EUROPEAN CENTRAL BANK

WORKING PAPER SERIES
NO 641 / JUNE 2006

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In 2006 all ECB publications will feature a motif taken from the €5 banknote.

1 Risk Management Division, European Central Bank, Kaiserstrasse 29, 60311 Frankfurt am Main, Germany; e-mail: carlos.bernadell@ecb.int, joachim.coche@ecb.int and ken.nyholm@ecb.int

Address
Kaiserstrasse 29
60311 Frankfurt am Main, Germany

Postal address
Postfach 16 03 19
60066 Frankfurt am Main, Germany

Telephone
+49 69 1344 0

Internet
http://www.ecb.int

Fax
+49 69 1344 6000

Telex
411 144 ecb d

ISSN 1561-0810 (print)
ISSN 1725-2806 (online)

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Abstract:

This paper develops a new methodology for simulating fixed-income return distributions. It is shown that a traditional factor risk model, when augmented with reference returns, is capable of generating visually consistent return distributions for a broad range of fixed income instruments such as government and non-government instruments in the US dollar and Japanese yen bond markets. The reference returns result from a regime-switching Nelson-Siegel yield curve model following Bernadell, Coche and Nyholm (2005). Empirical results are encouraging: simulated distributions exhibit most characteristics observed in the fixed income markets such as non-normal right-skewed distributions for short maturity instrument while instruments with longer maturity are closer to being normally distributed.

Keywords: Regime switching, scenario analysis, factor risk model

JEL classification: C15, C32, C53, G11, G15

Non-technical summary

This paper presents a new framework for simulating realistic return distributions for fixed income instruments relevant for risk management and asset allocation purposes. A factor risk model using reference returns is developed for government and non-government instruments in the US dollar and Japanese yen bond markets building on Bernadell, Coche and Nyholm (2005). The proposed model explains most of the volatility of the examined instruments' returns and account for skewed as well as fat-tailed return distributions. The developed framework proves relevant especially in the context of return simulation and easily integrates exogenous effects such as, for example, macro economic variables.

The developed factor-risk framework also facilitates absolute as well as relative decomposition of risk into either market risk (volatility, VaR) or risk relative to a benchmark (tracking error, relative VaR). Hence, risk can readily be attributed to systematic factors, diversification effects among factors and instrument-specific components.

Following the basic setup of a factor risk model, returns of fixed income instruments are expressed as a linear function of systematic factors (reference returns, endogenous and exogenous factors) and an idiosyncratic component (the error term). To approximate the time-series evolution of endogenous and exogenous factors a multivariate AR(1) process is assumed. The underlying yield-curve model, which is used to generate returns for the reference instruments, is based on a regime-switching extension of the Nelson-Siegel model that allow for integration of macroeconomic factors (see, Bernadell et al 2005).

The proposed modelling framework renders a linear specification of returns for a given fixed-income investment universe by relying on reference instrument returns in addition to traditional factors. When applied in a simulation context it allows for generation of distributions that very closely matches observed return distributions in terms of means, volatilities, correlations and higher order moments. For example, simulated return distributions for short term instruments in US dollar market show the non-normalities observed in historical data. This particular feature makes the suggested methodology especially useful for fixed-income asset allocation when the used optimisation techniques rely on higher-order moments, such as it is the case for scenario based optimisers and stochastic programming optimisers.

1. Introduction

This paper presents a new methodology for generating return distributions for fixed-income instruments. A practitioners approach is taken, and it is shown how to combine features from a yield curve model with those of a traditional factor risk model in order to simulate distributions that resemble historically observed fixed-income return distributions. In particular, to fill what seems to be a void in the factor-risk modelling literature, the present paper augments a traditional factor models by including reference returns as factors. Reference returns are derived through the "pricing" of notional reference instruments using the Bernadell, Coche and Nyholm (2005) regime-switching expansion of the Nelson and Siegel (1987) yield curve model; however, any model that is capable of simulating yield curves can in principle be used.

The main advantage of the suggested framework is that it is very flexible and gives the analyst the possibility of simulating distributions conditional on a variety of exogenous variables such as e.g. the general state of the macroeconomic environment. In addition, and from a practitioner oriented angle, it facilitates easy integration of new instruments into the investment and/or risk management process and, as such, represents a platform upon which new fixed-income instrument classes can be evaluated e.g. in the context of asset allocation - this without having to carry out time-consuming work on expanding existing yield curve models built to support a given investment universe.

Traditionally, factor risk models have been used in the area of risk management to perform risk decomposition and return attribution of investment portfolios to underlying factors. However, beyond general risk management purposes, factor risk models are also suitable for generating realistic return distributions, something that is particular relevant in the context of asset allocation when the objective function relies on the mean, the variance and higher order moments. A natural alternative to a parametric model, as the one suggested here, is to estimate return-distributions moments directly form historical data on individual securities or security indices. Despite its simplicity and first-sight attractiveness, such an approach has a number of severe drawbacks. First, considering individual bonds, means, variances and covariances calculated from historic return series are likely to be biased since the instruments' characteristics change over time. For example, as a bond ages its duration shortens and the bond price sensitivity to interest rate changes declines. Also credit-rating changes of an issuer can cause future bonds returns to be more or less volatile than those observed in the past. Furthermore, historic prices might either be unreliable or unavailable for illiquid instruments. Secondly, variances and covariances determined on basis of bond indices might be problematic as the indices' characteristics (e.g. duration) change over time and when the index is rebalanced. It might be less problematic to base estimation on constant maturity indices; however at the current juncture, such indices are not available for all asset classes with sufficient data history. Constant maturity indices are also often based on proprietary term structure models with unknown properties (e.g. Bloomberg indices): clearly an undesirable feature when considering that return distributions are meant to constitute inputs to asset allocation decisions.

To address the deficiencies mentioned above that pertain to the usage of historical return distributions, factor risk models and yield curve models represent viable alternatives. A factor risk model decomposes the total return of a financial instrument into effects arising from systematic factors that can be latent or observable, and instrument specific effects. Thus, the objective of a factor risk model is to generate a linear factor representation of the total return of every instrument in the investment universe. There exist three generic types of factor risk models: macroeconomic, fundamental and statistical models. Macroeconomic factor risk models propose that observable macro factors are the key drivers of asset returns. In these models the factor returns are directly observable while the factor loadings are obtained using time series regression. Typically these models are applied to equity portfolios. Fundamental factor models assume that factor loadings are directly observable or defined while the factor returns are latent and need to be estimated using cross-sectional regression. These models are applied to equity and fixed income portfolios alike. Statistical factor models use maximum likelihood and principal component analysis to estimate both factor loadings and returns.[1] Following the factor model setup, the return distribution estimated or simulated for an individual bond is not based on its historical performance but on the historical returns of all bonds with characteristics similar to those currently pertaining to the bond in question. In addition to quantifying return distributions, a factor model allows risk to be decomposed into underlying components. Either the total market risk (Volatility, value-at-risk) or risk relative to a benchmark (tracking error, relative value-at-risk) can be attributed to the systematic factors, diversification effects and instrument specific components. In the context of fixed-income asset allocation, factor risk models allow for estimation and simulation of return distributions of instruments holding the maturities of the instruments constant over time and comparable across different instrument classes.

As an alternative to a factor risk model, return distributions for constant maturity instruments can be generated by extending a yield curve model with bond a pricing functions. For example, a yield curve model augmented with a bond pricing function is employed by Campbell and Viceira (2002) in the context of optimal portfolio choice. It can be argued that return distributions derived contingent on yield curve projections are more realistic compared to modelling returns directly as it is the case when a traditional factor risk model is used. First, return scenarios that imply negative yields or unlikely shapes of the yield curve are ruled out by construction. Secondly, the pricing function translates yield curve distributions into maturity specific return distributions. For example, the return distribution for short-term instruments may be close to log-normal while longer term instruments may imply distributions closer to a normal distribution. Furthermore generating scenarios dependent on macro-economic projections is more straightforward in the context of yield curves models, given the growing literature on affine term structure models [see, among others, Ang and Piazzesi (2003) and Diebold, Rudebusch and Aruoba (2003)].

[1] See, e.g. Connor (1995) for a general introduction to there three types of factor risk models and Johnson and Wichern (1982, chapters 8 and 9) for a technical presentation.

Despite the above mentioned advantages of a yield curve model over the factor-risk model approach, the latter may still prove useful depending on the characteristics of the investment universe at hand. An investment universe comprising bonds with different liquidity, credit risk profiles and other issuer or issue specific characteristics than the instruments used in the estimation of the yield curve model will be difficult to simulate since their specificities are not accounted for in the model setup. To circumvent this deficiency a possibility is to build a more elaborate yield curve model - however, in a dynamic investment environment this may not constitute a practical solution because of considerable development and implementation time. As a viable and extremely flexible alternative, this paper presents an approach for simulating return distributions of fixed income instruments by combing features from a yield curve model with those of a factor risk model.

The rest of this paper is structured as follows: Section 2 introduces a factor risk model and a yield curve model which constitutes the two main building blocks of the modelling framework. The description of data and the estimation technique are discussed in Section 3 followed by the presentation and discussion of the results, which is presented in Section 4. Section 5 concludes the paper. All the figures and tables of the estimates are found in Annex 1 and Annex 2 respectively.

2. The model

This section outlines the proposed analysis framework by presenting the augmented factor risk model, its estimation technique and how it is used to project yields and returns.

