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Decomposition of the realized rate of return on investment in fixed-income securities

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Abstract

Paper presents decomposition of the realized rate of return on investment in fixed-income securities in order to identify the income/risk sources. The decomposition is accomplished applying the concept of factorization and factor analysis on treasury bonds returns. Weekly data from the interbank market in Poland for the period 30 June – 6 October, 2004 (14 weeks) are used. In the single-factor model of decomposition, the source of risk is assumed to be the change of yield-to-maturity (YTM) of the considered bond. Within the multi-factor model, decomposition is carried out by means of both the factorization concept and factor analysis. Factor analysis is undertaken as a preliminary action aimed to identify common factors of market risk that affect the realized rate of return of the examined securities. The results of factor analysis are used in the multi-factor model of decomposition. This approach allows to reduce the number of market risk factors and to investigate their influence on realized rate of returns on different fixed-income securities.

Keywords: fixed-income security, treasury bond, realized rate of return, duration, factorization, factor analisys, spot interest rate, yield to maturity

JEL codes: G11, G12

1. Introduction

Decomposition of the realized rate of return on investment in fixed-income securities aims to provide more precise information about the source of return on a bond (or portfolio). Holding period may be a day, a week, a month, etc. The main factors influencing the realized rate of return on investment in fixed-income securities are the time and changes in the interest rates. With the elapsing time, the price of a fixed-income bond goes up, if other conditions remain unchanged. An increase in interest rates causes the drop of the prices of fixed-income securities and *vice versa.*

Spot interest rates and yields-to-maturity (YTM) are the most frequently considered rates in the analysis of the fixed-income securities. When the bond price is being evaluated, spot interest rates are used for discounting cash flows. The YTM is the internal rate of return on investment and it takes into account the bond structure. Therefore, bond market is often characterized by yield-to-maturity curve.

The aim of the paper is to present the results of applying both the concept of factorization and factor analysis to decompose the realized rate of return on investment in treasury bonds. The concept of factorization is introduced by Tomas Ho (1999) with reference to the Capital Asset Pricing Model (CAPM) for the bond market. The factor analysis is applied to bond returns by Litterman and Scheinkman (1991). The combination of the two methods allows to isolate the common market risk factors and to measure their influence on the realized rate of return of various bonds or portfolios. This methodology can be used in an *ex post* analysis of bond performance or in analysis of different investment strategies pursued by investment funds, insurance companies and banks.

The paper is composed of 6 sections. After the introduction (section 1), section 2 describes the factorization concept, following Ho, who assumes that a change in the spot interest rates is a source of risk. We cannot apply directly this approach in our research, because, depending on its structure and maturity, each bond is evaluated by a different set of spot interest rates. Moreover, this set changes with the elapsing of time and approaching bond maturity date. Section 3 presents the methodology of decomposition used in this study, where the factorization concept is applied to changes in the YTM and not spot interest rates. In addition, section 3 shows how the factor analysis and factorization concept are used to obtain the multi-factor decomposition of the realized rate of return. Detailed data description and empirical results are provided in sections 4 and 5. The paper closes with conclusions (section 6).

2. The concept of factorization

Factor models postulate that the rate of return on investments in securities is expressed as a linear combination of common risk factors (representing a source of systematic risk) and a specific factor (representing a non-systematic risk, i.e. specific to a given security). Moreover, all the factors are usually specified as independent of each other, which often produces models that entail unobservable factors. On the other hand, factorization consists in decomposition of the rates of return into components generated by different and fully identifiable factors.

Ho (1999) proposes to apply the concept of factorization to the most familiar equilibrium model, the CAPM, to the bond market.

A classic CAPM assumes that the return on any risky asset is linearily related to the return on market portfolio in the following way:

$$E(R_i) = R^f + \beta \cdot [E(R_m) - R^f], \qquad (1)$$

where

$E(R_i)$ - the expected rate of return on a security,

$E(R_m)$ - the expected market rate of return,

R^f - a risk-free rate,

β - so-called beta coefficient.

This is a one-period equilibrium model of the capital market. In its simplest form, it states that assets valuation is based on their relation to a market portfolio containing all risky assets. Every security or portfolio on the equilibrium market should satisfy equation (1). The independent variable is the difference $[E(R_m) - R^f]$, called the risk premium, and slope coefficient β is the measure of systematic risk. It is assumed that the unsystematic risk does not occur, because investors can avoid it by appropriate diversification of their portfolio.

Model (1) cannot be directly applied to the bond markets, because – unlike shares – bonds have a limited 'life span' and, therefore, it is not possible to directly estimate the variance-covariance matrix of the rates of return on various bonds, as well as coefficients β. Besides, we need to take into account that the main source of risk on the bond market are the varying interest rates. The sensitivity of different bonds' prices to interest rate changes can differ substantially, which is the result of bonds' structure. The sensitivity of a bond price depends on the its coupon rate, maturity and the current level of interest rates. In practice, various measures are used to assess the bond price sensitivity to changes in interest rates. The most popular of them is Macaulay duration[1] (or modified Macaulay duration). In the factorization model, we shall introduce measures called factor durations, which show the bond price sensitivity to changes in each risk factor.

In the single-factor model of factorization for the bond market derived by Ho, the rate of return realized in an investment period is represented as the sum of two components: a risk-free rate R^f (a rate of return that could be achieved by the investor if a bond was held throughout the investment period and the interest rates remained unchanged) and a rate of return, either positive or negative, generated by an unanticipated small change in interest rates. Ho considers the parallel shift in the spot interest rates, denoted by Δr, to be the market risk factor.

The CAPM for the bond market is derived as follows:

$$\frac{B_1 - B_0}{B_0} = \frac{B^f - B_0}{B_0} - \frac{B^f - B_1}{B_0} \tag{2}$$

where,

B_0 is the full price of a bond (with accrued interest) at the beginning of the investment period,

B_1 is the full price of a bond (with accrued interest) at the end of the investment period,

B^f is the hypothetical full price of a bond (with accrued interest) at the end of the investment period for unchanged interest rates.

The left-hand side of equation (2) is equal to a one-period realized rate of return on investment in a bond. This rate is the sum of two increments. The first is the return caused by elapsing time, assuming that the interest rates do not change. The other increment shows the part of bond return that is caused by the unanticipated parallel change in the spot interest rates. The only source of systematic risk in this model is the parallel shift of the spot rates, whereas the measure of sensitivity (corresponding to coefficient β) is effective duration defined in the following way:

$$ED = -\frac{B_1 - B^f}{B_0} \cdot \frac{1}{\Delta r}. \tag{3}$$

For parallel change in interest rates, Δr, the second component of sum (2) is equal to:

[1] Duration is defined for the first time by Frederick Macaulay (1938).

$ED \cdot \Delta r$.

After substitutions, the single-factor CAPM for the bond market is as follows:

$$E(R_i) = R^f - ED_i \cdot \Delta r + \varepsilon , \qquad (4)$$

where ε is a random noise.

Ho generalizes the factorization approach for arbitrary changes of the spot yield curve represented by rates r_1, r_2,…, r_m, using key rate durations[2]:

$$R_i = R^f - KD_i^{(1)} \cdot \Delta r_1 - KD_i^{(2)} \cdot \Delta r_2 - ... - KD_i^{(j)} \cdot \Delta r_m + \varepsilon \qquad (5)$$

$KD_i^{(j)}$ denotes key rate durations of i-th bond, defined as:

$$KD^{(j)} = -\frac{B_1^j - B^f}{B_0} \cdot \frac{1}{\Delta r_j} \qquad j=1,2,\dots,m, \qquad (6)$$

where:

B_1^j is the full price of i-th bond at the end of the investment period corresponding to the change in interest rate r_j .

Considered in this model factors that influence the rate of return on a bond are the time and non-parallel changes in the spot interest rates. The sensitivity of a bond or portfolio price to a change in each interest rate (or risk factor) is measured by appropriate key rate duration, whereas R^f is the rate of return that an investor could achieve if the spot interest rates remain unchanged.

3. The methodology of decomposition

The approach proposed by Ho cannot be directly applied when the target is the comparison of bonds or portfolios, because each bond (or portfolio) is valued using different set of spot rates. In this paper we avoid this problem by applying the concept of factorization to the YTMs and not to the spot interest rates. Each bond has one YTM.

The single-factor model

The realized rate of return on investment in a fixed-income bond is the sum of two

[2] For more details on key rate durations application see e.g. Reitano (1990)

components: a risk-free rate (i.e. a return arising from the passing of time) and return caused by a small instantaneous change in the YTM, Δy. We assume, for simplicity, that the YTM changes immediately after the investment period has begun.

We derive the single-factor factorization model in the following way:

$$\frac{B_1 - B_0}{B_0} = \frac{B_1 - B^y}{B_0} + \frac{B^y - B_0}{B_0} \tag{7}$$

where

B_0 is the full price of a bond at the beginning of the investment period,

B^y is the full price of a bond at the beginning of the investment period after the change in YTM,

B_1 is the full price of a bond at the end of the investment period.

Transforming formula (7), we obtain:

$$R = R^t + R^y + R^t \cdot R^y \tag{8}$$

or

$$1 + R = (1 + R^t)(1 + R^y) \tag{9}$$

where

$R = \frac{B_1 - B_0}{B_0}$ is the realized one-period rate of return,

$R^t = \frac{B_1 - B^y}{B^y}$ is the rate of return resulting from the passing of time,

$R^y = \frac{B^y - B_0}{B_0}$ is the rate of return resulting from an immediate small change in the YTM, approximately equal to ($-MD \cdot \Delta y$), where MD is the modified Macaulay duration.

Product $R^t \cdot R^y$ in formula (8) is relatively small and therefore it will be neglected. For a one-week investment period, the single-factor model of decomposition is:

$$R_i = R_i^t - MD_i \cdot \Delta y_i + \varepsilon \tag{10}$$

where

R_i is the weekly rate of return on *i-th* bond,

R_i^t is the weekly rate of return generated by the passing of time,

MD_i is modified Macaulay duration,

ε is a balance component.

Model (10) is not an econometric model, but it is used to decompose the realized rate of return on *i*-th bond. The purpose of decomposition is to identify the source of income/risk. The single-factor model shows how time and an YTM change affect the realized rate of return. It does not inform about the influence of the common market factors, because the risk factor for each bond is the change of its own YTM.

