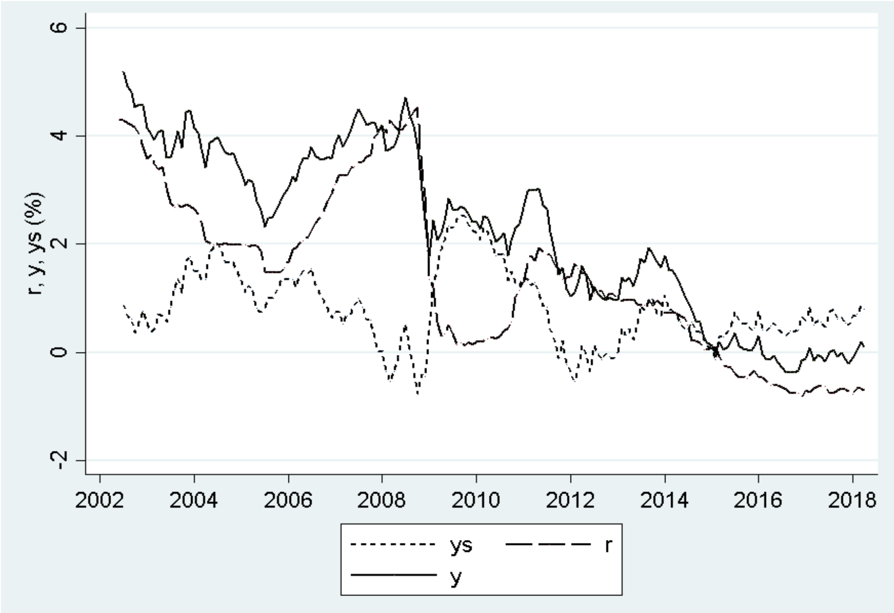
As mentioned in the findings, there could be several possible explanations for the inconsistencies. The Eurozone debt crisis culminated in 2012, sparking economic uncertainty in the entire Euro-region, which could have an impact on the movements of the macro-variables. We can see that the fall in *r* roughly happens during this period. Another possible explanation could be the unconventionally loose monetary policy, pursued by the Swedish Riksbank, especially apparent post-2011 as we first see a trough in the economy but no increase in *r* for the period until the following peak.

In 2015 the Swedish Riksbank introduced their quantitative easing (QE) program, initially signaling but after hand implementing large purchase programs of government bonds, especially in those of longer maturities. Lamoen, Mattheussens and Dröes (2017) researched the impact of the ECB's expanded asset purchase program, finding that the program was a significant driver of lowered government bond yields. This is intuitively sound as the asset purchase program increases the demand, therefore drives up the prices, and therefore decreases the yield, which moves opposite prices. Driscoll and Judson's (2013) investigated U.S. deposit rates and found, unsurprisingly, that the federal funds target rate is significantly and highly correlated with the U.S. 3-Month T-Bill. As the Swedish Riksbank also continuously decreased its short-term deposit rate and the Sweden 3-Month T-Bill has declined during the period it is not too unrealistic to think that the same positive correlation is applicable for the Swedish money market.

With the conclusion from Lamoen, Mattheussens and Dröes (2017) in mind, the Swedish long-term government bond yields (in our analysis the Sweden 5-Year government bond) should decrease as the asset purchase program is initiated. Paired with a roughly equal decline in deposit rates, positively correlated with short-term rate, we might be able to explain the stability of the yield spread post-2014 and therefore its inconsistency with previous patterns and research. In a conventional expansionary phase we should, according Kessel's (1965) conclusion, expect increasing short-term rates (more rapidly increasing) due to increased deposit rates, as well as increased yields on long-term bonds (less rapidly increasing), thus an increased yield spread. As seen in *Figure 5* below, we see a decline in both long-term yield on 5-year Sweden government bond, *y*, and short-term rate, *r*, which is roughly equal (illustrated in a more obvious manner by the relatively non-sloping yield spread, *ys*). In summary, one can observe a macro-economic development inconsistent with conventional financial theory. This unconventionally loose monetary policy could possibly explain the lack of variations with the business cycle extremes for post-2012.

Figure 5: Short-term rate, Yield and Yield Spread

The short-term rate, *r*, Sweden 5Y Gov. Bond, *y*, and yield spread, *ys*, plotted against each other for the time period 2002-07:2018-03.