2.1 Factor risk model for bond returns

A factor risk model expresses the returns of fixed income instruments as a function of systematic factors and an idiosyncratic component. According to equation [1]**,** the return $r_{i,t}$ of any instrument *i* at time *t* is a function of factor loadings $\mathbf{f}_i$, factor returns $\mathbf{x}_{i,t}$ and an idiosyncratic error term $\varepsilon_{i,t}$.

$$r_{i,t} = \mathbf{f}_i \mathbf{x}_{i,t}^{/} + \varepsilon_{i,t} \qquad [1]$$

In principle, a factor model is a linear regression, but in addition to estimating the parameters of the model a factor risk model also “estimates” what in a linear regression is referred to as regressors (i.e. the variables on the right hand side): it consists of two parts, the factor loadings *f* (which are akin to the parameters in a linear regression) and the factor returns *x* (which are akin to the regressors in a linear regression).

We consider three generic categories of factors: reference returns, endogenous and exogenous factors. Reference returns correspond to the return of a Government bond with the same maturity and coupon payments as the instrument under consideration; endogenous factors are those for which loadings are known but factor returns are estimated; both loadings and factor returns of exogenous factors are determined outside the model and are as such estimated. Examples of endogenous factors are asset class specific factors (excess returns of a given asset class over the reference instruments) and exogenous factors would for example be currency returns.

Accordingly factor loadings can be decomposed into 1 x (1+*J*+*K*) row vectors $\mathbf{f}_i = \left(f_i^r, f_{i,1}^{ex}, \ldots, f_{i,J}^{ex}, f_{i,1}^{en}, \ldots, f_{i,K}^{en}\right)$, $\mathbf{x}_{i,t} = \left(r_{i,t}^r, x_{1,t}^{ex}, \ldots, x_{J,t}^{ex}, x_{1,t}^{en}, \ldots, x_{K,t}^{en}\right)$ whereby J denotes the number of exogenous and K the number of endogenous factors. Reference returns $r_{i,t}^r$ are instrument specific while exogenous $x_{j,t}^{ex}$ and endogenous factors $x_{k,t}^{en}$ are common to all instruments in the universe.

Loadings of the reference factor f_i^r are estimated using time series regression of instrument returns $r_{i,t}$ against the reference returns $r_{i,t}^r$.[2] The endogenous factor returns, $x_{k,t}^{en}$, are estimated cross sectionally through stepwise regression while $f_{i,k}^{en}$, $f_{i,j}^{ex}$ and $x_{j,t}^{ex}$ are determined outside the model.

Turning now to the simulation aspects of the model, endogenous and exogenous factor returns, $x_{k,t}^{en}$ and $x_{j,t}^{ex}$, are projected forward assuming a multivariate AR(1) process and shown in [2].

$$\overline{\mathbf{x}}_{i,t} = \mathbf{D}\,\overline{\mathbf{x}}_{t-1} + \varsigma_t \qquad [2]$$

where $\overline{\mathbf{x}}_t = \left(x_{1,t}^{ex}, \ldots, x_{J,t}^{ex}, x_{1,t}^{en}, \ldots, x_{K,t}^{en}\right)$, D is the matrix of autoregressive parameters where a diagonallity is imposed to ensure a multivariate AR(1) structure. This structure is chosen since it from a practical perspective yields a sufficiently flexible functional form while remaining parsimonious. ς is the error term.

The dynamics of the residual returns from [1] are also assumed to follow an AR(1) process independently from the process in [2].

$$\boldsymbol{\varepsilon}_t = \mathbf{E}\,\boldsymbol{\varepsilon}_{t-1} + \boldsymbol{\xi}_t \qquad [3]$$

with $E_{i,j} = 0$ for $i \neq j$ being a diagonal matrix of AR(1) coefficients.

According to equation [4], the variance of an individual instrument σ_i^2 can be attributed the variance of reference returns $\sigma_{r_i^r}^2$, exogenous and endogenous returns, $\sigma_{r_j^{ex}}^2$ and $\sigma_{r_k^{en}}^2$, covariance effects and the variance of residual returns $\sigma_{\varepsilon_i}^2$.

[2] In a sense, the reference return fills a role similar to that of the "market" factor return in the Capital Asset Pricing Model (CAPM); however, since we include one reference factor for each instrument the equilibrium concept of the CAPM does not carry out to our model. Nonetheless, to gain an intuitive understanding of the model in [1] it might be helpful to consider its similarity to the CAPM.

$$\sigma_i^2 = \underbrace{{f_i^r}^2 \sigma_{r_i^r}^2}_{\text{Reference returns}} + \underbrace{\sum_j^J {f_j^{ex}}^2 \cdot \sigma_{x_f^{ex}}^2}_{\text{Exogenous returns}} + \underbrace{\sum_k^K {f_k^{en}}^2 \cdot \sigma_{x_k^{en}}^2}_{\text{Endogenous returns}} + \underbrace{\sum_l^L \sum_{m \neq l}^L f_l \cdot f_m \cdot C_{l,m}}_{\text{Covariance effects}} + \underbrace{\sigma_{\varepsilon_i}^2}_{\text{Residual risk}} \quad [4]$$

whereby C refers to the covariance matrix of factors with diagonal $\left(\sigma_{r_i^r}^2, \delta_{x_1^{ex}}^2, \ldots, \delta_{x_J^{ex}}^2, \delta_{x_1^{en}}^2, \ldots, \delta_{x_K^{en}}^2\right)$

2.2 Projection of yields and reference returns

In order to obtain the yield projections required to derive reference returns the yield curve model set out in Bernadell et al (2005) is used. This model relies on two building blocks: first, the shape and location of yield curves is approximated by the parametric form suggested by Nelson and Siegel (1987), and second, a regime switching model [following Hamilton (1994) using the implementation of Kim and Nelson(1999)] is extended with time-varying transition probabilities. The time-variation of the transition probabilities depends on exogenous macro-economic variables exogenous to the model.

According to a formulation proposed by Nelson and Siegel (1987), the vector of yields at time t can be expressed as a function of yield curve factors and yield curve factor sensitivities. In equation [5] **Y** is a vector of yield observation at time t, $\boldsymbol{\beta}_t$ is the vector of Nelson-Siegel factors, **H** is the matrix of Nelson-Siegel sensitivities and $\mathbf{e}_t$ is a vector of error-terms.

$$\mathbf{Y}_t = \mathbf{H}\boldsymbol{\beta}_t + \mathbf{e}_t, \quad [5]$$

where the matrix of Nelson-Siegel sensitivities for maturities $\tau = \left(\tau_1, \tau_2, \ldots, \tau_n\right)$ is defined as:[3]

$$\mathbf{H} = \begin{bmatrix} 1 & \frac{1-\exp(-\lambda\tau_1)}{\lambda\tau_1} & \frac{1-\exp(-\lambda\tau_1)}{\lambda\tau_1} - \exp(-\lambda\tau_1) \\ 1 & \frac{1-\exp(-\lambda\tau_2)}{\lambda\tau_2} & \frac{1-\exp(-\lambda\tau_2)}{\lambda\tau_2} - \exp(-\lambda\tau_2) \\ \vdots & \vdots & \vdots \\ 1 & \frac{1-\exp(-\lambda\tau_n)}{\lambda\tau_n} & \frac{1-\exp(-\lambda\tau_n)}{\lambda\tau_n} - \exp(-\lambda\tau_n) \end{bmatrix}.$$

The interpretation of the yield curve sensitivities are as follows: the first factor proxies the yield curve level, i.e. the yield at infinite maturity; the second factor can be interpreted as the negative of the yield curve slope, i.e. the difference between the short and the long ends of the yield curve; the last yield curve

[3] Here we follow the parameterisation used by Diebold and Li (2003).

factor can be interpreted as the curvature. The parameter, λ, determines the time-decay in the maturity spectrum of factor sensitivities 2 and 3 as can be seen from the definition of **H** above.

As our setup closely follows Bernadell et al (2005), the evolution of the Nelson-Siegel factors $\boldsymbol{\beta}_t = \left\{\beta_t^{level}, \beta_t^{slope}, \beta_t^{curvature}\right\}^{/}$ are assumed to follow an AR(1) process with regime-switching means. In equation [6] we assume three regimes (*S*, *N*, *I*) which imply distinct arithmetic means for each Nelson-Siegel factor. $\boldsymbol{\pi}_t = \left\{\pi_t^S, \pi_t^N, \pi_t^I\right\}^{/}$ refers to the regime switching probabilities at time *t*, and a diagonal matrix **F** collects the autoregressive parameters.

$$\boldsymbol{\beta}_t = \mathbf{C}\boldsymbol{\pi}_t + \boldsymbol{\beta}_{t-1}\mathbf{F} + \mathbf{v}_t \qquad [6]$$

where $\mathbf{C} = \begin{bmatrix} c_N^{level} & c_S^{level} & c_I^{level} \\ c_N^{slope} & c_S^{slope} & c_I^{slope} \\ c_N^{curv} & c_S^{curv} & c_I^{curv} \end{bmatrix}$.