The multi-factor model

Within the multi-factor model, the decomposition of the realized rate of return is the linear combination of the common market factors and the specific factor that causes the price change. Prior to multi-factor decomposition, the common factors of market risk must be identified. Their number and identity can be established by means of factor analysis. Generally, factor analysis aims to find out, whether the observed variables can be explained entirely or to a large extent with the use of smaller number of variables called factors.

The factor analysis is applied to the YTM of n bonds, and each bond is represented by T-dimensional observation vector: $\mathbf{y}_1, \mathbf{y}_2, ..., \mathbf{y}_n$, where n is the number of variables, and T is the number of observations. Let $\mathbf{Z} = [\mathbf{Z}_1, \mathbf{Z}_2, ..., \mathbf{Z}_n]$ denotes $T \times n$ observation matrix of original standardized variables. The correlation matrix calculated from $\mathbf{Z}$ is denoted by $\mathbf{R} = [r_{ij}]$. Factor analysis aims to express the standardized variables by means of k common factors, (where $k < n$), and one specific factor in the following way:

$$\mathbf{Z} = \mathbf{F}\mathbf{W}^T + \mathbf{V}, \qquad (11)$$

where

$\mathbf{F}$ is $n \times k$ factor scores matrix,

$\mathbf{W}$ is $n \times k$ factor loadings matrix,

$\mathbf{V}$ is $T \times n$ matrix corresponding to specific factors and $\text{var}(\mathbf{V}_i) = \psi_i^2$ for i=1,2,…,n. Column vectors $\mathbf{V}_i$ can be presented as $\mathbf{V}_i = \psi_i \mathbf{U}_i$, where ψ_i is considered to be a specific factor loading for i-th variable, whereas specific factor scores $\mathbf{U}_i$ are standardized.

Elements w_{il} for i=1,2,…,n, l=1,2,…,k of matrix $\mathbf{W}$ are equal to correlation coefficients between i-th variable and l-th common factor. Furthermore, common factors $\mathbf{F}_l$ are assumed to be standardized and uncorrelated, specific factors $\mathbf{V}_i$ are also uncorrelated and each common factor and each specific factor are not correlated either.

Therefore, the variance of *i*-th variable can be expressed as the sum of squares of factor loadings. Correlation matrix can be written as follows:

$$\mathbf{R} = \mathbf{W}\mathbf{W}^T + \mathbf{\Psi}, \qquad (12)$$

where $\mathbf{\Psi} = \begin{bmatrix} \psi_1^2 & 0 & \dots & 0 \\ 0 & \psi_2^2 & \dots & 0 \\ \dots & \dots & \dots & \dots \\ 0 & 0 & \dots & \psi_n^2 \end{bmatrix}$ is the covariance matrix of specific factors distribution.

Equation (12) shows that the correlation matrix **R** can be expressed as the sum of: variability arising from common factors, and variability caused by the specific factors. Diagonal elements of matrix $\mathbf{W}\mathbf{W}^T$ are called communalities of *i*-th variable; the remaining elements of matrix $\mathbf{W}\mathbf{W}^T$ are equal to correlation coefficients between variables.

In this model, factor scores and factor loadings are not known. For this reason, factor loadings w_{il}, are calculated in such a way, that the influence of specific factors in favour of common factors is eliminated as much as possible. It is also assumed that the rank of matrix **R** is equal to *n*.

There are various methods of factor extraction – in our research we take advantage of the principal factor analysis using STATISTICA software. In this method communalities are assumed being equal to multiple R-squares (R^2), so prior to factoring, the diagonal elements of matrix $\mathbf{W}\mathbf{W}^T$ (communalities) are computed as the multiple R-squares of the regression of each considered variable against all other variables. This is a default method for estimating communalities in the principal factor analysis that can be applied before the number of common factors is determined.

As a result of the factor analysis, the initial variables (bond YTMs) after standardization can be presented as follows:

$$\frac{y_i - \bar{y}_i}{\sigma_i} = w_{i1}F_1 + \ldots + w_{ik}F_k + \psi_i U_i \text{ for } i = 1,2,\ldots,n, \qquad (13)$$

where

y_i is the YTM of *i*-th bond,

$\bar{y}_i$ is the average YTM of *i*-th bond,

σ_i is the standard deviation of the YTM of *i*-th bond,

$F_1, \ldots, F_k$ are standardized common factors,

U_i are standardized specific factors, $i=1,2,\ldots,n$,

w_{il} are factor loadings, for l=1,2,…,k,

ψ_i is the standard deviation of the specific factor.

Finally, after transformations, the YTMs of bonds are presented as:

$$y_i = \bar{y}_i + w_{i1}F_1\sigma_i + ... + w_{ik}F_k\sigma_i + \psi_i U_i \sigma_i, \text{ for } i=1,2,\dots,n. \quad (14)$$

The realized rate of return can be decomposed according to the multi-factor model (after the factor analysis has been applied) in the following way:

$$R_i = R_i^t - FD_i^{(1)} \cdot \Delta F_1 - ... - FD_i^{(k)} \cdot \Delta F_k - UD_i \cdot \Delta U_i + \xi \text{ for } i=1,2,\dots,n \quad (15)$$

where

$\Delta F_1, \dots, \Delta F_k$ are increments in the standardized common factors,

ΔU_i is an increment in the standardized specific factor,

ξ is a balancing component,

$FD_i^{(1)} \ \dots \ FD_i^{(k)}$ are factor durations of i-th bond, calculated according to formulas:

$$FD_i^{(1)} = w_{i1} \cdot \sigma_i \cdot MD_i,$$
$$\dots \quad (16)$$
$$FD_i^{(k)} = w_{ik} \cdot \sigma_i \cdot MD_i,$$

UD_i is a specific factor duration of i-th bond, calculated as follows:

$$UD_i = \psi_i \cdot \sigma_i \cdot MD_i. \quad (17)$$

4. The data

A weekly realized rate of return will be decomposed for the following set of treasury fixed-income bonds traded on the Polish interbank market: PS1005, PS0206, PS1106, PS0507, PS0608, DS0509, DS1110, DS1013, WS0922. The decomposition is carried out for the period 30 June – 6 October, 2004. The bonds have been selected in respect of their different maturity and quite considerable liquidity. The only exception is bond WS0922; it is less liquid than the other bonds, but it has been included in the set for its longest maturity.

Nine initial variables are taken into account in the investigation. These are the YTMs of the listed bonds. In our analysis the investment horizon is measured in days and its length is 7 days; consequently, the weekly changes are considered. The data are derived from the website: http://www.parkiet.com.pl, where the prices of bonds traded on the Polish interbank market are available. The YTM of each bond is computed using Wednesday quotations. The missing data are replaced by the linear interpolation of prices for the adjacent days.

The basic characteristics of the bonds, e.g. time to maturity, modified Macaulay duration, accrued interests, full price, as well as full price of the bond after an instantaneous change of rate y to a new level, have been calculated with the use of the program written by the author in *Visual Basic.*

5. Empirical results

The single-factor decomposition model

Using calculated characteristics and prices of the examined bonds, the one-period (weekly) rate of return is decomposed according to model (10). Results are shown in Tables 1 to 9. The subscript in the heading of a table denotes the successive number of a bond. Figure 1 shows the decomposition of the weekly rates of return for individual bonds.

The realized weekly rates of return are mainly determined by the second component of model (10), R^y, equal to ($-MD_i \cdot \Delta y_i$), whose share is the greater the longer the period of time remaining to maturity. This component is highly volatile, $R^y \in (-0{,}0269;0{,}0321)$. The first component, so-called rate generated by the passing of time, R^t, is always positive and less volatile, $R^t \in (0{,}0012;0{,}0015)$.

The realized weekly rates of return on all bonds are illustrated in Figure 2. Different bonds have the highest rate of return in different periods, which can be explained by the market circumstances and different sensitivity of bonds' prices to interest rate changes.

The multi-factor decomposition model

Decomposition starts from the result provided by the factor analysis. The correlation matrix of the considered bonds' YTM is shown in Table 10.

Two common factors were extracted by means of the principal factor analysis. Factor loadings are shown in Table 11.

The first common factor is strongly correlated with the levels of all YTMs and explains it 89.68% of total variance. The second factor shows negative correlation with the short-term YTMs and positive with the long-term ones and it explains 6.51% of total variance. Therefore, we can interpret the first factor as the level of the YTM curve and the second as the slope of the yield curve. Less than 3.82% of total variance remains unexplained by the two-factor model. Table 12 shows the residual correlation matrix, i.e. the correlation that the two-factor model did not explain. Variance of specific factor ψ_i^2, (the diagonal elements of the matrix) is the highest for bonds PS1005 and WS0922.

Results of the factor analysis are used in the further stage of research. Tables 13-21 illustrate multi-factor decomposition of the realized rates of return on selected bonds in accordance with model (15) and also factor durations. Four sources of income are considered in the decomposition. One source is time; is generates the rate R^t similarly to the single-factor model. The second and third sources are common market factors affecting the realized rates of return on all bonds. The degree and direction of their influence depend on characteristics of a bond. Finally, the fourth source is factor specific to each bond. Crucial results necessary for the decomposition are coefficients $FD_i^{(1)}$ and $FD_i^{(2)}$. The coefficients change in time, because the modified Macaulay duration also changes. However, they are an important characteristic of the bonds. Factor durations show the sensitivity of a bond price to changes in the common risk factors.

Figure 3 shows the rate of return on bonds, generated by change in the factor F_1. Its influence is proportional to bond maturity – the longer the maturity, the stronger the influence of the first factor change upon the realized rate of return. The first factor produces a negative effect in periods 30 June – 28 July and 25 August – 5 September 2004. These are the periods when the level of the YTM curve is rising. In the periods 28 July – 25 August and 5 September – 6 October 2004 its influence is positive - these periods are profitable for investors, because of the falling interest rates.

Figure 4 shows the rate of return on bonds, generated by change in the factor F_2. The influence of the second factor also depends on bond maturity, but the relationship is more complicated. For the medium-term bonds, i.e. PS0608, its influence is the weakest. For the short-term and long-term maturity bonds the influence rises, but with different signs. When the second factor changes are favorable for the long-term bonds (periods 30 June – 9 July, 26 July – 23 August and 27 August – 27 September), they are unfavorable for the short-term bonds and *vice versa*. An explanation is that second factor is interpreted as the slope of the yield curve. The influence of the slope change is the weakest for the medium-term bonds and rises (but with a different sign) for the short- and long-term bonds.