Notes: r is the annualized yield on the Sweden 3-Month T-Bill. *y* is the annualized yield on the Sweden 5-Year government bond. *ys* is the difference between annualized yield on the on the Sweden 5-Year government bond and the annualized yield on the Sweden 3-Month T-Bill.

3.2 FINDINGS FROM VAR AND IRF ANALYSIS

When looking at shocks of dividend yield, the effect on stock return is the opposite than the positive coefficient in the vector autoregression. Both correlated and uncorrelated structural shocks of dividend yield have a negative impact on excess stock return. The dividend yield is the return predictive macro-variable which has most impact on excess stock return, both when examining correlated and uncorrelated shocks. However, our findings suggest that the negative relation between stock return and shocks in dividend yield is mainly explained in the denominator of dividend yield, i.e. by changes in the stock index. Our cross-correlation of residuals in *Table 5b* shows that the positive relation between unexpected stock return and shocks in stock return is much stronger than the negative relation between unexpected stock return and shocks in dividend yield. Our data supports that positive shocks in dividend yield is mainly explained by rapid decrease of the stock index (See *Figure 2,* where dividend yield has its highest value at the 2008-09 crisis). Thus, our findings support that the strong negative relation between unexpected stock return and shocks to dividend yield should have more to do with prior shocks in the stock index than increased dividends in itself.

In the cross-correlation of residuals, the macro-variable that has most impact on unexpected bond return is dividend yield. Unexpected excess bond return is positively correlated to shocks in dividend yield, but the negative correlation between unexpected bond return and shocks in stock return is almost seven times as high. Thus, we suggest that the same reasoning holds for excess bond return; rapid decreases (increases) of the stock index causes dividend yield to experience a positive (negative) shock which affects unexpected excess bond return positively (negatively). The effect on unexpected excess bond return is mainly explained by the rapid change in the stock index and not by substantial changes in dividends.

Our findings from the vector autoregression is not identical to similar models in terms of slope and significance of coefficients. Bams, Schotman and Tyagi (2016), and Campbell, Chan and Viceira (2003) have found significant negative relation between lags in short-term rate and excess stock return. Our research of autocorrelation and business cycles suggests that a possible explanation to the insignificance in our VAR might be the lag length. We suggest that short-term rate tracks part of return related to more persistent aspects of business cycles in contrast to yield spread and dividend yield that is more closely related to short-term variations in business conditions. Thus, this difference is a possible explanation to the significance of yield spread and dividend yield and insignificance of short-term rate in the VAR for excess stock return.

3.3 FINDINGS FROM FUND ALLOCATION REGRESSIONS

An interesting observation from *Figure 1* is the fact that the four AP funds of interest in this paper have on average increased their allocation to equities and decreased their allocation to bonds for the period 2013:2017. This development coincides with period of unconventionally loose monetary policy from the Swedish Riksbank. Obviously we see higher risk-taking in the funds as they move towards a higher equity allocation. Could these two developments be related?

Choi and Kronlund (2017) found that in markets with narrow default spreads and low yield curves that U.S. corporate bond funds tend to take higher risk. This risk-taking behavior was highlighted by the fact that the funds tended to hold more illiquid bonds as well as a larger fraction of equities. Comparing with the state of the Swedish buffer pension funds, we know that they have a regulated high bond exposure, as well as market dynamics that for the outlined period are similar to what Choi and Kronlund (2017) describe for their analyzed funds. A possible explanation to development of the AP funds' allocation development is that they, like the U.S. funds, in a macro-economic environment with low yield curves, have actively searched for yield in equities. Thus, the development that we see in the AP funds could be consistent and related to the findings of Choi and Kronlund (2017).

4. CONCLUSION

In this paper we study whether the short-term rate, maturity yield spread and dividend yield can act as predictors of excess stock and bond return on the Swedish market. These findings are cross-checked against the strategic asset allocation decisions of the Swedish buffer pension funds in order to examine if they incorporate the information according to our conclusions.

The results suggest that yield spread and dividend yield track similar parts of return. These two variables are assumed to track parts of return related to short-term variations in business conditions, whereas short-term rate is related to more persistent aspects of business conditions.