The regime-switching probabilities evolve according to equation [7], where $\boldsymbol{\pi}_{t-1}$ is the regime-switching probability on the previous period and $\mathbf{p}^{Z_t}$ is the transition probability matrix which indicates the probability of switching from one state to another, given the current state.

$$\boldsymbol{\pi}_t = \mathbf{p}^{Z_t}\boldsymbol{\pi}_{t-1} \qquad [7]$$

Equation [8] shows how Z_t links the transition probabilities to the projected GDP growth Δgdp_t and the inflation rate Δcpi_t as well as threshold values for these variables (Δgdp^* and Δcpi^*) which are used to identify distinct macroeconomic environments.[4] In effect we hypothesise the existence of three transition probability matrices: $\mathbf{p}^2$ refers to the transition matrix applicable in a recession environment (GDP growth and inflation rate below threshold values), $\mathbf{p}^3$ refers to an inflationary environment (GDP growth and inflation rate above threshold values), and $\mathbf{p}^1$ to a residual environment which either could be "normal" (GDP growth above and inflation rate below threshold values) or a stagflation-type of environment (GDP growth below and inflation rate above threshold values). More precisely, define:

$$Z_t = \begin{cases} 1 & otherwise \\ 2 & if \quad \Delta gdp_t < \Delta gdp^* \text{ and } \Delta cpi_t < \Delta cpi^* \\ 3 & if \quad \Delta gdp_t > \Delta gdp^* \text{ and } \Delta cpi_t > \Delta cpi^* \end{cases} \qquad [8]$$

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[4] It is worth noting that the macroeconomic environments mentioned here are conceptually different from the regimes estimated by the regime switching model. Whereas the macroeconomic environments are identified exogenously on the basis of the observed macroeconomic variables and the chosen cut-off values [see equation 8 above], the regime classifications for the yield curve are determined endogenously by the model and refer in principle only to the shape (slope) of the yield curve, although they given the link between the macro economy and the slope of the yield curve have can be attributed an economical interpretation e.g. following arguments derived from a Taylor rule [see Taylor(1993)].

In the projection of the GDP growth and the inflation rate we rely, as a first step, on a vector auto-regressive process of order 2 as set out in equation [9]. In a second step the means implied by equation [9] are adjusted according to exogenous forecasts, as described below.

$$\mathbf{y}_t^s = \mathbf{A}\mathbf{y}_{t-1}^s + c + \varepsilon_t \qquad [9]$$

where $\mathbf{y}_t^s = \{gdp_t^s, gdp_{t-1}^s, cpi_t^s, cpi_{t-1}^s\}$

$$\mathbf{y}_t = \mathbf{y}_t^s - \overline{\mathbf{y}}_t^s + \mathbf{y}_t^e \qquad [10]$$

where $\overline{\mathbf{y}}_t^s$ refers to the mean of process $\mathbf{y}_t^s$ at time t and $\mathbf{y}_t^e$ to an exogenous forecast based e.g. on surveys (consensus forecasts) or ad-hoc assumptions reflecting different macroeconomic scenarios. In essence, equations [9] and [10] capture the dynamics of the macro series, while allowing the analysis to be based on a broad range of possible scenarios defined exogenously.

Finally projected yield curves are translated into reference returns $r_{i,t}^r$ for the individual instruments. To this end a standard pricing function[5] P is used according to which, the price is a function of the instrument's maturity $\tau_{i,t}$, its coupon, $C_{i,t-1}$ and the prevailing yield in the market $Y_{i,t}$. The term $C_{i,t-1}\Delta_t$ is the deterministic time return for the holding period ($t-1$, t). It is assumed that at time $t-1$ the coupon corresponds to the prevailing yields, thus $C_{i,t-1} = Y_{i,t-1}$. Hence,

$$r_{i,t}^r = \frac{P(\tau_{i,t}, C_{i,t-1}, Y_{i,t})}{100} - 1 + C_{i,t-1}\Delta_t \qquad [11]$$

3. Data and estimation

The model is applied to an investment universe comprising government and non-government instruments in the US dollar and Japanese yen bond markets. Non-government instruments refer to instruments of highest credit quality as issued by the US Agencies and the Bank for International Settlements (BIS). Returns are modelled form the perspective of European investor thus comprise interest rate and exchange rate risk. The investment universe is summarised in Table 1.

In a first step the model is estimated whereby the focus is on the yield curve model equations shown in [5] to [7]. In a second step the factor risk model, shown in equations [1] to [3], is estimated. The yield

[5] The price is determined using the following function whereby DC is the number of days from settlement to next coupon date, DE the number of days in the coupon period in which the settlement date falls, DA the number of days from beginning of the coupon period to the settlement date and N refers to the number of coupon payment between settlement date and redemption date.

$$P(\tau_{i,t}, C_{i,t-1}, Y_{i,t}) = \frac{100}{\left(1+Y_{i,t}\right)^{(N-1+\frac{DC}{DE})}} + \sum_{k=1}^{N} \frac{100\,C_{i,t-1}}{\left(1+Y_{i,t}\right)^{(k-1+\frac{DC}{DE})}} - 100\,C_{i,t-1}\frac{DA}{DE}$$

curve model is estimated for the US dollar market only as we are interested in the model properties in the presence or absence of adequate reference returns for the different markets. As a natural consequence of this, the explanatory power for reference returns for Japanese instruments will be lower. Thirdly, the model is simulated in a Monte Carlo study generating yield and return distributions for the asset classes included in the analysis.

Table 1: Investment universe

Market	Asset Class	Maturity	Modified duration (years)	Source	Bloomberg code	Mnemonic
US	Government	1 - 3 years	1.6	Merrill Lynch	G1O2 Index	US Gov 1-3Y
US	Government	3 - 5 years	3.6	Merrill Lynch	G2O2 Index	US Gov 3-5Y
US	Government	5 - 7 years	5.1	Merrill Lynch	G3O2 Index	US Gov 5-7Y
US	Government	7 - 10 years	7.3	Merrill Lynch	G4O2 Index	US Gov 7-10Y
US	Non-government	1 - 3 years	1.6	Merrill Lynch	G1P0 Index	US Sprd 1-3Y
US	Non-government	3 - 5 years	3.6	Merrill Lynch	G2P0 Index	US Sprd 3-5Y
US	Non-government	5 - 7 years	5.1	Merrill Lynch	G3P0 Index	US Sprd 5-7Y
US	Non-government	7 - 10 years	7.3	Merrill Lynch	G4P0 Index	US Sprd 7-10Y
US	Government	0 - 1 years	0.5	Merrill Lynch	G0O1 Index	US Gov 0-1Y
US	Non-government	1 month	0.08	BBA	US0001M Index	US Deposits
US	Non-government	0 - 1 years	0.5	BIS	FIXBUC3M Index	US Sprd 0-1Y
JP	Government	1 - 3 years	1.8	Merrill Lynch	G1Y0 Index	JP Gov 1-3Y
JP	Government	3 - 5 years	4.7	Merrill Lynch	G2Y0 Index	JP Gov 3-5Y
JP	Government	5 - 7 years	6.5	Merrill Lynch	G3Y0 Index	JP Gov 5-7Y
JP	Government	7 - 10 years	8.9	Merrill Lynch	G4Y0 Index	JP Gov 7-10Y
JP	Government	3 months	0.25	Bloomberg	I01803M	JP Gov 0-1Y
JP	Non-government	1 month	0.08	BBA	JY0001M Index	JP Deposits

"Market" refers to the geographical region where the assets trade. "US" represents the American market and "JP" the Japanese market. "Asset Class" refers to issuer, and two categories are included: "Government" and "Non-government" where the latter represents highly rated government supported agencies. "Maturity" gives the maturity of a given market segment. "Modified duration" gives in years the modified duration of a given market segment; the used data source, Bloombergcode and used mnemonic is shown in the last three columns of the table.

Analogues to Bernadell et al (2005), equations [5] to [7] are estimated using nominal yield curve data calculated by the Treasury Department and reported by the Federal Reserve for constant maturities of 3, 6, 12, 24, 36, 60, 84, 120 months.[6] The data cover the period from December 1953 to December 2004 and is collected at a monthly frequency. A monthly sampling frequency is also applied to GDP and inflation data. Since GDP data is available at a quarterly frequency it is assumed that months within each quarter have equal GDP figures. The macroeconomic data is calculated as year-on-year percentage changes.[7]

For the actual simulation of the yield and return distributions facilitated by the modelling framework set forth, a number of implementation issues need to be addressed. First, to account for any auto-correlation

[6] To ensure a full data history covering 1953 to 2004 we use interpolated data for maturities 6, 24, 84 months, from 1953 to 1958 for the 6 months segment, from 1953 to 1976 for the 24 months segment and from 1953 to 1969 for the 84 months segment.

[7] As outlined in Bernadell et al (2005), this data transformation induces a moving average structure of order eleven in the data, however this does not affect the theoretical specification of the model. In fact, the time series properties of the macro factors enter the likelihood function only through the mean of the series; since an induced moving average process does not effect the unconditional mean of the time series no change is required.

in the error terms of equations [5] and [6], the dynamics of $\mathbf{e}_t$ and $\mathbf{v}_t$ assumed to follow an AR1 processes such that $\mathbf{e}_t = \mathbf{B}\mathbf{e}_{t-1} + \boldsymbol{\varepsilon}_t$ and $\mathbf{v}_t = \mathbf{G}\mathbf{v}_{t-1} + \boldsymbol{\varepsilon}_t$. Secondly, initial estimates for the Nelson-Siegel factors and regime probabilities are obtained by equations [11] and [12]. Here date T refers to the starting point of the simulation (1 April 2005), $\mathbf{C}^j$ indicates to the j-th column of matrix $\mathbf{C}$ form [6] while / denotes element-by-element division.

$$\min_{\pi_T^S, \pi_T^N, \pi_T^I} \sum \left(Y_T - \pi_T^S H\beta_G^1 - \pi_T^N H\beta_G^2 - \pi_T^I H\beta_G^3 \right)^2 \text{ where } \beta_G^j = \mathbf{C}^j / (1 - diag(\mathbf{F})), \qquad [11]$$

$$\min_{\beta_T} \sum \left(Y_T - H\beta_T \right)^2 , \qquad [12]$$

where [11] determines the regime probabilities that best fit the current (starting) yield curve conditional on the shape of the generic yield curves as defined by parameter estimates from [5]; equation [12] is subsequently used to find accompanying betas for the starting yield curve.[8]

Furthermore, to mitigate the potential problem of generating negative yields that stem form projections being based on a Nelson-Siegel-type of model, the resulting yield distributions are transformed from a normal to a log-normal distribution, ensuring however, that means and variances of the distributions are left unchanged.