Figure 5 shows how the specific factor influences the weekly realized rate of return on the examined bonds. The specific factor affects the realized return rate on bond WS0922 the most strongly, which can be explained in terms of the relatively small liquidity of this bond.

6. Conclusions

The combination of factor analysis and factorization can be successfully applied to the bond market in order to decompose the realized rate of return on bonds or portfolios, and to identify the sources of income/risk. In one-factor model of decomposition the risk factor is the change in the YTM of a bond. The multi-factor decomposition endeavors to identify the market risk factors, called common factors and to measure their influence on the realized rate of return. In the research presented in the paper, two common factors affecting the realized rate of return on bonds were identified. They can be interpreted as the level and slope of the yield curve. In order to identify them, the principal factor analysis was used. Important results of the multi-factor decomposition are factor durations measuring the bond price sensitivity to changes in the common risk factors. The multi-factor model of decomposition is particularly useful for comparing the performance of different investment strategies and can be applied by funds, banks or other financial institutions interested in bond portfolio analysis.

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Annex

Table 1. Basic characteristics of bond PS1005 and decomposition of weekly realized rate of return according to model (10)

Date	y_1	MD_1	B_1	B_1^y	R_1	R_1^t	$-MD_1 \cdot \Delta y_1$
2004-06-30	0,0725	1,140419	1074,971	1074,657	0,001043	0,001338	-0,000232
2004-07-07	0,0728	1,122282	1076,101	1075,716	0,001051	0,001343	-0,000342
2004-07-14	0,0731	1,10399	1077,166	1076,774	0,00099	0,001348	-0,000337
2004-07-21	0,0735	1,085657	1078,231	1077,836	0,000989	0,001354	-0,000442
2004-07-28	0,0738	1,067293	1079,301	1080,106	0,000992	0,00136	-0,000326
2004-08-04	0,0731	1,051351	1081,582	1082,397	0,002113	0,001367	0,0007471
2004-08-11	0,0723	1,035475	1083,862	1083,990	0,002108	0,001354	0,0008411
2004-08-18	0,0722	1,018178	1085,442	1082,374	0,001458	0,00134	0,0001035
2004-08-25	0,0751	0,993908	1083,822	1082,698	-0,00149	0,001338	-0,002953
2004-09-01	0,0762	0,973781	1084,202	1083,688	0,000351	0,00139	-0,001093
2004-09-08	0,0767	0,954967	1085,215	1086,172	0,000934	0,001409	-0,000487
2004-09-15	0,0757	0,939557	1087,712	1087,818	0,002301	0,001418	0,000955
2004-09-22	0,0756	0,922172	1089,342	1088,550	0,001499	0,001401	9,396E-05
2004-09-29	0,0765	0,902583	1090,073	1095,055	0,000671	0,001399	-0,00083
2004-10-06	0,0712	0,897531	1096,603	1011,897	0,00599	0,001414	0,0047837

Table 2. Basic characteristics of bond PS0206 and decomposition of weekly realized rate of return according to model (10)

Date	y_2	MD_2	B_2	B_2^y	R_2	R_2^t	$-MD_2 \cdot \Delta y_2$
2004-06-30	0,0737	1,445967	1048,137	1046,999	0,001558	0,001366	0,0001463
2004-07-07	0,0745	1,42695	1048,427	1047,524	0,000277	0,001364	-0,001157
2004-07-14	0,0751	1,40821	1048,968	1048,357	0,000516	0,001378	-0,000856
2004-07-21	0,0755	1,389837	1049,813	1049,324	0,000806	0,001389	-0,000563
2004-07-28	0,0758	1,371612	1050,789	1050,201	0,00093	0,001396	-0,000417
2004-08-04	0,0763	1,353224	1051,674	1050,955	0,000842	0,001403	-0,000686
2004-08-11	0,0768	1,334621	1052,437	1052,768	0,000726	0,00141	-0,000677
2004-08-18	0,0765	1,317541	1054,262	1056,183	0,001734	0,00142	0,0004004
2004-08-25	0,0751	1,302865	1057,678	1056,590	0,00324	0,001415	0,0018446
2004-09-01	0,0759	1,283639	1058,058	1056,954	0,000359	0,00139	-0,001042
2004-09-08	0,0768	1,264341	1058,438	1058,007	0,000359	0,001404	-0,001155
2004-09-15	0,0771	1,246068	1059,508	1061,856	0,001011	0,001419	-0,000379
2004-09-22	0,0753	1,232298	1063,369	1065,245	0,003644	0,001425	0,0022429
2004-09-29	0,0738	1,217845	1066,729	1068,356	0,00316	0,001393	0,0018484
2004-10-06	0,0725	1,20305	1069,816	1072,105	0,002894	0,001367	0,0015832

Table 3. Basic characteristics of bond PS1106 and decomposition of weekly realized rate of return according to model (10)

Date	y_3	MD_3	B_3	B_3^y	R_3	R_3^t	$-MD_3 \cdot \Delta y_3$
2004-06-30	0,0756	2,006895	1072,562	1070,794	-0,00211	0,001367	-0,003451
2004-07-07	0,0764	1,986538	1072,292	1065,217	-0,00025	0,001399	-0,001606
2004-07-14	0,0798	1,957396	1066,722	1068,877	-0,00519	0,001413	-0,006754
2004-07-21	0,0788	1,943374	1070,452	1068,528	0,003497	0,001474	0,0019574
2004-07-28	0,0797	1,922524	1070,082	1071,801	-0,00035	0,001455	-0,001749
2004-08-04	0,0789	1,907855	1073,379	1076,773	0,003081	0,001472	0,001538
2004-08-11	0,0772	1,896161	1078,342	1081,430	0,004624	0,001457	0,0032434
2004-08-18	0,0757	1,884052	1082,973	1085,000	0,004295	0,001427	0,0028442
2004-08-25	0,0747	1,870151	1086,519	1081,739	0,003274	0,0014	0,0018841
2004-09-01	0,0771	1,843919	1083,233	1083,320	-0,00302	0,001381	-0,004488
2004-09-08	0,077	1,826495	1084,863	1084,949	0,001505	0,001424	0,0001844
2004-09-15	0,077	1,809065	1086,493	1091,070	0,001502	0,001423	0
2004-09-22	0,0746	1,800214	1092,623	1096,739	0,005642	0,001423	0,0043418
2004-09-29	0,0725	1,790662	1098,253	1100,008	0,005153	0,00138	0,0037804
2004-10-06	0,0716	1,776636	1101,484	1101,153	0,002942	0,001342	0,0016116

Table 4. Basic characteristics of bond PS0507 and decomposition of weekly realized rate of return according to model (10)

Date	y_4	MD_4	B_4	B_4^y	R_4	R_4^t	$-MD_4 \cdot \Delta y_4$
2004-06-30	0,0757	2,45722	1034,161	1034,193	-0,00349	0,001365	-0,004712
2004-07-07	0,0757	2,439884	1035,641	1029,729	0,001431	0,0014	0
2004-07-14	0,0781	2,415742	1031,171	1027,818	-0,00432	0,0014	-0,005856
2004-07-21	0,0794	2,394413	1029,301	1029,422	-0,00181	0,001443	-0,00314
2004-07-28	0,0794	2,377096	1030,932	1034,046	0,001585	0,001467	0
2004-08-04	0,0781	2,363347	1035,562	1038,193	0,004491	0,001466	0,0030902
2004-08-11	0,077	2,349079	1039,692	1043,337	0,003988	0,001444	0,0025997
2004-08-18	0,0755	2,336105	1044,822	1045,990	0,004934	0,001423	0,0035236
2004-08-25	0,0751	2,32015	1047,452	1042,635	0,002517	0,001397	0,0009344
2004-09-01	0,0771	2,296704	1044,082	1044,774	-0,00322	0,001388	-0,00464
2004-09-08	0,0768	2,280142	1046,262	1047,855	0,002088	0,001424	0,000689
2004-09-15	0,0761	2,264753	1049,342	1056,486	0,002944	0,001419	0,0015961
2004-09-22	0,0731	2,256653	1057,973	1061,168	0,008225	0,001408	0,0067943
2004-09-29	0,0717	2,243502	1062,603	1065,717	0,004376	0,001353	0,0031593
2004-10-06	0,0704	2,230323	1067,133	1066,471	0,004263	0,001329	0,0029166

Table 5. Basic characteristics of bond PS0608 and decomposition of weekly realized rate of return according to model (10)

Date	y_5	MD_5	B_5	B_5^y	R_5	R_5^t	$-MD_5 \cdot \Delta y_5$
2004-06-30	0,0758	3,401622	939,945	939,731	-0,00229	0,001367	-0,006043
2004-07-07	0,0758	3,382758	941,048	932,943	0,001173	0,001401	0
2004-07-14	0,0784	3,354285	934,251	932,403	-0,00722	0,001402	-0,008795
2004-07-21	0,079	3,333298	933,753	929,999	-0,00053	0,001448	-0,002013
2004-07-28	0,0802	3,309872	931,356	935,074	-0,00257	0,001459	-0,004
2004-08-04	0,079	3,29582	936,459	942,687	0,005479	0,001481	0,0039718
2004-08-11	0,077	3,285037	944,062	952,309	0,008119	0,001459	0,0065916
2004-08-18	0,0743	3,276947	953,664	956,451	0,010171	0,001423	0,0088696
2004-08-25	0,0734	3,261948	957,767	948,381	0,004302	0,001376	0,0029493
2004-09-01	0,0765	3,231036	949,67	949,930	-0,00845	0,001359	-0,010112
2004-09-08	0,0764	3,212696	951,273	952,730	0,001688	0,001414	0,0003231
2004-09-15	0,0759	3,195966	954,075	965,922	0,002946	0,001412	0,0016063
2004-09-22	0,072	3,193366	967,278	964,094	0,013839	0,001403	0,0124643
2004-09-29	0,0731	3,17044	965,381	975,065	-0,00196	0,001335	-0,003513
2004-10-06	0,0699	3,165222	976,384	974,722	0,011398	0,001353	0,0101454

Table 6. Basic characteristics of bond DS0509 and decomposition of weekly realized rate of return according to model (10)