Lags in dividend yield have a significant positive relation to expected stock return. However, when looking at the relation between unexpected stock return and shocks in dividend yield, the relationship is substantially negative. Furthermore, we find a significant positive relationship between yield spread and excess stock return, both when looking at "ordinary" changes and shocks in yield spread. Thus, yield spread is the most consistent return predictive variable for excess returns on equities on the Swedish market for the sample period. Our results from examining the predictability of excess bond return do not end up in any absolute conclusions, where our VAR fails to predict excess bond return significantly.

The Swedish buffer pension funds do on average increase (decrease) their holdings in equities when short-term rate, yield spread and dividend yield decreases (increases). The relation between the macro-variables and allocation to bonds is the opposite. Short-term rate seems to be the main variable included in the funds' strategic asset allocation. Our findings suggest that the funds' equity allocation should be positively correlated with lags in yield spread, but the funds act in the opposite way.

5. SUGGESTION FOR FURTHER STUDIES

Our findings suggest that the effect a return predictive variable has on excess stock and bond return might differ depending on whether the change of the variable is assumed to be a shock or not. We find that unexpected stock return is negatively related to shocks in dividend yield and expected stock return positively related to dividend yield. Therefore, given the limitations of our data set, we suggest that further studies on the subject should look into how funds' strategic asset allocation differs during periods of stable conditions (when the macro-variables remain un-shocked) and unstable conditions. Due to our semi-annual data on the Swedish buffer pension funds' asset allocation, we were not able to look in to this difference. To thoroughly examine what is the optimal strategic asset allocation, one must analyze the funds' strategic asset allocation in periods of stable conditions where the macro-variables are not exposed to shocks.

Furthermore, when the Swedish corporate bond market is more developed and data is available and adequate, it would be interesting to look into the return predictive power of credit spread (difference between the yield on high yield corporate bonds and yield on safe government bonds) on the Swedish market.

6. LITERATURE

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7. APPENDIX

7.1 TESTS FOR OPTIMAL LAG LENGTH

In order to decide which lag length to use in the vector autoregression we have performed different tests. *Table 9* shows the outcome for these tests and the suggested lag length. The tests performed are likelihood ratio test, final prediction error, Akaike's information criterion, Hannan and Quinn information criterion and Schwarz's Bayesian information criterion.

Table 9: Tests for optimal lag length

Results from *LR*, *FPE*, *AIC*, *HQIC* and *SBIC.*

Lag	LR	FPE	AIC	HQIC	SBIC
0		4.335300	15.6562	15.6926	15.7459
1	2234.10	0.000019	3.3166	3.53493*	3.85494*
2	59.64	0.000018	3.2621	3.6624	4.2491
3	56.05	0.000017	3.2279	3.8101	4.6635
4	1.46	0.000017	3.2015	3.9656	5.0857
5	54.68	0.000016*	3.16147*	4.1075	5.4942
6	57.09	0.000019	3.2780	4.4061	6.0594
7	45.67	0.000019	3.3025	4.6124	6.5325
8	29.38	0.000022	3.4190	4.9109	7.0976
9	45.82	0.000023	3.4426	5.1164	7.5698
10	40.25*	0.000025	3.4977	5.3535	8.0735
11	35.28	0.000028	3.5808	5.6185	8.6053
12	28.77	0.000032	3.7008	5.9204	9.1738

Notes: *LR* is the like likelihood ratio test, *FPE* the final prediction error, *AIC* Akaike's information criterion, *HQIC* Hannan and Quinn information criterion and SBIC Schwarz's Bayesian information criterion.
* denotes suggested lag length for the tests.

7.2 CROSS-CORRELATION OF RESIDUALS AND IMPULSE-RESPONSE FUNCTIONS

The formula for cross-correlation of residuals is the following:

$$\rho_{\varepsilon_a,\varepsilon_b} = \frac{cov(\varepsilon_a, \varepsilon_b)}{\sigma_{\varepsilon_a} * \sigma_{\varepsilon_b}}$$

where ε_a and ε_b are the error terms (residuals) for variable *a* and *b*, *cov* is the covariance and σ the standard deviation.

In the vector autoregression, that the impulse-response functions are based on, we use rolling 6-month lags (lags from 1 to 6 months) in order to see the effect for all periods and not just every 6 periods.