Data used for the estimation of the factor risk model, equations [1] to [3], are obtained, via Bloomberg, form Merrily Lynch, the BIS and the British Bankers' Association (BBA). Prices, total returns, modified durations, maturities and prevailing yields for the individual instrument classes are available in monthly frequency starting in 1986. In addition return data for US Government bonds available from 1976 onwards is used in the evaluation of results.

The actual model specification discussed in this paper comprises one reference return, two exogenous factors (the returns of the US dollar and Japanese yen against the euro) and five endogenous factors capturing return fluctuations respectively common to all in US dollar bonds, money market and spread instruments (non-government instruments) as well as Japanese yen bonds and money market instruments.

Loadings of endogenous and exogenous factors are determined by definition. As currency returns affect equally all instruments of a given currency, the loading of this exogenous factors is either 0 or 1. Assuming that the endogenous factors affect equally yields of the respective instrument classes, factor loadings are set to instrument classes' modified duration to capture the factors' return effect. Loadings of the reference factor are obtained by time series regression of instrument class return, $r_{i,t}$, against the

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[8] The starting yield curve refers to the yield curve at which simulations are initiated.

reference factor return, $r_{i,t}^{r}$. The resulting factor loading matrix is shown in Table 2. It is seen that estimated parameters f_i^r are close to one for US dollar government bonds indicating a dominance of this factor. Also for spread instruments reference returns are important, though estimates are generally lower than the ones for government bonds. As expected, loadings of the reference factor for Japanese yen Government bonds are comparably small.

Reference returns are determined on basis of simulated yield realisations, see [11]; exogenous factor returns correspond to observed currency returns; while endogenous factor returns are determined by cross sectional stepwise regression.[9] This variant of OLS consists of separately regressing the instrument returns, after subtracting reference and exogenous returns, on each of the loadings of the endogenous factors. The regression order is determined according to Table 2. Thus, first the instrument returns are regressed against the loading of the US dollar bond market. Second, the residuals from this first regression are used as the dependent variable and are regressed against the loading of US dollar money market. The procedure is repeated for all endogenous factors in Table 2. Applying the five endogenous factors, the residual terms $\varepsilon_{i,t}$ remain. Repeating the stepwise regression approach for each historic date determines time series of endogens factors and residuals which are then used, alongside the exogenous returns, to estimate equations [2] and [3] in a final step.

Estimation results are summarised in Tables 3 to 9 of the Annex 2.

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[9] The application of stepwise regression has been controversially discussed in the literature. For example Kennedy (2001) points to the fact that estimations might be biased. Furthermore, the regression order matters. Usually the regression order is determined on basis of economic intuition, thus introducing the variable with the highest expected explanatory power first. Despite theoretical problems, stepwise regression in combination with ad-hoc regression order is frequently used by factor risk models in practise. This technique seems to offer stable and intuitive results for alternative market segments. For example, Lehman Brothers' Multi-factor Risk Model (Bonds), Quantec XC Global Model (Equities) and Northfield Global and Country Models (Equities) are based on stepwise regression in combination with ad-hoc regression order (Ametistova et al. 2001).

Table 2: Factor loading matrix

	US dollar	Japanese yen	Reference return[1)]	US bond market	US money market	US spread instruments	JP bond market	JP money market
US Gov 1-3Y	1	0	0.815 (0.059)	1.636	0	0	0	0
US Gov 3-5Y	1	0	0.854 (0.067)	3.600	0	0	0	0
US Gov 5-7Y	1	0	0.813 (0.065)	5.100	0	0	0	0
US Gov 7-10Y	1	0	0.784 (0.064)	7.300	0	0	0	0
US Sprd 1-3Y	1	0	0.783 (0.052)	1.636	0	1.636	0	0
US Sprd 3-5Y	1	0	0.755 (0.056)	3.600	0	3.600	0	0
US Sprd 5-7Y	1	0	0.725 (0.058)	5.100	0	5.100	0	0
US Sprd 7-10Y	1	0	0.707 (0.057)	7.300	0	7.300	0	0
US Gov 0-1Y	1	0	1.069 (0.022)	0	0.250	0	0	0
US Deposits	1	0	1.175 (0.020)	0	0.083	0.083	0	0
US Sprd 0-1Y	1	0	1.168 (0.021)	0	0.500	0.500	0	0
JP Gov 1-3Y	0	1	0.295 (0.070)	0	0	0	1.800	0
JP Gov 3-5Y	0	1	0.281 (0.076)	0	0	0	4.700	0
JP Gov 5-7Y	0	1	0.275 (0.079)	0	0	0	6.500	0
JP Gov 7-10Y	0	1	0.280 (0.084)	0	0	0	8.900	0
JP Gov 0-1Y	0	1	0.711 (0.096)	0	0	0	0.000	0.500
JP Deposits	0	1	0.772 (0.094)	0	0	0	0	0.083

The table shows the factor loading matrix of exogenous and endogenous factors as well as the loading for the reference returns. This corresponds to each of the columns in f(i) in [1].

[1)] Standard errors for the parameter estimates are given in brackets.

4. Results

To illustrate the proposed technique, this section discusses the properties of yield and return projections in detail. Against the backdrop of two hypothetical macroeconomic scenarios, yield curves and returns are projected over a horizon of 60 months whereby means, variances, correlations and higher moments are analysed using 10,000 simulation runs.

Table 10 shows the two alternative hypothetical scenarios for GDP and inflation used in this section. These scenarios are chosen on an ad-hoc basis to exemplify future normal and pessimistic economic environments. In the normal environment annual GDP growth rates are assumed to gradually decrease from 4.3% to 2.6% while inflation goes up by 1.3% to 2.8% at the end of the horizon. The hypothetical recession scenario assumes that average GDP growth will gradually fall from 3% to -1% and inflation will decrease by 1.5% to 2% at the end of the projection horizon. Furthermore we assume a standard deviation of 1.5% and 1% for GDP growth rate and inflation rates, respectively.

4.1 Projection of yields

Means, volatilities and correlations of the historical and simulated yield distribution are summarised in Table 11. Both for the normal and the recession scenario, mean yields are upward sloping with respect to maturity. Compared to the historic samples, simulated yields are lower by between 0.5 and 1.7 percentage points depending on maturity and scenario. Similar to the historical volatilities, volatilities of simulated returns peak at the one year maturity for both scenarios. While volatilities for the normal scenario are lower than in both sample periods, volatilities for the recession scenario are in between both sample periods.

Serial correlations in levels are somewhat lower in simulation than what is observed empirically. While in the normal scenario and the sample period starting in 1986, serial correlations in levels decrease with maturity, they increase for both the recession scenario and the sample period starting in 1953. With respect to yield changes, the recession scenario shows serial correlations increasing with maturity while they decrease for the 1986 sample. Opposed to these sample scenarios for both the 1953 sample and the normal scenario show no clear trend. Simulated cross correlations for the normal scenario are fairly close to those obtained for the 1986 sample as shown in Table 12.

Furthermore, Table 11 shows higher order moments of the empirical yield distributions. It is observed that yields are negatively skewed using the data sub-sample starting in 1986 and positively skewed using the full data sample from 1953 to 2004. Yields simulated using the described methodology are positively skewed for both of the analysed scenarios, although the skewness is more pronounced in the recession scenario. Also with regard to kurtosis, the two sample periods exhibit different characteristics. While yields are leptokurtic for data from 1953 until today they show a kurtosis below 3 for data starting in 1986. Simulated yields are slightly leptokurtic for the normal scenario and more pronounced for the recession scenario.

In summary, simulated yields for the recession scenario resemble more closely the 1953 sample period while the normal scenario is more akin to the 1986 sample.

4.2 Projection of returns

Similar to the previous discussion of yield distributions, this section analyses means, volatilities, correlations and higher moments of the return distributions using the ad-hoc scenarios outlined above. It is worth remembering that the results referred below depend on the chosen macroeconomic scenarios as well as the shape and location of the starting yield curve, see footnote 8.

According to Table 13, the "normal" scenario shows expected returns decreasing with maturity for the US government bonds. Thus, in this case, the additional risk in terms of standard deviation is not rewarded by higher expected return. For US spread instruments, expected returns are almost flat (i.e. showing no variation across the maturity dimension) while in the Japanese yen market expected returns increase with maturity. This pattern can be attributed to the dominance of reference returns for the US government instruments and the relative low importance of reference returns for US spread instruments and Japanese yen Government bonds. Thus, the latter instruments are influenced to a larger extent by the endogenous factor for which have a positive mean. For the recession scenario, all market segments show expected returns increasing as a function of maturity. Both the "normal" and "recession" scenario imply return expectations below historic average returns since 1976 and 1986.