Date	y_6	MD_6	B_6	B_6^y	R_6	R_6^t	$-MD_6 \cdot \Delta y_6$
2004-06-30	0,0745	4,042381	948,082	944,306	0,0024	0,001383	0,0008119
2004-07-07	0,0755	4,018609	945,608	937,635	-0,00261	0,001379	-0,004042
2004-07-14	0,0776	3,988801	938,944	932,198	-0,00705	0,001396	-0,008439
2004-07-21	0,0794	3,960472	933,534	934,315	-0,00576	0,001434	-0,00718
2004-07-28	0,0792	3,942867	935,685	939,462	0,002304	0,001466	0,0007921
2004-08-04	0,0782	3,929652	940,836	949,472	0,005505	0,001462	0,0039429
2004-08-11	0,0758	3,923613	950,843	957,793	0,010636	0,001444	0,0094312
2004-08-18	0,074	3,915216	959,137	955,979	0,008723	0,001403	0,0070625
2004-08-25	0,0748	3,891958	957,288	953,119	-0,00193	0,001369	-0,003132
2004-09-01	0,0759	3,867072	954,438	958,473	-0,00298	0,001384	-0,004281
2004-09-08	0,0749	3,854544	959,819	963,306	0,005638	0,001404	0,0038671
2004-09-15	0,0739	3,841253	964,64	975,305	0,005023	0,001385	0,0038545
2004-09-22	0,0711	3,839037	976,64	978,253	0,01244	0,001368	0,0107555
2004-09-29	0,0706	3,823033	979,541	983,655	0,00297	0,001317	0,0019195
2004-10-06	0,0695	3,810951	984,942	985,072	0,005514	0,001309	0,0042053

Table 7. Basic characteristics of bond DS1110 and decomposition of weekly realized rate of return according to model (10)

Date	y_7	MD_7	B_7	B_7^y	R_7	R_7^t	$-MD_7 \cdot \Delta y_7$
2004-06-30	0,0752	4,871296	960,003	958,153	0,000644	0,001389	-0,000489
2004-07-07	0,0756	4,848474	959,486	957,215	-0,00054	0,001392	-0,001939
2004-07-14	0,0761	4,824704	958,554	954,345	-0,00097	0,001399	-0,002424
2004-07-21	0,077	4,796695	955,688	959,472	-0,00299	0,001407	-0,004342
2004-07-28	0,0762	4,785812	960,838	964,630	0,005389	0,001424	0,0038374
2004-08-04	0,0754	4,775016	965,989	969,788	0,005361	0,001409	0,0038286
2004-08-11	0,0746	4,7643	971,14	975,045	0,005332	0,001394	0,00382
2004-08-18	0,0737	4,753872	976,39	975,709	0,005406	0,00138	0,0042879
2004-08-25	0,0739	4,733454	977,041	969,366	0,000667	0,001365	-0,000951
2004-09-01	0,0755	4,697461	970,692	980,972	-0,0065	0,001367	-0,007574
2004-09-08	0,0733	4,701406	982,342	993,712	0,012002	0,001397	0,0103344
2004-09-15	0,0709	4,707862	995,06	1003,276	0,012947	0,001357	0,0112834
2004-09-22	0,0691	4,707391	1004,594	1009,500	0,009581	0,001313	0,0084742
2004-09-29	0,0681	4,69964	1010,795	1000,680	0,006173	0,001283	0,0047074
2004-10-06	0,0702	4,658102	1001,945	1002,623	-0,00876	0,001264	-0,009869

Table 8. Basic characteristics of bond DS1013 and decomposition of week's realized rate of return according to model (10)

Date	y_8	MD_8	B_8	B_8^y	R_8	R_8^t	$-MD_8 \cdot \Delta y_8$
2004-06-30	0,073	6,674787	882,11	883,874	0,00428	0,001359	0,0026749
2004-07-07	0,0727	6,660005	885,068	875,649	0,003353	0,001351	0,0020024
2004-07-14	0,0743	6,612586	876,827	869,791	-0,00931	0,001346	-0,010656
2004-07-21	0,0755	6,571727	870,986	866,735	-0,00666	0,001374	-0,007935
2004-07-28	0,0762	6,538912	867,945	877,043	-0,00349	0,001396	-0,0046
2004-08-04	0,0746	6,546123	878,279	879,648	0,011906	0,001409	0,0104623
2004-08-11	0,0744	6,530185	880,863	889,597	0,002942	0,001381	0,0013092
2004-08-18	0,0729	6,536323	890,822	888,581	0,011306	0,001377	0,0097953
2004-08-25	0,0733	6,50963	889,781	891,531	-0,00117	0,00135	-0,002615
2004-09-01	0,073	6,494903	892,74	897,735	0,003326	0,001357	0,0019529
2004-09-08	0,0721	6,489989	898,949	907,645	0,006955	0,001352	0,0058454
2004-09-15	0,0707	6,496232	908,858	927,800	0,011023	0,001336	0,009086
2004-09-22	0,0675	6,532854	929,016	923,417	0,022179	0,00131	0,0207879
2004-09-29	0,0685	6,496497	924,575	929,353	-0,00478	0,001254	-0,006533
2004-10-06	0,0677	6,491043	930,534	930,324	0,006445	0,001271	0,0051972

Table 9. Basic characteristics of bond WS0922 and decomposition of weekly realized rate of return according to model (10)

Date	y_9	MD_9	B_9	B_9^y	R_9	R_9^t	$-MD_9 \cdot \Delta y_9$
2004-06-30	0,0711	9,955614	906,61	907,515	-0,00566	0,001306	-0,007007
2004-07-07	0,071	9,941631	908,712	885,149	0,002319	0,001319	0,0009956
2004-07-14	0,0737	9,788217	886,315	888,706	-0,02465	0,001317	-0,026842
2004-07-21	0,0734	9,782858	889,918	892,308	0,004065	0,001364	0,0029365
2004-07-28	0,0731	9,777468	893,521	901,732	0,004049	0,00136	0,0029349
2004-08-04	0,0722	9,805417	902,953	889,536	0,010556	0,001354	0,0087997
2004-08-11	0,0737	9,708763	890,726	893,942	-0,01354	0,001338	-0,014708
2004-08-18	0,0734	9,708192	895,162	898,379	0,00498	0,001365	0,0029126
2004-08-25	0,073	9,707571	899,599	902,814	0,004957	0,001358	0,0038833
2004-09-01	0,0726	9,706875	904,034	933,880	0,00493	0,001352	0,003883
2004-09-08	0,0693	9,856876	935,137	944,924	0,034405	0,001346	0,0320327
2004-09-15	0,0683	9,891916	946,14	961,014	0,011766	0,001286	0,0098569
2004-09-22	0,0667	9,954036	962,232	913,813	0,017008	0,001267	0,0158271
2004-09-29	0,0658	10,64499	914,945	905,940	0,010614	0,001239	0,0089586
2004-10-06	0,0667	10,58461	907,048	917,344	-0,00863	0,001223	-0,00958

Table 10. Correlation matrix of YTM of the selected bonds

YTM	PS1005	PS0206	PS1106	PS0507	PS0608	DS0509	DS1110	DS1013	WS0922
PS1005	1,0000	0,9766	0,9493	0,9205	0,8810	0,8175	0,7821	0,7138	0,6474
PS0206	0,9766	1,0000	0,9699	0,9490	0,9134	0,8576	0,8262	0,7619	0,6823
PS1106	0,9493	0,9699	1,0000	0,9860	0,9670	0,9304	0,9026	0,8583	0,7919
PS0507	0,9205	0,9490	0,9860	1,0000	0,9831	0,9565	0,9316	0,9059	0,8281
PS0608	0,8810	0,9134	0,9670	0,9831	1,0000	0,9665	0,9347	0,9182	0,8296
DS0509	0,8175	0,8576	0,9304	0,9565	0,9665	1,0000	0,9678	0,9562	0,8882
DS1110	0,7821	0,8262	0,9026	0,9316	0,9347	0,9678	1,0000	0,9564	0,9001
DS1013	0,7138	0,7619	0,8583	0,9059	0,9182	0,9562	0,9564	1,0000	0,9171
WS0922	0,6474	0,6823	0,7919	0,8281	0,8296	0,8882	0,9001	0,9171	1,0000

Table 11. Factor loadings[3] (**W** matrix)

Factor / Variable	Factor 1	Factor 2
PS1005	**0,898872**	-0,393008
PS0206	**0,929989**	-0,342749
PS1106	**0,979938**	-0,170063
PS0507	**0,992705**	-0,075987
PS0608	**0,983507**	-0,011171
DS0509	**0,976169**	0,146053
DS1110	**0,957230**	0,200845
DS1013	**0,932976**	0,311200
WS0922	**0,863248**	0,347428
Variance explained	8,070715	0,585974
Fraction (%)	89,6746	6,5108

[3] Factor loadings larger than 0.7 are shown bold

Table 12. Residual correlation matrix

YTM	PS1005	PS0206	PS1106	PS0507	PS0608	DS0509	DS1110	DS1013	WS0922
PS1005	0,0376	0,0060	0,0016	-0,0017	-0,0074	-0,0026	0,0006	-0,0025	0,0080
PS0206	0,0060	0,0176	0,0003	-0,0002	-0,0051	-0,0002	0,0048	0,0009	-0,0014
PS1106	0,0016	0,0003	0,0108	0,0002	0,0014	-0,0013	-0,0013	-0,0030	0,0050
PS0507	-0,0017	-0,0002	0,0002	0,0088	0,0059	-0,0014	-0,0033	0,0034	-0,0024
PS0608	-0,0074	-0,0051	0,0014	0,0059	0,0326	0,0081	-0,0045	0,0041	-0,0156
DS0509	-0,0026	-0,0002	-0,0013	-0,0014	0,0081	0,0258	0,0041	0,0000	-0,0052
DS1110	0,0006	0,0048	-0,0013	-0,0033	-0,0045	0,0041	0,0434	0,0008	0,0040
DS1013	-0,0025	0,0009	-0,0030	0,0034	0,0041	0,0000	0,0008	0,0327	0,0036
WS0922	0,0080	-0,0014	0,0050	-0,0024	-0,0156	-0,0052	0,0040	0,0036	0,1341

Table 13. Decomposition of weekly realized rate of return of PS1005 according to model (15)