We create the following VAR model:

$$\begin{bmatrix} r_t \\ ys_t \\ dy_t \\ esr_t \\ ebr_t \end{bmatrix} = \alpha_0 + A_1 \begin{bmatrix} r_{t-1} \\ ys_{t-1} \\ dy_{t-1} \\ esr_{t-1} \\ ebr_{t-1} \end{bmatrix} + A_2 \begin{bmatrix} r_{t-2} \\ ys_{t-2} \\ dy_{t-2} \\ esr_{t-2} \\ ebr_{t-2} \end{bmatrix} + A_3 \begin{bmatrix} r_{t-3} \\ ys_{t-3} \\ dy_{t-3} \\ esr_{t-3} \\ ebr_{t-3} \end{bmatrix} + A_4 \begin{bmatrix} r_{t-4} \\ ys_{t-4} \\ dy_{t-4} \\ esr_{t-4} \\ ebr_{t-4} \end{bmatrix} + A_5 \begin{bmatrix} r_{t-5} \\ ys_{t-5} \\ dy_{t-5} \\ esr_{t-5} \\ ebr_{t-5} \end{bmatrix} + A_6 \begin{bmatrix} r_{t-6} \\ ys_{t-6} \\ dy_{t-6} \\ esr_{t-6} \\ ebr_{t-6} \end{bmatrix} + \begin{bmatrix} \boldsymbol{\varepsilon_{1,t}} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \\ \varepsilon_{4,t} \\ \varepsilon_{5,t} \end{bmatrix}$$

where α_0 is a vector of intercept terms and each of *A1* to *A6* is a 5*5 matrix of coefficients. We do not present the result from this regression since it includes $5^2*6 = 150$ coefficients. We focus on the post estimation (impulse-response functions) since they are more informative.

In the impulse-response functions it is assumed that there are underlying structural shocks, u_t, which are related to the cross-correlation of residuals matrix via the following relationship:

$$\varepsilon_t = A * u_t$$

and

$$E(u_t * u_t') = 1$$

then, we can estimate get the covariance matrix of error terms ($\sum$) by:

$$\sum = E(\varepsilon_t * \varepsilon_t') = E(A * u_t * u_t' * A') = A * E(u_t * u_t') * A' = A * A'$$

thus the estimation is

$$\hat{\sum} = \hat{A} * \hat{A}'$$

To narrow down the candidates of *A* matrixes satisfying this estimation, we assume that *A* is a lower triangular matrix. Then, *A* can be found via a Cholesky decomposition of $\sum$. The assumption that *A* is lower triangular makes the ordering of the variables matter. With *A*, we can now produce shocks that are uncorrelated across equations and find the effect of these shocks in the vector autoregression. Finally, we orthogonalize the shocks, meaning that we are decomposing the reduced-form errors into mutually uncorrelated shocks.

7.3 VARIANCE INFLATION FACTORS

Variance inflation factor (VIF) quantifies the severity of multicollinearity in an ordinary least squares (OLS) regression. VIF is calculated as the variance in a model with multiple terms divided by the variance of a model with one explanatory variable alone.

The VIFs for our regressions on the pension funds' strategic asset allocation is shown in *Table 10* . A rule of thumb is that the VIF should not be larger than 10. Since the VIFs in our regressions all are below 1.50, there is no severe multicollinearity in our OLS regressions on the pension funds' strategic asset allocation.

Table 10: Variance Inflation Factors

Variance inflation factors for the 6M Lag regression, Prev. 6M Avg. regression and 6M Delta regression.

Variables	6M Lag	Prev. 6M Avg.	6M Delta
r	1.10	1.09	1.03
ys	1.40	1.44	1.02
dy	1.47	1.47	1.01

6M Lag regression: $w_t^j = \alpha + \beta_1 * r_{t-1} + \beta_2 * ys_{t-1} + \beta_3 * dy_{t-1} + \varepsilon_t$
Previous 6M Avg.: $w_t^j = \alpha + \beta_1 * r_{t,t-6}^{avg} + \beta_2 * ys_{t,t-6}^{avg} + \beta_3 * dy_{t,t-6}^{avg} + \varepsilon_t$
6M Delta: $w_t^j = \alpha + \beta_1 * \Delta r_{t,t-1} + \beta_2 * \Delta ys_{t,t-1} + \beta_3 * \Delta dy_{t,t-1} + \varepsilon_t$
Notes: VIF is the variance in the model including all variables divided by the variance of the model with one explanatory variable alone.