With regard to volatility, simulated returns do not show consistent deviations from historical values. For US government bonds, volatilities of simulated returns are higher than sample volatilities based on data starting in 1986 but lower than sample covariances based on data starting in 1976. Volatilities of simulated money market instruments are slightly lower compared to historical data starting in 1986. Furthermore, the higher yield volatility observed for the recession scenario does not translate into higher return volatility. Across the individual maturities, return volatilities are hardly affected by the alternative macro-scenarios.

In Table 14 variance decomposition following [4] identifies reference returns as major contributor to the uncertainty of returns for most US dollar instruments. Generally the importance of reference returns decreases with the instruments' maturity and is lower for US spread bonds compared to US government bonds. Furthermore for Japanese bonds, the variance of reference returns explains only a small fraction of the overall return variation.

To give a visual impression of the fit between historic and simulated return distributions for the normal scenario, Figure 1 plots the distributions using data form 1986 and onwards. As mentioned above, the historical sampling period does not yield a consistent picture for skewness and kurtosis. While the historical distribution of US government bonds starting in 1986 is slightly skewed to the left, it is skewed to the right for the full data sample starting in 1976. Generally, skewness decreases with maturity for both samples. Skewness of simulated bond market returns is close to zero. Substantial positive skewness is however observed for simulated US dollar money market instruments while deposits and other money market instruments in the Japanese yen market are closer to a normal distribution. The skewness in the returns of US dollar short term instruments can be attributed to the dominance of reference returns (factor loadings in the range between 1.06 and 1.18) for these instruments. Reference returns for short term instruments are primarily driven by coupon income rather than of price changes. Thus the imposed log-normality of the yields results in returns being skewed to the right. For longer term instruments normally distributed price returns dominate and the impact of reference returns on short term Japanese yen instruments is comparably small.

For US government bonds, kurtosis of the 1986 data sample is close to normal (3.0) while data from 1976 onwards indicates a leptokurtic distribution. Simulated returns are marginally leptokurtic whereas kurtosis for the recession scenarios is slightly higher than the one for the normal scenario. A more pronounced leptokurtosis is observed only for short term US dollar instruments under the recession scenario.

Finally, Table 13 compares projected and sample serial correlation. Historical data shows positive serial correlations of monthly returns for all maturities and both sample periods. Generally serial correlation is higher for short maturities. Both, US dollar and Japanese yen deposits show a correlation of 0.98. Simulated returns are serial correlated and a decreasing function of maturity. However, levels of serial correlations of simulated returns, both for the normal and the recession scenario, are lower than historical observations. Cross correlations of simulated (normal scenario) and historical (data starting in 1986) returns are shown in Table 15. For the US dollar instruments, simulated correlations are close to historical estimates. Simulated returns for the Japanese yen show a correlation with US dollar instruments, which is somewhat higher than historical estimates. This reflects the use of US dollar reference returns also for Japanese instruments.

The above referred conclusions are all based on visual inspection, but find support when formal statistical tests are conducted. Perhaps this is not surprising, since the simulated yields and returns are functions of macro economic scenarios and hence to some extent at the discretion of the authors of the paper. Effectively, the devils advocate (or a mean referee, if such a referee ever existed) could claim that the statistical tests carried out below are useless as ratification of the model. Hence, we do not want to emphasise these results too much, but just mention them here to further document the flexibility in and realism of the generated return distributions. We conduct a Kolmogorov-Smirnov test at the 99% level to analyse if there are any statistical differences between the simulated and observed return distributions. In the tests we use the shorter data sample and the two previously mentioned macro economic scenarios. The test for the first set of macro data confirms that it is difficult to capture precisely the non-normality of the shorter maturity buckets: only maturity buckets beyond 1 year are accepted as being sampled from identical distributions when the simulated and original data are compared. The second set of macro data is more benign towards the shorter maturity buckets. Here all maturity buckets for the US market are accepted as being drawn from identical distributions when comparing simulated and observed data; this conclusion, however, does not apply to the maturity buckets below one year in the Japanese market.

In summary, simulated return distributions exhibit realistic properties as assessed in terms of means, volatilities, correlations and higher moments. In particular distributions of short term instruments in the US dollar market reflect the non normality of returns observed empirically. Therefore return projections based on the augmented factor risk model may be well suited as input for portfolio optimisations. However, variance decomposition shows that for some Japanese yen instrument classes part of the returns is still unexplained.

5. Conclusions

This paper introduced a new approach for simulating return distributions of fixed income instruments by combing a yield curve model and a factor risk model. In essence reference returns are used as an additional explanatory component in the factor risk model. Reference returns are derived by pricing notional instruments on basis of the Bernadell, Coche and Nyholm (2005) yield curve model.

To illustrate the proposed technique return distributions of US dollar and Japanese yen bond market and money market instruments are analysed assuming two alternative hypothetical macroeconomic scenarios. It is shown that projected returns and their distribution capture well the properties of sample returns but at the same time show sensitivity to the macro scenarios.

A main result from the proposed methodology is that simulated distributions of short instruments exhibit the non-normality of return distributions observed empirically. Return projections based on this framework may thus be well suited as input for portfolio optimisation when the objective function depends on higher order moments.

Two possible extensions of the model are apparent. The first one is the integration of yield curve projections for additional markets and market segments. In the context of the investment universe discussed in the paper, i.e. government and non-government instruments in the US dollar and Japanese yen markets, this could for example comprise the integration of a Japanese yield curve model and an explicit modelling of yield spreads in the US dollar market. A second possible extension would integrate credit risk events and optionalities in the pricing function used in the calculation of the reference returns.

References

Ang, A. and M. Piazzesi, 2003, A No-Arbitrage Vector Autoregression of the Term Structure Dynamics with Macroeconomic and Latent Variables, Journal of Monetary Economics, Vol. 50, pp 745-787.

Ametistova, E, Y. M. Sharaiha and S. Emrich, 2001, Risk at the ForeFront – Choosing a Model, Morgan Stanley Quantitative Strategies.

Bernadell, C., J. Coche and K. Nyholm, 2005, Yield curve prediction for the strategic investor, Working Paper, The European Central Bank, No. 472/April.

Campbell, J. Y. and L. M. Viceira, 2002, Strategic asset allocation, portfolio choice for long-term investors, New York, Oxford University Press.

Connor, G., 1995, The Three Types of Factor Models: A Comparison of Their Explanatory Power, *Financial Analyst Journal*, May-June, pp 42-46.

Diebold F. X. and G. D. Rudebusch and S. B. Aruoba, 2005, The Macroeconomy and the Yield Curve: A Nonstructural Analysis, *Journal of Econometrics*, Forthcoming.

Hamilton, J. D., 1994, Time Series Analysis, Princeton University Press

Johnson R. A. and D. W. Wichern, 1982, Applied multivariate statistical analysis, 3ed. Prentice- Hall.

Kennedy, P., 2001, A Guide to Econometrics, MIT Press, Cambridge Massachusetts.

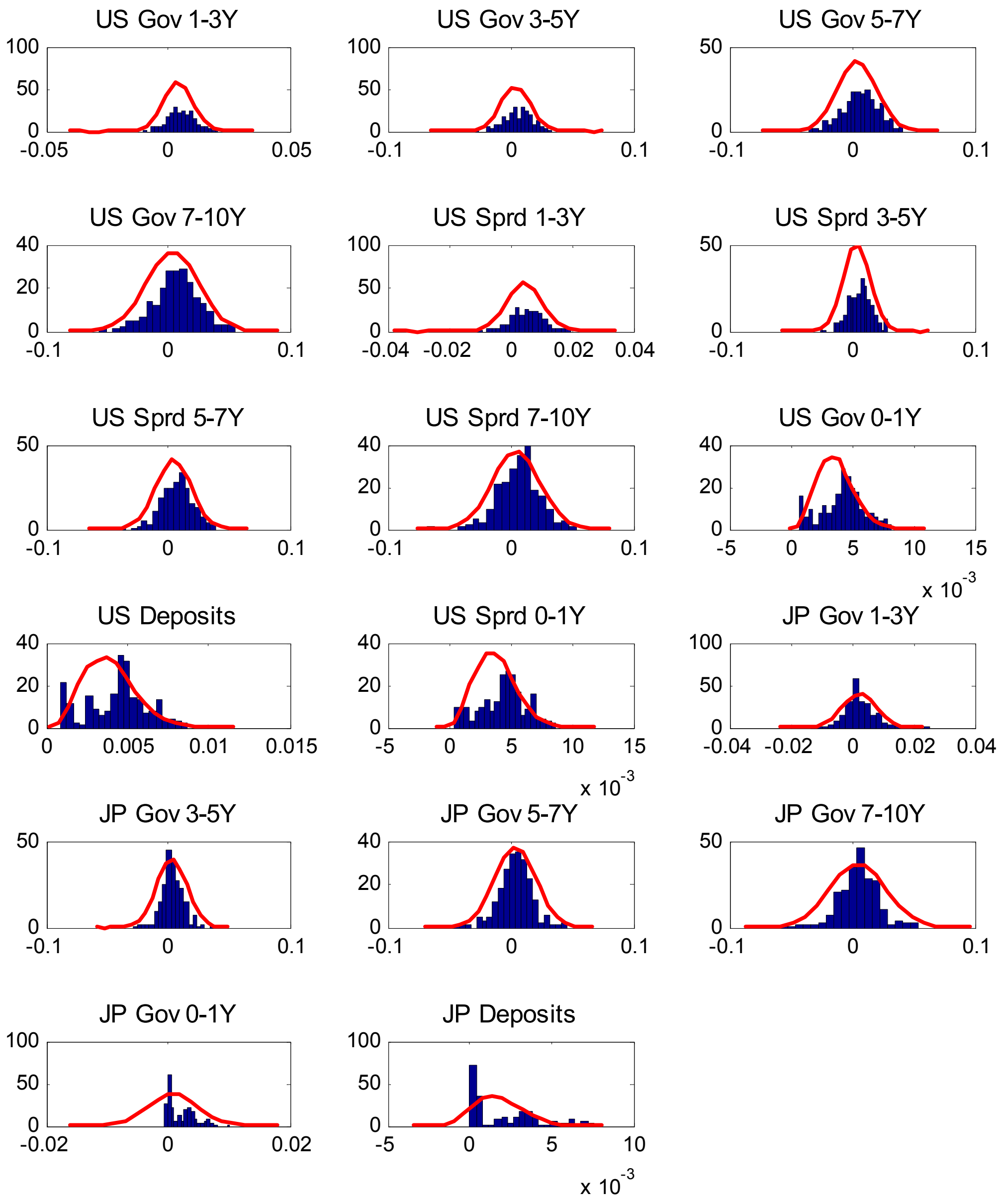
Kim, C. J and C. R. Nelson, 2000, State Space Models with Regime Switching, MIT press.