Date	R_1	R_1^t	$-FD_1^{(1)}\Delta F_1$	$-FD_1^{(2)}\Delta F_2$	$-UD_1\Delta U_1$	$FD_1^{(1)}$	$FD_1^{(2)}$	UD_1
2004-06-30	0,001043	0,001338	-0,00099	-0,00043	0,001201	0,006243	-0,00273	0,001182
2004-07-07	0,001051	0,001343	-0,00042	-0,00024	0,000322	0,006144	-0,00269	0,001163
2004-07-14	0,00099	0,001348	-0,00244	0,000824	0,001289	0,006044	-0,00264	0,001144
2004-07-21	0,000989	0,001354	-0,00087	0,000982	-0,00055	0,005944	-0,0026	0,001125
2004-07-28	0,000992	0,00136	-0,00019	-0,00032	0,000187	0,005843	-0,00255	0,001106
2004-08-04	0,002113	0,001367	0,001161	-0,0011	0,000677	0,005756	-0,00252	0,001089
2004-08-11	0,002108	0,001354	0,001234	-0,00045	4,22E-05	0,005669	-0,00248	0,001073
2004-08-18	0,001458	0,00134	0,001462	-0,00078	-0,00058	0,005574	-0,00244	0,001055
2004-08-25	-0,00149	0,001338	6,48E-05	0,000602	-0,00355	0,005441	-0,00238	0,00103
2004-09-01	0,000351	0,00139	-0,00144	-0,00044	0,000812	0,005331	-0,00233	0,001009
2004-09-08	0,000934	0,001409	0,000713	-0,00168	0,000488	0,005228	-0,00229	0,000989
2004-09-15	0,002301	0,001418	0,000873	-0,00124	0,001302	0,005144	-0,00225	0,000973
2004-09-22	0,001499	0,001401	0,002485	-0,00118	-0,00122	0,005049	-0,00221	0,000955
2004-09-29	0,000671	0,001399	0,000851	0,000429	-0,00209	0,004941	-0,00216	0,000935
2004-10-06	0,00599	0,001414	0,000756	0,001347	0,002654	0,004914	-0,00215	0,00093

Table 14. Decomposition of weekly realized rate of return of PS0206 according to model (15)

Date	R_2	R_2^t	$-FD_2^{(1)}\Delta F_1$	$-FD_2^{(2)}\Delta F_2$	$-UD_2\Delta U_2$	$FD_2^{(1)}$	$FD_2^{(2)}$	UD_2
2004-06-30	0,001558	0,001366	-0,00139	-0,00051	0,002042	0,008704	-0,00321	0,000971
2004-07-07	0,000277	0,001364	-0,00058	-0,00029	-0,00027	0,00859	-0,00317	0,000958
2004-07-14	0,000516	0,001378	-0,00343	0,000974	0,00161	0,008477	-0,00312	0,000946
2004-07-21	0,000806	0,001389	-0,00123	0,001166	-0,0005	0,008366	-0,00308	0,000934
2004-07-28	0,00093	0,001396	-0,00026	-0,00038	0,000234	0,008257	-0,00304	0,000921
2004-08-04	0,000842	0,001403	0,001643	-0,00131	-0,00101	0,008146	-0,003	0,000909
2004-08-11	0,000726	0,00141	0,001749	-0,00053	-0,00188	0,008034	-0,00296	0,000896
2004-08-18	0,001734	0,00142	0,00208	-0,00094	-0,00075	0,007931	-0,00292	0,000885
2004-08-25	0,00324	0,001415	9,34E-05	0,000731	0,000999	0,007843	-0,00289	0,000875
2004-09-01	0,000359	0,00139	-0,00209	-0,00054	0,001603	0,007727	-0,00285	0,000862
2004-09-08	0,000359	0,001404	0,001038	-0,00206	-0,00012	0,007611	-0,00281	0,000849
2004-09-15	0,001011	0,001419	0,001273	-0,00152	-0,00013	0,007501	-0,00276	0,000837
2004-09-22	0,003644	0,001425	0,003652	-0,00146	2,22E-05	0,007418	-0,00273	0,000828
2004-09-29	0,00316	0,001393	0,001262	0,000536	2,82E-05	0,007331	-0,0027	0,000818
2004-10-06	0,002894	0,001367	0,001114	0,001674	-0,00122	0,007242	-0,00267	0,000808

Table 15. Decomposition of weekly realized rate of return of PS1106 according to model (15)

Date	R_3	R_3^t	$-FD_3^{(1)}\Delta F_1$	$-FD_3^{(2)}\Delta F_2$	$-UD_3\Delta U_3$	$FD_3^{(1)}$	$FD_3^{(2)}$	UD_3
2004-06-30	-0,00211	0,001367	-0,00199	-0,00035	-0,00107	0,012504	-0,00217	0,001116
2004-07-07	-0,00025	0,001399	-0,00084	-0,00019	-0,00056	0,012377	-0,00215	0,001105
2004-07-14	-0,00519	0,001413	-0,00493	0,00066	-0,00238	0,012195	-0,00212	0,001089
2004-07-21	0,003497	0,001474	-0,00177	0,000794	0,002923	0,012108	-0,0021	0,001081
2004-07-28	-0,00035	0,001455	-0,00038	-0,00026	-0,00109	0,011978	-0,00208	0,001069
2004-08-04	0,003081	0,001472	0,002397	-0,0009	3,19E-05	0,011887	-0,00206	0,001061
2004-08-11	0,004624	0,001457	0,002572	-0,00037	0,001022	0,011814	-0,00205	0,001055
2004-08-18	0,004295	0,001427	0,003078	-0,00065	0,000402	0,011738	-0,00204	0,001048
2004-08-25	0,003274	0,0014	0,000139	0,000512	0,00122	0,011652	-0,00202	0,00104
2004-09-01	-0,00302	0,001381	-0,00311	-0,00038	-0,00094	0,011488	-0,00199	0,001026
2004-09-08	0,001505	0,001424	0,001551	-0,00145	8,08E-05	0,01138	-0,00197	0,001016
2004-09-15	0,001502	0,001423	0,001913	-0,00107	-0,00084	0,011271	-0,00196	0,001006
2004-09-22	0,005642	0,001423	0,005521	-0,00104	-0,00016	0,011216	-0,00195	0,001001
2004-09-29	0,005153	0,00138	0,001921	0,000384	0,001455	0,011156	-0,00194	0,000996
2004-10-06	0,002942	0,001342	0,001702	0,001205	-0,00131	0,011069	-0,00192	0,000988

Table 16. Decomposition of weekly realized rate of return of PS0507 according to model (15)

Date	R_4	R_4^t	$-FD_4^{(1)}\Delta F_1$	$-FD_4^{(2)}\Delta F_2$	$-UD_4\Delta U_4$	$FD_4^{(1)}$	$FD_4^{(2)}$	UD_4
2004-06-30	-0,00349	0,001365	-0,0023	-0,00018	-0,0022	0,014423	-0,0011	0,001138
2004-07-07	0,001431	0,0014	-0,00097	-9,9E-05	0,001068	0,014321	-0,0011	0,00113
2004-07-14	-0,00432	0,0014	-0,00574	0,000339	-0,0004	0,014179	-0,00109	0,001119
2004-07-21	-0,00181	0,001443	-0,00206	0,000407	-0,00146	0,014054	-0,00108	0,001109
2004-07-28	0,001585	0,001467	-0,00044	-0,00013	0,000578	0,013952	-0,00107	0,001101
2004-08-04	0,004491	0,001466	0,002798	-0,00046	0,000739	0,013872	-0,00106	0,001095
2004-08-11	0,003988	0,001444	0,003001	-0,00019	-0,00023	0,013788	-0,00106	0,001088
2004-08-18	0,004934	0,001423	0,003595	-0,00034	0,000246	0,013712	-0,00105	0,001082
2004-08-25	0,002517	0,001397	0,000162	0,000264	0,000502	0,013618	-0,00104	0,001075
2004-09-01	-0,00322	0,001388	-0,00365	-0,00019	-0,00075	0,013481	-0,00103	0,001064
2004-09-08	0,002088	0,001424	0,001825	-0,00075	-0,00039	0,013383	-0,00102	0,001056
2004-09-15	0,002944	0,001419	0,002256	-0,00056	-0,00011	0,013293	-0,00102	0,001049
2004-09-22	0,008225	0,001408	0,00652	-0,00054	0,00079	0,013245	-0,00101	0,001045
2004-09-29	0,004376	0,001353	0,002267	0,0002	0,000673	0,013168	-0,00101	0,001039
2004-10-06	0,004263	0,001329	0,002013	0,000628	0,000258	0,013091	-0,001	0,001033

Table 17. Decomposition of weekly realized rate of return of PS0608 according to model (15)

Date	R_5	R_5^t	$-FD_5^{(1)}\Delta F_1$	$-FD_5^{(2)}\Delta F_2$	$-UD_5\Delta U_5$	$FD_5^{(1)}$	$FD_5^{(2)}$	UD_5
2004-06-30	-0,00229	0,001367	-0,003	-3,4E-05	-0,00343	0,018817	-0,00021	0,003303
2004-07-07	0,001173	0,001401	-0,00127	-1,9E-05	0,001286	0,018713	-0,00021	0,003284
2004-07-14	-0,00722	0,001402	-0,00751	6,57E-05	-0,00128	0,018555	-0,00021	0,003257
2004-07-21	-0,00053	0,001448	-0,0027	7,92E-05	0,000622	0,018439	-0,00021	0,003236
2004-07-28	-0,00257	0,001459	-0,00058	-2,6E-05	-0,00336	0,01831	-0,00021	0,003214
2004-08-04	0,005479	0,001481	0,003677	-9,1E-05	0,000368	0,018232	-0,00021	0,0032
2004-08-11	0,008119	0,001459	0,003956	-3,7E-05	0,002652	0,018172	-0,00021	0,003189
2004-08-18	0,010171	0,001423	0,004753	-6,6E-05	0,004161	0,018128	-0,00021	0,003182
2004-08-25	0,004302	0,001376	0,000215	5,18E-05	0,002669	0,018045	-0,0002	0,003167
2004-09-01	-0,00845	0,001359	-0,00484	-3,8E-05	-0,00514	0,017874	-0,0002	0,003137
2004-09-08	0,001688	0,001414	0,002423	-0,00015	-0,00195	0,017772	-0,0002	0,003119
2004-09-15	0,002946	0,001412	0,003	-0,00011	-0,00129	0,01768	-0,0002	0,003103
2004-09-22	0,013839	0,001403	0,008696	-0,00011	0,003865	0,017665	-0,0002	0,0031
2004-09-29	-0,00196	0,001335	0,00302	3,95E-05	-0,00655	0,017538	-0,0002	0,003078
2004-10-06	0,011398	0,001353	0,002692	0,000125	0,007312	0,01751	-0,0002	0,003073

Table 18. Decomposition of weekly realized rate of return of DS0509 according to model (15)