Nelson, C.R and A.F. Siegel, 1987, Parsimonious Modeling of Yield Curves, *Journal of Business*, 60, 473-489.

Taylor, J. B., 1993, Discretion versus policy rules in practice, Carnegie-Rochester Conference Series on Public Policy, Vol. 39, pp 195-214.

ANNEX 1: FIGURES

Figure 1: Return distribution (local returns)



The figure shows the simulated return distributions in local return for the "Main" economic scenario. Both the simulated frequency plots as well as a fitted distribution (shown by the line plots) are shown. Return distributions are shown in local currency i.e. without converting returns into a common currency e.g. euros.

ANNEX 2: TABLES

Table 3: Estimated transition matrices

Main economic scenario p^1

	Normal	Steep	Inverse
Normal	0.97(*)	0.03(*)	0.05
Steep	0.0000	0.97(*)	0.00
Inverse	0.03(*)	0.0000	0.95(*)

Recession p^2

	Normal	Steep	Inverse
Normal	0.80(*)	0.05	0.19
Steep	0.17(*)	0.95(*)	0.02
Inverse	0.03	0.00	0.79(*)

Inflation p^3

	Normal	Steep	Inverse
Normal	0.96(*)	0.40(*)	0.00
Steep	0.0	0.60(*)	0.00
Inverse	0.04	0.00	1.00

Parameter estimates obtained from Bernadell et al (2005). QML standard errors are used to assess the significance of the parameter estimates: (*) indicates that a parameter is different from zero at a 5% level of significance.

Table 4: Estimated parameters

a_1	0.89(*)
a_3	0.84(*)
σ_e	0.01(*)
σ_v	0.20(*)
λ	0.08(*)
c_1	0.04(*)
c_2^1	-0.34(*)
c_2^2	-0.73(*)
c_2^3	-0.07(*)
c_3	0.00

Parameter estimates obtained from Bernadell et al (2005). QML standard errors are used to assess the significance of the parameter estimates: (*) indicates that a parameter is different from zero at a 5% level of significance. Shown parameter estimates refer to the scaled data; rescaling can be done by multiplying by the average value for the level factor in [6] i.e. $mean\left(\beta_{1,t}\right)$ for $t = \{1,2,...,T\}$.

Table 5: Matrix *A*

	GDP_t	CPI_t
GDP_{t-1}	0.948(**)	-0.004
GDP_{t-2}	-0.003	0.024
CPI_{t-1}	0.027	1.276(**)
CPI_{t-2}	-0.096	-0.311(**)

Parameter estimates for the A matrix in [9]. (**) indicates significance at a 99% level.

Table 6: Matrix *B*

	3M	6M	1Y	2Y	3Y	5Y	7Y	10Y
3M	0.785	0.724	1.004**	0.438	0.542	0.328	0.624	0.824*
6M	-0.022	1.109**	0.416*	0.137	0.216	0.114	0.302	0.414
1Y	-0.206	-0.049	0.479**	-0.349	-0.188	-0.124	-0.220	-0.018
2Y	-0.172	-0.391	-0.696**	0.165	-0.337	-0.257	-0.383	-0.470*
3Y	-0.088	-0.445	-0.658**	-0.293	0.281	-0.265	-0.393	-0.399
5Y	0.268	-0.014	-0.139	0.105	0.125	0.930**	0.027	-0.162
7Y	0.108	-0.049	0.017	0.229	0.062	0.070	0.721**	-0.113
10Y	0.274	0.115	0.536*	0.543*	0.255	0.184	0.270	0.913**

Parameter estimates for the matrix used in the simulation exercise to provide dynamics to the error term of the observation equation [5], i.e. the above matrix is the B matrix in: $\mathbf{e}_t = \mathbf{B}\mathbf{e}_{t-1} + \boldsymbol{\varepsilon}_t$. (**) indicates significance at a 99% level, and (*) indicates significance at a 95% level.

Table 7: Matrix G

	$\beta_{1,t}$	$\beta_{2,t}$	$\beta_{3,t}$
$\beta_{1,t-1}$	0.464**	-0.142	0.578**
$\beta_{2,t-1}$	-0.030	0.897**	0.152**
$\beta_{3,t-1}$	-0.028	0.042	0.400**

Parameter estimates for the matrix used in the simulation exercise to provide dynamics for the error term in the state equation [6], i.e. the above matrix is the G in: $\mathbf{v}_t = \mathbf{G}\mathbf{v}_{t-1} + \boldsymbol{\varepsilon}_t$. (**) indicates significance at a 99% level.

Table 8: Matrix *D*

	$x^{en}_{USBond,t}$	$x^{en}_{USMoney,t}$	$x^{en}_{USSpread,t}$	$x^{en}_{JPBond,t}$	$x^{en}_{JPMoney,t}$	$x^{ex}_{USDollar,t}$	$x^{ex}_{JPYen,t}$
$x^{en}_{USBond,t-1}$	-0.325**	-0.100*	0.024	-0.077	0.212	-1.595	-0.419
$x^{en}_{USMoney,t-1}$	0.081	0.276**	0.010	-0.016	0.081	-0.879	2.775
$x^{en}_{USSpread,t-1}$	0.710	0.420	-0.055	0.434	0.410	3.080	-5.424
$x^{en}_{JPBond,t-1}$	-0.009	0.058	-0.005	0.111	-0.414**	0.837	0.342
$x^{en}_{JPMoney,t-1}$	0.006	-0.005	0.001	0.027	0.950**	-0.212	0.270
$x^{ex}_{USDollar,t-1}$	0.005	-0.007	-0.001	-0.004	-0.010	0.073	-0.024
$x^{ex}_{JPYen,t-1}$	-0.004	0.000	0.000	0.011	0.003	0.115	0.064

Parameter estimates for the matrix used in the simulation exercise to provide time series dynamics for the factors in the factor risk model i.e. the D matrix in [2]. (**) indicates significance at a 99% level.

Table 9: Diagonal of matrix *E*

US Gov 1-3Y	-0.243
US Gov 3-5Y	-0.252
US Gov 5-7Y	-0.160
US Gov 7-10Y	-0.114
US Sprd 1-3Y	-0.190
US Sprd 3-5Y	-0.155
US Sprd 5-7Y	-0.251
US Sprd 7-10Y	-0.207
US Gov 0-1Y	0.167
US Deposits	0.488*
US Sprd 0-1Y	0.127
JP Gov 1-3Y	0.208
JP Gov 3-5Y	-0.018
JP Gov 5-7Y	-0.052
JP Gov 7-10Y	0.031
JP Gov 0-1Y	0.950**

Parameter estimates for the diagonal elements of the E matrix in [3]. These parameter estimates are applied in the simulation exercise to provide time series dynamics for the returns generated from [1]. (**) indicates significance at a 99% level, and (*) indicates significance at a 95% level.

Table 10: Assumed macro scenarios

	Normal		Recession	
	GDP	CPI	GDP	CPI
Year 1	4.19	2.80	4.19	2.80
Year 2	3.10	2.60	2.50	2.50
Year 3	2.85	2.90	2.50	2.50
Year 4	2.87	2.90	1.50	2.00
Year 5	2.80	2.80	-0.50	1.00

Assumption used in the simulation exercise for the values of the macro economic variables.

Table 11: Yield distributions

Mean yields	3M	6M	1Y	2Y	3Y	5Y	7Y	10Y
1986 to 2004	4.75	4.84	5.25	5.66	5.88	6.22	6.47	6.61
1953 to 2004	5.22	5.37	5.80	6.06	6.21	6.41	6.54	6.61
Normal	4.17	4.35	4.63	4.98	5.30	5.47	5.64	5.68
Recession	3.78	3.91	4.14	4.51	4.81	5.13	5.32	5.45
Volatility								
1986 to 2004	1.92	1.92	2.02	1.95	1.85	1.67	1.57	1.51
1953 to 2004	2.83	2.81	3.01	2.95	2.86	2.79	2.76	2.72
Normal	1.55	1.58	1.59	1.57	1.53	1.42	1.35	1.30
Recession	2.12	2.14	2.14	2.11	2.07	1.98	1.93	1.89
Serial correlation level								
1986 to 2004	0.994	0.994	0.992	0.989	0.988	0.985	0.985	0.985
1953 to 2004	0.987	0.988	0.989	0.991	0.991	0.993	0.994	0.995
Normal	0.967	0.966	0.963	0.956	0.955	0.952	0.950	0.950
Recession	0.930	0.932	0.934	0.934	0.937	0.942	0.945	0.950
Serial correlation changes								
1986 to 2004	0.463	0.433	0.415	0.369	0.358	0.334	0.313	0.291
1953 to 2004	0.316	0.323	0.357	0.353	0.342	0.351	0.334	0.312
Normal	0.398	0.416	0.439	0.436	0.428	0.415	0.398	0.397
Recession	0.281	0.308	0.344	0.362	0.379	0.400	0.414	0.442
Skewness								
1986 to 2004	-0.314	-0.392	-0.351	-0.403	-0.361	-0.242	-0.138	-0.007
1953 to 2004	1.033	0.923	0.962	0.888	0.888	0.884	0.844	0.837
Normal	0.548	0.567	0.590	0.648	0.605	0.625	0.609	0.615
Recession	1.217	1.200	1.198	1.182	1.158	1.127	1.106	1.093
Kurtosis								
1986 to 2004	2.634	2.607	2.574	2.630	2.600	2.440	2.298	2.092
1953 to 2004	4.530	4.168	4.174	3.872	3.824	3.685	3.531	3.437
Normal	3.173	3.213	3.272	3.445	3.331	3.390	3.316	3.313
Recession	4.718	4.653	4.723	4.691	4.638	4.573	4.542	4.536

This table provides summary information on the historical yield distribution and the simulated yields. The mean, volatility, first order autocorrelation, skewness and kurtosis is shown for two different time-periods (1986-2004) and (1953-2004) for the historical data, and for the simulated data using the normal and recession macro economic scenarios.

Table 12: Projected and sample yield correlations

	3M	6M	1Y	2Y	3Y	5Y	7Y	10Y
3M	1.000	0.993	0.974	0.941	0.924	0.897	0.877	0.858
	(1.000)	(0.997)	(0.988)	(0.966)	(0.946)	(0.900)	(0.869)	(0.822)
6M	0.993	1.000	0.990	0.967	0.952	0.927	0.907	0.887
	(0.997)	(1.000)	(0.995)	(0.979)	(0.961)	(0.918)	(0.888)	(0.842)
1Y	0.974	0.990	1.000	0.990	0.979	0.957	0.938	0.918
	(0.988)	(0.995)	(1.000)	(0.992)	(0.980)	(0.943)	(0.917)	(0.875)
2Y	0.941	0.967	0.990	1.000	0.997	0.983	0.968	0.950
	(0.966)	(0.979)	(0.992)	(1.000)	(0.997)	(0.975)	(0.955)	(0.920)
3Y	0.924	0.952	0.979	0.997	1.000	0.993	0.982	0.968
	(0.946)	(0.961)	(0.980)	(0.997)	(1.000)	(0.989)	(0.975)	(0.947)
5Y	0.897	0.927	0.957	0.983	0.993	1.000	0.996	0.989
	(0.900)	(0.918)	(0.943)	(0.975)	(0.989)	(1.000)	(0.996)	(0.983)
7Y	0.877	0.907	0.938	0.968	0.982	0.996	1.000	0.996
	(0.869)	(0.888)	(0.917)	(0.955)	(0.975)	(0.996)	(1.000)	(0.994)
10Y	0.858	0.887	0.918	0.950	0.968	0.989	0.996	1.000
	(0.822)	(0.842)	(0.875)	(0.920)	(0.947)	(0.983)	(0.994)	(1.000)

This table documents the serial correlation of projected and observed yields. Correlations from the historical yield sample are shown in brackets.

Table 13: Summary statistics of return distributions (local returns)

	US Gov 1-3Y	US Gov 3-5Y	US Gov 5-7Y	US Gov 7-10Y	US Sprd 1-3Y	US Sprd 3-5Y	US Sprd 5-7Y	US Sprd 7-10Y	US Gov 0-1Y	US Deposits	US Sprd 0-1Y	JP Gov 1-3Y	JP Gov 3-5Y	JP Gov 5-7Y	JP Gov 7-10Y	JP Gov 0-1Y	JP Deposits
Mean returns																	
1986 to 2004	6.55	7.57	8.08	8.32	6.78	7.64	8.38	8.56	5.15	5.41	5.34	3.35	4.53	5.28	5.75	2.51	2.57
1976 to 2004	12.54	13.60	14.15	14.33													
Normal	5.19	4.85	4.62	4.45	5.34	5.30	5.30	5.25	4.47	4.85	4.69	2.61	3.89	4.62	5.42	1.05	2.14
Recession	5.36	5.54	5.58	5.68	5.50	5.91	6.15	6.36	3.49	3.76	3.66	2.75	4.39	5.28	6.32	0.51	1.46
Volatility																	
1986 to 2004	1.88	3.95	5.15	6.51	1.88	3.43	4.63	5.82	0.61	0.65	0.66	1.76	3.28	4.63	6.20	0.77	0.75
1976 to 2004	3.16	5.17	6.49	7.93													
Normal	2.18	4.48	5.77	7.62	2.04	3.88	5.18	6.82	0.50	0.54	0.59	1.68	4.18	5.85	8.09	1.20	0.60
Recession	2.20	4.53	5.84	7.72	2.06	3.93	5.24	6.91	0.46	0.50	0.55	1.68	4.18	5.85	8.10	1.23	0.61
Serial correlation																	
1986 to 2004	0.24	0.14	0.12	0.10	0.27	0.18	0.12	0.11	0.92	0.98	0.97	0.31	0.21	0.21	0.16	0.92	0.98
1976 to 2004	0.20	0.16	0.14	0.12													
Normal	0.18	0.07	0.04	0.00	0.22	0.11	0.06	0.03	0.80	0.92	0.78	0.18	0.13	0.13	0.10	0.71	0.90
Recession	0.18	0.08	0.06	0.02	0.22	0.12	0.08	0.05	0.72	0.88	0.72	0.19	0.14	0.13	0.10	0.72	0.91
Skewness																	
1986 to 2004	0.04	-0.28	-0.22	-0.20	-0.01	-0.31	-0.43	-0.46	-0.21	-0.22	-0.20	0.73	0.19	-0.32	-0.68	0.87	0.80
1976 to 2004	1.59	0.50	0.35	0.36													
Normal	0.07	0.02	0.02	0.01	0.08	0.03	0.02	0.02	0.54	0.57	0.47	0.02	0.00	-0.01	-0.02	0.09	0.35
Recession	0.15	0.04	0.03	0.01	0.16	0.05	0.02	0.01	1.07	1.15	0.87	0.03	0.00	-0.01	-0.01	-0.01	0.17
Kurtosis																	
1986 to 2004	3.02	2.99	2.94	3.33	3.22	3.47	4.04	4.42	2.60	2.50	2.47	5.19	4.98	4.58	5.60	3.02	2.50
1976 to 2004	14.72	7.70	6.92	6.27													
Normal	3.50	3.22	3.17	3.11	3.56	3.23	3.16	3.11	3.31	3.33	3.26	3.03	3.00	2.99	3.00	3.26	3.28
Recession	3.77	3.28	3.19	3.11	3.87	3.31	3.20	3.12	4.79	5.06	4.36	3.04	3.02	3.01	3.00	3.42	3.53

This table provides summary information on the historical and simulated return distributions. The mean, volatility, first order autocorrelation, skewness and kurtosis is shown for two different time-periods (1986-2004) and (1976-2004) for the historical data, and for the simulated data using the normal and recession macro economic scenarios. For the historical period 1976-2004 only US government instruments are available with a maturity less than 10 years, hence summary information are only provided for these instruments during this period.

Table 14: Variance decomposition (as percentages of total risk)

	US Gov 1-3Y	US Gov 3-5Y	US Gov 5-7Y	US Gov 7-10Y	US Sprd 1-3Y	US Sprd 3-5Y	US Sprd 5-7Y	US Sprd 7-10Y	US Gov 0-1Y	US Deposits	US Sprd 0-1Y	JP Gov 1-3Y	JP Gov 3-5Y	JP Gov 5-7Y	JP Gov 7-10Y	JP Gov 0-1Y	JP Deposits
Decomposition of total local returns																	
Reference returns	66.4	72.8	66.1	61.4	61.2	57.1	52.5	50.0	114.2	138.0	136.5	8.7	7.9	7.6	7.8	50.6	59.6
Endogenous returns	27.3	33.8	39.5	45.7	30.4	42.8	49.2	55.8	6.8	0.7	20.6	67.2	83.4	89.7	90.2	96.6	22.6
Residual returns	4.3	2.6	1.4	1.4	5.7	1.9	0.7	0.5	5.4	7.2	2.6	21.1	6.3	1.3	1.9	0.6	42.7
Covariance effects	2.0	-9.3	-7.0	-8.5	2.7	-1.8	-2.4	-6.4	-26.5	-45.9	-59.7	3.0	2.4	1.4	0.1	-47.7	-24.9
Decomposition of endogenous returns																	
US bond market	100.0	100.0	100.0	100.0	97.0	97.0	97.0	97.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
US money market	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	93.5	93.5	0.0	0.0	0.0	0.0	0.0	0.0
US spread instruments	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	0.0	6.5	6.5	0.0	0.0	0.0	0.0	0.0	0.0
JP bond market	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0	100.0	0.0	0.0
JP money market	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Decomposition of total euro returns																	
Currency returns	95.9	85.4	77.2	65.6	96.2	87.8	80.4	69.3	99.8	99.8	99.7	97.2	86.5	78.2	66.0	98.3	99.8
Reference returns	2.8	10.9	15.3	21.5	2.4	7.1	10.5	15.6	0.2	0.3	0.4	0.2	1.1	1.6	2.7	0.9	0.1
Endogenous returns	1.2	5.1	9.2	16.0	1.2	5.4	9.9	17.4	0.0	0.0	0.1	1.9	11.2	19.4	30.8	1.7	0.0
Residual returns	0.2	0.4	0.3	0.5	0.2	0.2	0.1	0.2	0.0	0.0	0.0	0.6	0.8	0.3	0.6	0.0	0.1
Covariance effects	-0.1	-1.8	-2.1	-3.6	-0.1	-0.6	-0.9	-2.5	-0.1	-0.1	-0.2	0.2	0.4	0.4	-0.1	-0.9	0.0

This table shows a variance decomposition of the total risk in accordance with the suggested factor risk model. The decomposition is shown as percentage of total risk and decomposes the total local return risk as well as risk in Euro terms.