Date	R_6	R_6^t	$-FD_6^{(1)}\Delta F_1$	$-FD_6^{(2)}\Delta F_2$	$-UD_6\Delta U_6$	$FD_6^{(1)}$	$FD_6^{(2)}$	UD_6
2004-06-30	0,0024	0,001383	-0,00312	0,000466	0,003462	0,019587	0,002931	0,002864
2004-07-07	-0,00261	0,001379	-0,00132	0,000263	-0,00296	0,019472	0,002913	0,002848
2004-07-14	-0,00705	0,001396	-0,00782	-0,0009	0,000344	0,019328	0,002892	0,002826
2004-07-21	-0,00576	0,001434	-0,00281	-0,00109	-0,00323	0,01919	0,002871	0,002806
2004-07-28	0,002304	0,001466	-0,00061	0,00036	0,001036	0,019105	0,002858	0,002794
2004-08-04	0,005505	0,001462	0,00384	0,001247	-0,00116	0,019041	0,002849	0,002785
2004-08-11	0,010636	0,001444	0,004138	0,000514	0,004765	0,019012	0,002845	0,00278
2004-08-18	0,008723	0,001403	0,004974	0,000911	0,001162	0,018971	0,002838	0,002774
2004-08-25	-0,00193	0,001369	0,000225	-0,00071	-0,00262	0,018858	0,002822	0,002758
2004-09-01	-0,00298	0,001384	-0,00508	0,000528	0,000294	0,018738	0,002804	0,00274
2004-09-08	0,005638	0,001404	0,002546	0,002051	-0,00074	0,018677	0,002794	0,002731
2004-09-15	0,005023	0,001385	0,003159	0,001529	-0,00085	0,018613	0,002785	0,002722
2004-09-22	0,01244	0,001368	0,009157	0,001482	0,00011	0,018602	0,002783	0,00272
2004-09-29	0,00297	0,001317	0,00319	-0,00055	-0,00073	0,018525	0,002772	0,002709
2004-10-06	0,005514	0,001309	0,00284	-0,00173	0,003085	0,018466	0,002763	0,0027

Table 19. Decomposition of weekly realized rate of return of DS1110 according to model (15)

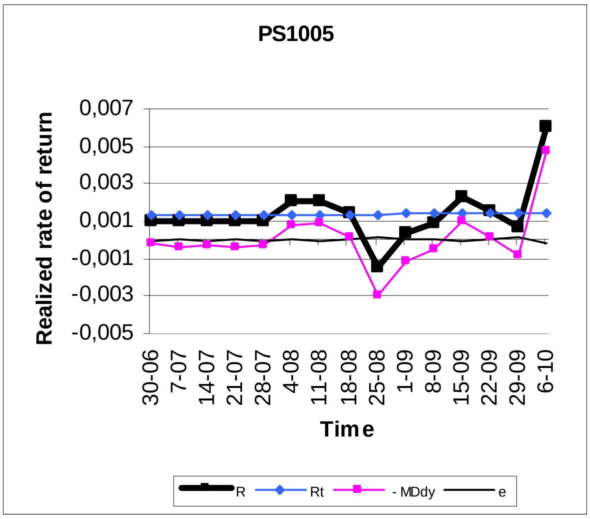
Date	R_7	R_7^t	$-FD_7^{(1)}\Delta F_1$	$-FD_7^{(2)}\Delta F_2$	$-UD_7\Delta U_7$	$FD_7^{(1)}$	$FD_7^{(2)}$	UD_7
2004-06-30	0,000644	0,001389	-0,00338	0,000708	0,002182	0,021198	0,004448	0,004231
2004-07-07	-0,00054	0,001392	-0,00143	0,0004	-0,00091	0,021099	0,004427	0,004212
2004-07-14	-0,00097	0,001399	-0,00849	-0,00137	0,007454	0,020995	0,004405	0,004191
2004-07-21	-0,00299	0,001407	-0,00306	-0,00166	0,000397	0,020873	0,00438	0,004167
2004-07-28	0,005389	0,001424	-0,00066	0,00055	0,003941	0,020826	0,00437	0,004157
2004-08-04	0,005361	0,001409	0,004191	0,001908	-0,00228	0,020779	0,00436	0,004148
2004-08-11	0,005332	0,001394	0,004513	0,000786	-0,00149	0,020732	0,00435	0,004139
2004-08-18	0,005406	0,00138	0,005424	0,001393	-0,00254	0,020687	0,004341	0,004129
2004-08-25	0,000667	0,001365	0,000245	-0,00109	-9,9E-05	0,020598	0,004322	0,004112
2004-09-01	-0,0065	0,001367	-0,00554	0,000808	-0,00279	0,020442	0,004289	0,00408
2004-09-08	0,012002	0,001397	0,002789	0,003151	0,004403	0,020459	0,004293	0,004084
2004-09-15	0,012947	0,001357	0,003477	0,002361	0,005461	0,020487	0,004299	0,004089
2004-09-22	0,009581	0,001313	0,010084	0,002289	-0,0039	0,020485	0,004298	0,004089
2004-09-29	0,006173	0,001283	0,003521	-0,00085	0,00203	0,020451	0,004291	0,004082
2004-10-06	-0,00876	0,001264	0,003117	-0,00267	-0,01023	0,02027	0,004253	0,004046

Table 20. Decomposition of weekly realized rate of return of DS1013 according to model (15)

Date	R_8	R_8^t	$-FD_8^{(1)}\Delta F_1$	$-FD_8^{(2)}\Delta F_2$	$-UD_8\Delta U_8$	$FD_8^{(1)}$	$FD_8^{(2)}$	UD_8
2004-06-30	0,00428	0,001359	-0,00408	0,00136	0,005393	0,025633	0,00855	0,004048
2004-07-07	0,003353	0,001351	-0,00173	0,00077	0,002959	0,025576	0,008531	0,004039
2004-07-14	-0,00931	0,001346	-0,01027	-0,00264	0,002334	0,025394	0,00847	0,00401
2004-07-21	-0,00666	0,001374	-0,0037	-0,00318	-0,00101	0,025237	0,008418	0,003985
2004-07-28	-0,00349	0,001396	-0,0008	0,001054	-0,00483	0,025111	0,008376	0,003966
2004-08-04	0,011906	0,001409	0,00507	0,00367	0,001733	0,025139	0,008385	0,00397
2004-08-11	0,002942	0,001381	0,005459	0,001511	-0,00566	0,025078	0,008365	0,00396
2004-08-18	0,011306	0,001377	0,006582	0,002688	0,000535	0,025101	0,008373	0,003964
2004-08-25	-0,00117	0,00135	0,000298	-0,00211	-0,00079	0,024999	0,008339	0,003948
2004-09-01	0,003326	0,001357	-0,00676	0,001567	0,007139	0,024942	0,00832	0,003939
2004-09-08	0,006955	0,001352	0,003398	0,006102	-0,00366	0,024923	0,008313	0,003936
2004-09-15	0,011023	0,001336	0,004234	0,00457	0,000291	0,024947	0,008321	0,00394
2004-09-22	0,022179	0,00131	0,01235	0,004456	0,004099	0,025088	0,008368	0,003962
2004-09-29	-0,00478	0,001254	0,004296	-0,00165	-0,00914	0,024948	0,008322	0,00394
2004-10-06	0,006445	0,001271	0,003833	-0,00522	0,006575	0,024928	0,008315	0,003937

Table 21. Decomposition of weekly realized rate of return of WS0922 according to model (15)

Date	R_9	R_9^t	$-FD_9^{(1)}\Delta F_1$	$-FD_9^{(2)}\Delta F_2$	$-UD_9\Delta U_9$	$FD_9^{(1)}$	$FD_9^{(2)}$	UD_9
2004-06-30	-0,00566	0,001306	-0,00569	0,002286	-0,00357	0,035694	0,014366	0,014439
2004-07-07	0,002319	0,001319	-0,00241	0,001295	0,002112	0,035644	0,014345	0,014419
2004-07-14	-0,02465	0,001317	-0,0142	-0,00441	-0,00783	0,035094	0,014124	0,014196
2004-07-21	0,004065	0,001364	-0,00514	-0,00534	0,01341	0,035074	0,014116	0,014188
2004-07-28	0,004049	0,00136	-0,00111	0,001776	0,002272	0,035055	0,014108	0,01418
2004-08-04	0,010556	0,001354	0,00709	0,006193	-0,00446	0,035155	0,014149	0,014221
2004-08-11	-0,01354	0,001338	0,007577	0,002531	-0,02467	0,034809	0,014009	0,014081
2004-08-18	0,00498	0,001365	0,009127	0,004497	-0,01071	0,034807	0,014009	0,01408
2004-08-25	0,004957	0,001358	0,000414	-0,00354	0,007012	0,034805	0,014008	0,014079
2004-09-01	0,00493	0,001352	-0,00943	0,002638	0,010673	0,034802	0,014007	0,014078
2004-09-08	0,034405	0,001346	0,004818	0,01044	0,017269	0,03534	0,014223	0,014296
2004-09-15	0,011766	0,001286	0,006019	0,007839	-0,00397	0,035465	0,014274	0,014346
2004-09-22	0,017008	0,001267	0,017568	0,007648	-0,00929	0,035688	0,014363	0,014437
2004-09-29	0,010614	0,001239	0,006572	-0,00305	0,006057	0,038165	0,01536	0,015439
2004-10-06	-0,00863	0,001223	0,005835	-0,00958	-0,00578	0,037949	0,015273	0,015351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Realized rate of return
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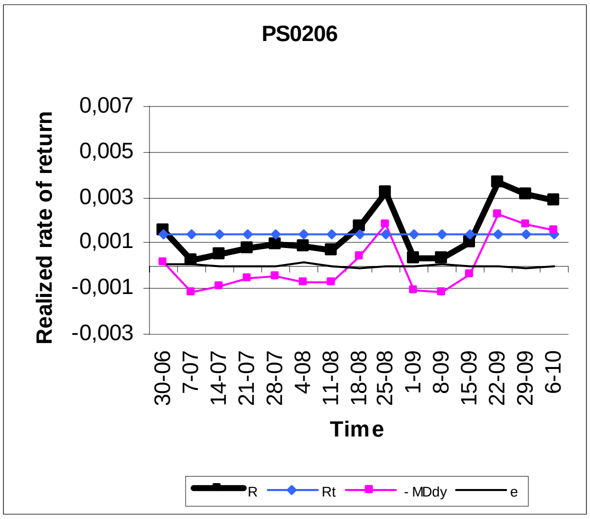
0,005
0,003
0,001
-0,001
-0,003
-0,005
30-06
7-07
14-07
21-07
28-07
4-08
11-08
18-08
25-08
1-09
8-09
15-09
22-09
29-09
6-10
Time
R
Rt
- MDdy
e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Realized rate of return
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0,005
0,003
0,001
-0,001
-0,003
30-06
7-07
14-07
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28-07
4-08
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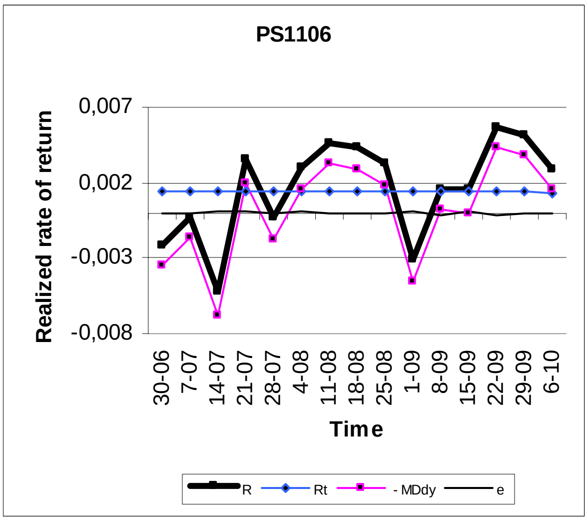
Time
R
Rt
- MDdy
e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0,002
-0,003
-0,008
30-06
7-07
14-07
21-07
28-07
4-08
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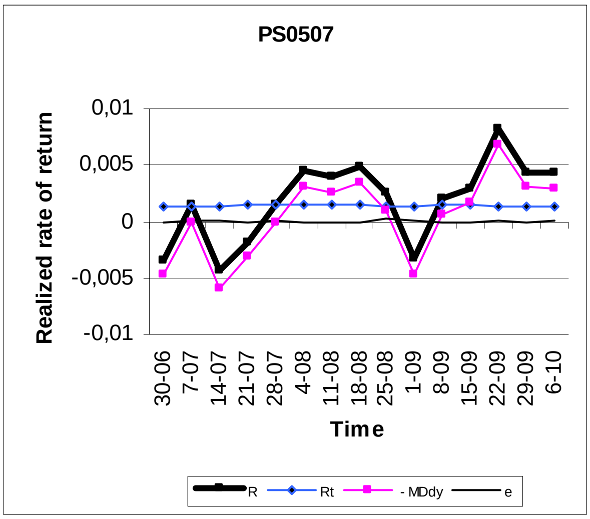
Time
R
Rt
- MDdy
e



PS0507
Realized rate of return
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0,005
0
-0,005
-0,01
30-06
7-07
14-07
21-07
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4-08
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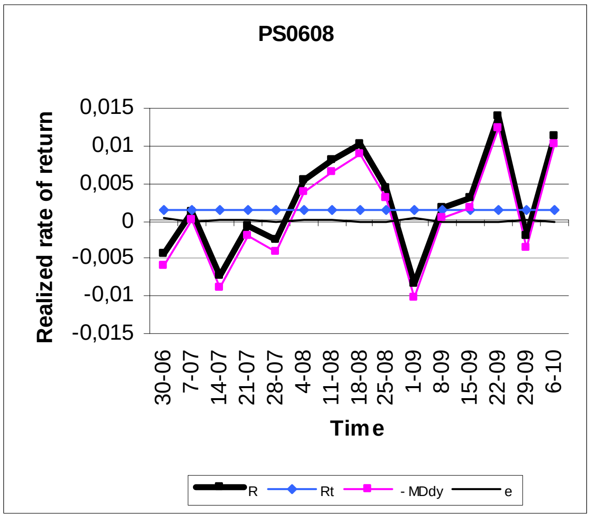
Time
R
Rt
- MDdy
e



PS0608
Realized rate of return
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0,005
0
-0,005
-0,01
-0,015
30-06
7-07
14-07
21-07
28-07
4-08
11-08
18-08
25-08
1-09
8-09
15-09
22-09
29-09
6-10
Time
R
Rt
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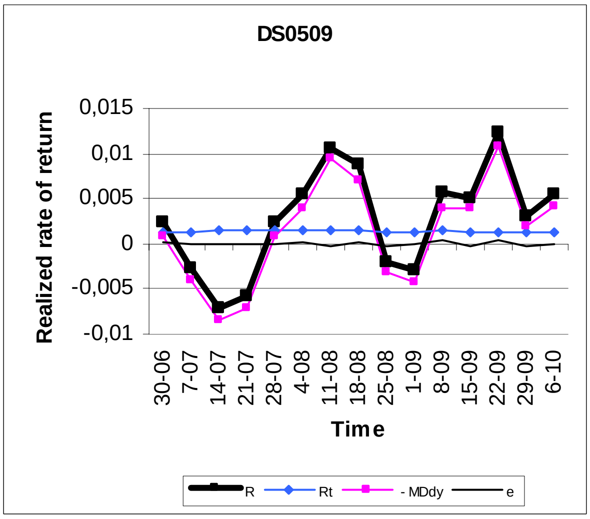

DS0509
Realized rate of return
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0,005
0
-0,005
-0,01
30-06
7-07
14-07
21-07
28-07
4-08
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R
Rt
- MDdy
e

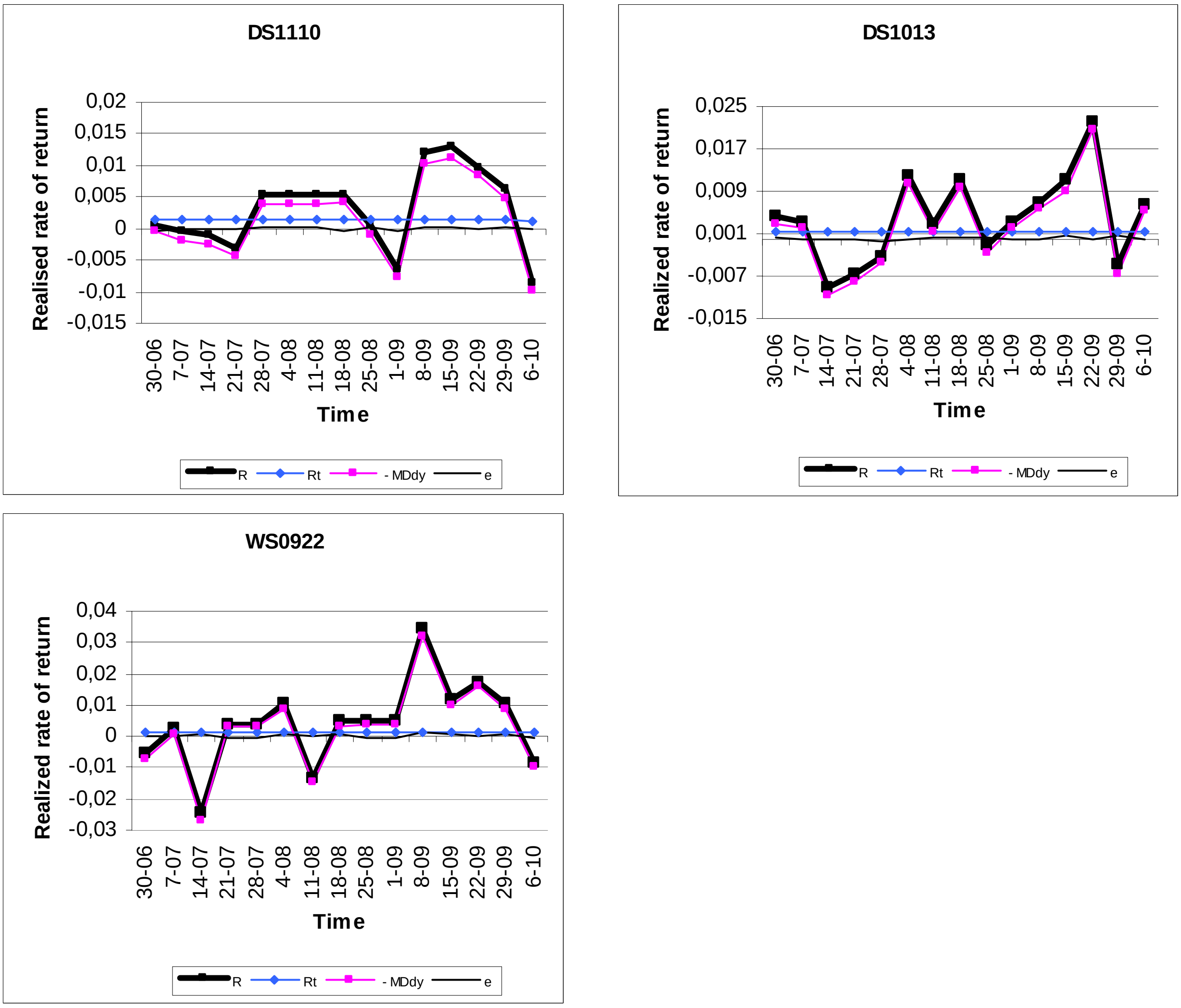

Figure 1. Decomposition of weekly realized rate of return of bonds according to model (10)