Table 15: Projected and sample correlations (local returns)

	US Gov 1-3Y	US Gov 3-5Y	US Gov 5-7Y	US Gov 7-10Y	US Sprd 1-3Y	US Sprd 3-5Y	US Sprd 5-7Y	US Sprd 7-10Y	US Gov 0-1Y	US Deposits	US Sprd 0-1Y	JP Gov 1-3Y	JP Gov 3-5Y	JP Gov 5-7Y	JP Gov 7-10Y	JP Gov 0-1Y	JP Deposits
US Gov 1-3Y	1.000	0.962	0.937	0.900	0.991	0.957	0.928	0.891	0.267	0.252	0.260	0.495	0.409	0.370	0.332	0.070	0.195
	(1.000)	(0.950)	(0.920)	(0.882)	(0.978)	(0.945)	(0.901)	(0.866)	(0.430)	(0.254)	(0.339)	(0.265)	(0.256)	(0.271)	(0.271)	(0.260)	(0.247)
US Gov 3-5Y	0.962	1.000	0.988	0.960	0.950	0.988	0.978	0.949	0.194	0.175	0.188	0.466	0.419	0.383	0.350	0.048	0.137
	(0.950)	(1.000)	(0.990)	(0.970)	(0.928)	(0.973)	(0.966)	(0.951)	(0.242)	(0.091)	(0.161)	(0.240)	(0.255)	(0.284)	(0.290)	(0.155)	(0.134)
US Gov 5-7Y	0.937	0.988	1.000	0.986	0.927	0.980	0.989	0.975	0.173	0.155	0.171	0.448	0.415	0.385	0.355	0.043	0.118
	(0.920)	(0.990)	(1.000)	(0.991)	(0.898)	(0.961)	(0.969)	(0.964)	(0.212)	(0.074)	(0.134)	(0.248)	(0.267)	(0.302)	(0.309)	(0.138)	(0.115)
US Gov 7-10Y	0.900	0.960	0.986	1.000	0.890	0.955	0.978	0.989	0.152	0.135	0.152	0.428	0.400	0.380	0.355	0.038	0.099
	(0.882)	(0.970)	(0.991)	(1.000)	(0.862)	(0.939)	(0.962)	(0.971)	(0.193)	(0.068)	(0.120)	(0.249)	(0.268)	(0.303)	(0.312)	(0.121)	(0.098)
US Sprd 1-3Y	0.991	0.950	0.927	0.890	1.000	0.958	0.925	0.889	0.265	0.253	0.262	0.495	0.407	0.366	0.324	0.071	0.193
	(0.978)	(0.928)	(0.898)	(0.862)	(1.000)	(0.958)	(0.909)	(0.874)	(0.427)	(0.260)	(0.343)	(0.276)	(0.262)	(0.273)	(0.261)	(0.263)	(0.250)
US Sprd 3-5Y	0.957	0.988	0.980	0.955	0.958	1.000	0.984	0.958	0.190	0.172	0.188	0.467	0.415	0.379	0.342	0.049	0.131
	(0.945)	(0.973)	(0.961)	(0.939)	(0.958)	(1.000)	(0.980)	(0.960)	(0.271)	(0.119)	(0.191)	(0.247)	(0.249)	(0.276)	(0.272)	(0.170)	(0.148)
US Sprd 5-7Y	0.928	0.978	0.989	0.978	0.925	0.984	1.000	0.983	0.168	0.152	0.171	0.444	0.407	0.378	0.346	0.043	0.117
	(0.901)	(0.966)	(0.969)	(0.962)	(0.909)	(0.980)	(1.000)	(0.986)	(0.209)	(0.078)	(0.139)	(0.243)	(0.252)	(0.286)	(0.288)	(0.142)	(0.122)
US Sprd 7-10Y	0.891	0.949	0.975	0.989	0.889	0.958	0.983	1.000	0.145	0.133	0.156	0.424	0.395	0.372	0.345	0.039	0.100
	(0.866)	(0.951)	(0.964)	(0.971)	(0.874)	(0.960)	(0.986)	(1.000)	(0.182)	(0.067)	(0.121)	(0.250)	(0.264)	(0.294)	(0.294)	(0.121)	(0.102)
US Gov 0-1Y	0.267	0.194	0.173	0.152	0.265	0.190	0.168	0.145	1.000	0.948	0.949	0.111	0.051	0.041	0.033	0.240	0.724
	(0.430)	(0.242)	(0.212)	(0.193)	(0.427)	(0.271)	(0.209)	(0.182)	(1.000)	(0.946)	(0.958)	(0.183)	(0.087)	(0.062)	(0.078)	(0.513)	(0.549)
US Deposits	0.252	0.175	0.155	0.135	0.253	0.172	0.152	0.133	0.948	1.000	0.944	0.126	0.067	0.054	0.040	0.253	0.707
	(0.254)	(0.091)	(0.074)	(0.068)	(0.260)	(0.119)	(0.078)	(0.067)	(0.946)	(1.000)	(0.977)	(0.125)	(0.037)	(0.008)	(0.018)	(0.477)	(0.512)
US Sprd 0-1Y	0.260	0.188	0.171	0.152	0.262	0.188	0.171	0.156	0.949	0.944	1.000	0.088	0.034	0.020	0.008	0.230	0.671
	(0.339)	(0.161)	(0.134)	(0.120)	(0.343)	(0.191)	(0.139)	(0.121)	(0.958)	(0.977)	(1.000)	(0.128)	(0.044)	(0.013)	(0.024)	(0.475)	(0.509)
JP Gov 1-3Y	0.495	0.466	0.448	0.428	0.495	0.467	0.444	0.424	0.111	0.126	0.088	1.000	0.940	0.877	0.819	0.204	0.255
	(0.265)	(0.240)	(0.248)	(0.249)	(0.276)	(0.247)	(0.243)	(0.250)	(0.183)	(0.125)	(0.128)	(1.000)	(0.942)	(0.862)	(0.774)	(0.557)	(0.430)
JP Gov 3-5Y	0.409	0.419	0.415	0.400	0.407	0.415	0.407	0.395	0.051	0.067	0.034	0.940	1.000	0.973	0.923	0.226	0.156
	(0.256)	(0.255)	(0.267)	(0.268)	(0.262)	(0.249)	(0.252)	(0.264)	(0.087)	(0.037)	(0.044)	(0.942)	(1.000)	(0.955)	(0.866)	(0.362)	(0.235)
JP Gov 5-7Y	0.370	0.383	0.385	0.380	0.366	0.379	0.378	0.372	0.041	0.054	0.020	0.877	0.973	1.000	0.970	0.235	0.132
	(0.271)	(0.284)	(0.302)	(0.303)	(0.273)	(0.276)	(0.286)	(0.294)	(0.062)	(0.008)	(0.013)	(0.862)	(0.955)	(1.000)	(0.951)	(0.277)	(0.157)
JP Gov 7-10Y	0.332	0.350	0.355	0.355	0.324	0.342	0.346	0.345	0.033	0.040	0.008	0.819	0.923	0.970	1.000	0.236	0.115
	(0.271)	(0.290)	(0.309)	(0.312)	(0.261)	(0.272)	(0.288)	(0.294)	(0.078)	(0.018)	(0.024)	(0.774)	(0.866)	(0.951)	(1.000)	(0.228)	(0.119)
JP Gov 0-1Y	0.070	0.048	0.043	0.038	0.071	0.049	0.043	0.039	0.240	0.253	0.230	0.204	0.226	0.235	0.236	1.000	0.525
	(0.260)	(0.155)	(0.138)	(0.121)	(0.263)	(0.170)	(0.142)	(0.121)	(0.513)	(0.477)	(0.475)	(0.557)	(0.362)	(0.277)	(0.228)	(1.000)	(0.965)
JP Deposits	0.195	0.137	0.118	0.099	0.193	0.131	0.117	0.100	0.724	0.707	0.671	0.255	0.156	0.132	0.115	0.525	1.000
	(0.247)	(0.134)	(0.115)	(0.098)	(0.250)	(0.148)	(0.122)	(0.102)	(0.549)	(0.512)	(0.509)	(0.430)	(0.235)	(0.157)	(0.119)	(0.965)	(1.000)

This table documents the serial correlation of local returns for the simulated as well as the historical sample. The correlations for the sample data are shown in brackets.

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ISSN 1561081-0