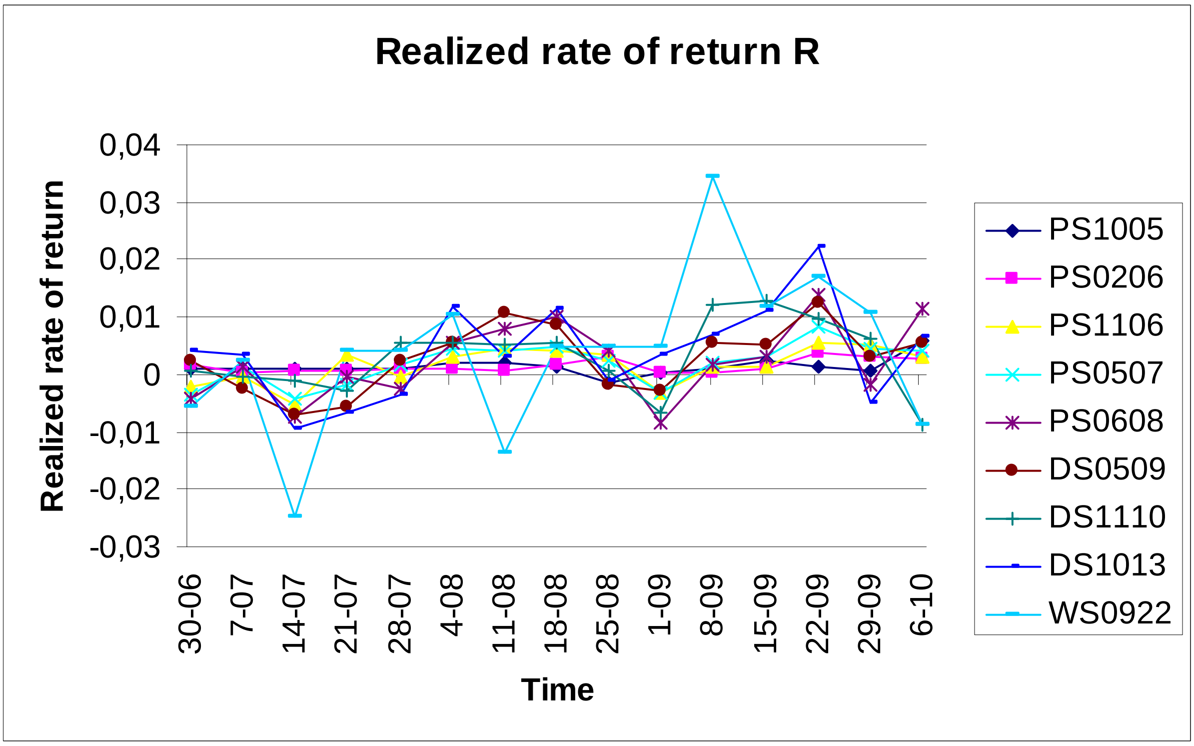

Figure 2. Weekly realized rate of return, R

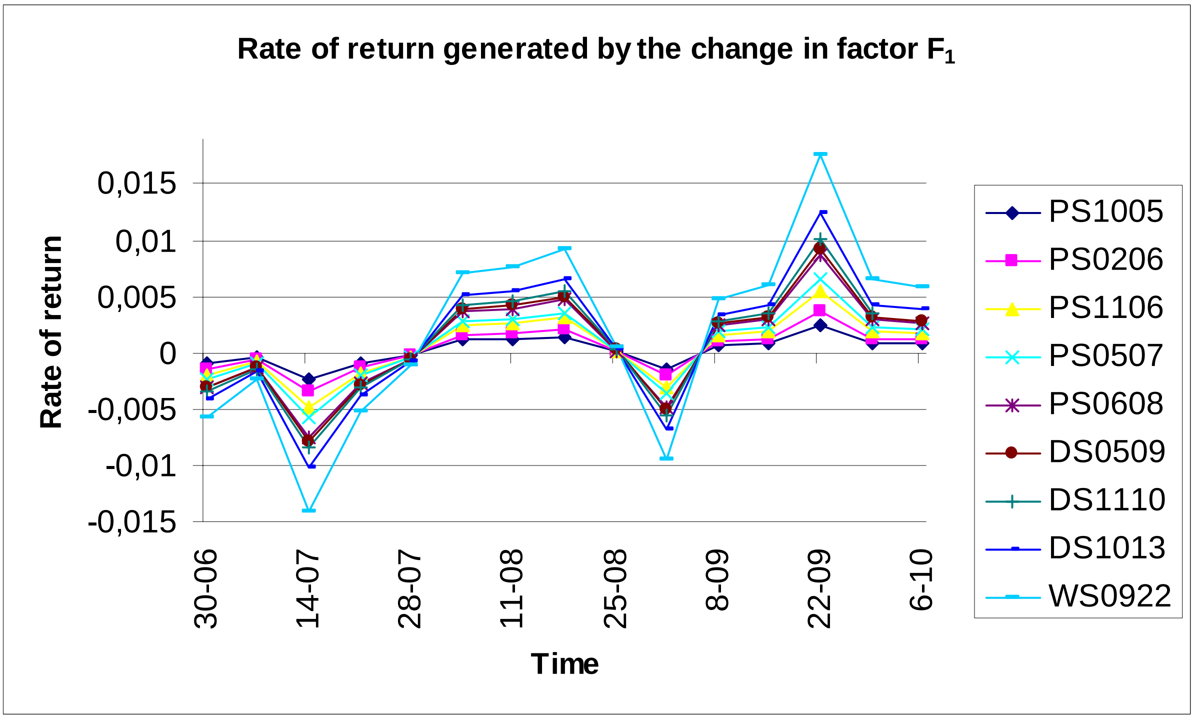

Figure 3. Rate of return generated by the change in the first common factor F_1

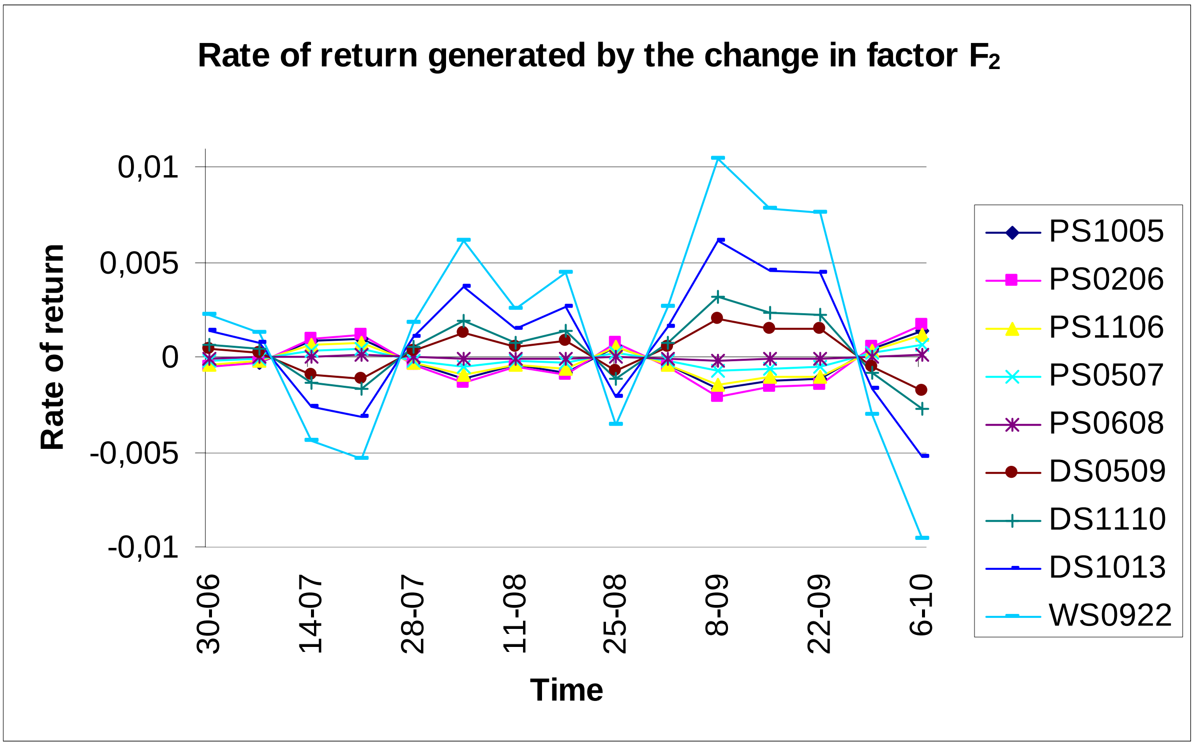

Figure 4. Rate of return generated by the change in the second common factor F_2

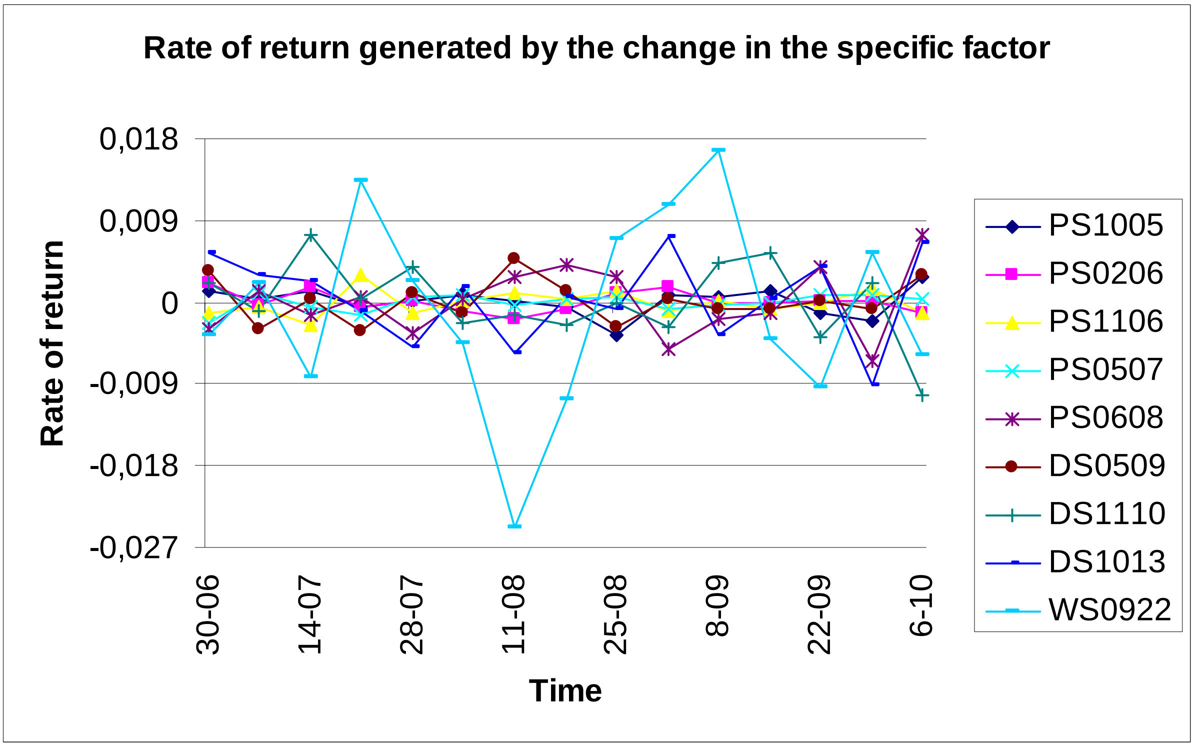

Figure 5. The rate of return generated by the change in the specific factor