DEUTSCHE BUNDESBANK
EUROSYSTEM

Discussion Paper

Deutsche Bundesbank
No 35/2014

Financial conditions, macroeconomic factors and (un)expected bond excess returns

Christoph Fricke
(Deutsche Bundesbank)

Lukas Menkhoff
(Kiel Institute for the World Economy and University of Kiel)

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

Internet http://www.bundesbank.de

ISBN 978–3–95729–088–5 (Printversion)
ISBN 978–3–95729–089–2 (Internetversion)

Non-technical summary

Research Question

The term structure of interest rates mostly shows an upward sloping shape. This means that long-term bonds deliver higher interest rates than short-term bonds. Consequently, holding long-term bonds usually yields higher returns over the short term than holding short-term instruments directly. These higher returns from holding long-term bonds compensate for risk, thus they reflect "bond risk premia". Large parts of bond risk premia are still not well understood despite some degree of predictability.

Contribution

We propose to integrate financial condition variables into the set of independent variables which is usually made up by macro factors. Financial condition variables, e.g. financial stress indices, capture information beyond macro factors, in particular information of shorter-term nature, and may be also forward looking. These variables should differ from macro variables of financial origin, such as money or interest rates, which are already included in the macro factors. Instead, we aim to cover information about behavior of professional investors and its outcomes. Our coverage of such financial condition variables is necessarily explorative, i.e. we cover a broader set of interesting variables in order to learn about their relevance. These variables about financial conditions incorporate financial paper issuance, position-taking by primary dealers, measures of financial stress, order flow as an indicator of risk shifting and liquidity in the bond market.
This motivates to split bond excess returns into two components, i.e. the predictable part that is to be expected, and the remaining part that results from unexpected developments. Whereas predictability has been examined comprehensively, the analysis of unexpected bond risk premia is rather new to the best of our knowledge. In order to address this issue we rely on a recently proposed term structure model which disaggregates the bond excess returns into two components: the first component can be understood as the regular term premium or the excess return that is rationally to be expected. Thus the second component captures innovations to the term premium, i.e. all those influences on bond risk premia that cannot be expected according to the model.

Results

We consistently find across bonds with different maturities that the expected part of the risk premium is explained by macro factors, the most important being those from the real side of the economy, i.e. cyclical output and employment. This result fits nicely into the literature. We go beyond this literature by examining the unexpected component of the risk premium - here the indicators of financial conditions seem to be more important. In detail, we obtain significant coefficients for one variable on position-taking, financial stress and order flow each. Overall and simply put, expected bond risk premia seem to be explained mainly by dynamics of the real economy whereas financial conditions dynamics explain innovations in these premia. Explanatory power increases tentatively if we leave out the recent financial crisis.

Nichttechnische Zusammenfassung

Fragestellung

Die Zinsstrukturkurve weist zumeist eine positive Steigung auf. Dies bedeutet, dass langfristige Anleihen höher verzinst werden als kurzfristige Anleihen. Somit liefert das kurzfristige Halten einer langfristigen Anleihe üblicherweise eine höhere Rendite als das direkte Halten einer kurzfristigen Anleihe. Diese Überschussrendite des Haltens einer langfristigen Anleihe entlohnt Risiken, somit reflektiert sie eine „Risikoprämie“. Allerdings sind große Teile der Risikoprämie von Anleihen noch nicht ausreichend verstanden; gleichwohl kann diese bereits zu einem gewissen Grad prognostiziert werden.

Beitrag

Zum besseren Verständnis der Wirkung von makroökonomischen Variablen und Finanzvariablen auf die Anleihe-Überschussrenditen werden diese mittels eines Zinsstrukturmodells in zwei Kompenten zerlegt: Die erste Komponente kann als die reguläre Risikoprämie oder diejenige Überschussrendite, welche rational zu erwarten ist, verstanden werden. Die zweite Komponente erfasst Innovationen der Risikoprämie, das heißt Einflüsse auf Anleihe-Überschussrenditen, die innerhalb des Modells nicht erwartet werden können.
Zur Erklärung von Anleihe-Überschussrenditen werden neben makroökonomischen Variablen auch Finanzvariablen betrachtet. Finanzvariablen erfassen Informationen, die über makroökonomische Variablen hinausgehen, insbesondere Informationen von kurzfristigerer Natur, und könnten gegebenenfalls auch Auskunft über zukünftige Entwicklungen geben. Diese Variablen sollten sich von makroökonomischen Variablen wie Geldmengen oder Zinssätzen unterscheiden, die bereits durch makroökonomische Faktoren einbezogen sind. Die Abdeckung solcher Finanzvariablen ist zwangsläufig explorativ, weshalb wir eine breite Auswahl an potentiell relevanten Variablen berücksichtigen. Diese Finanzvariablen berücksichtigen die Emission von Geldmarktpapieren, die Positionen von Primärhändlern, Messgrößen von Finanzstress, die Differenz von Kauf- und Verkaufsaufträgen am Anleihemarkt als Indikator für die Verschiebung der Risikoneigung von Investoren und die Liquidität am Anleihemarkt.

Ergebnisse

Wir finden über unterschiedliche Laufzeiten hinweg, dass der erwartete Teil der Risikoprämie durch makroökonomische Faktoren erklärt wird, insbesondere diejenigen mit realwirtschaftlicher Bedeutung, wie Produktion und Erwerbstätigkeit. Dieses Ergebnis bettet sich in die bestehende Literatur ein. Wir erweitern diese Literatur durch die Untersuchung der unerwarteten Komponente der Risikoprämie, bei der die Finanzindikatoren wichtiger scheinen. Genauer gesagt finden wir signifikante Koeffizienten für die Positionsvariablen der Primärhändler, den Finanzstress und die Differenz von Kauf- und Verkaufsaufträgen am Anleihemarkt. Insgesamt scheinen die erwarteten Risikoprämien im Wesentlichen durch realwirtschaftliche Variablen erklärt zu werden, wohingegen die Dynamik der Finanzvariablen Innovationen der Überschussrendite erklärt. Der Erklärungsgehalt steigt bei der Nichtberücksichtigung der Finanzkrise leicht an.

BUNDESBANK DISCUSSION PAPER NO 35/2014

Financial conditions, macroeconomic factors and (un)expected bond excess returns*

Christoph Fricke†
Deutsche Bundesbank

Lukas Menkhoff‡
Kiel Institute for the World Economy
University of Kiel

Abstract

Bond excess returns can be predicted by macro factors, however, large parts remain still unexplained. We apply a novel term structure model to decompose bond excess returns into expected excess returns (risk premia) and the unexpected part. In order to explore these risk premia and innovations, we complement macro variables by financial condition variables as possible determinants of bond excess returns. We find that the expected part of bond excess returns is driven by macro factors, whereas innovations seem to be mainly influenced by financial conditions, before and after the financial crisis. Thus, financial conditions, such as financial stress, deserve attention when analyzing bond excess returns.

Keywords: Financial conditions, bond excess returns, term premia

JEL classification: E43, G12.

*We would like to thank participants of the Annual Meetings of the German Economic Association in Frankfurt and the Swiss Society of Economics and Statistics in Lucerne, the Cass Business School EMG-ESRC Workshop on the Microstructure of Financial Markets, the Royal Economic Society Conference in London, the Warwick Business School Workshop "Recent Advances in Finance" and the Deutsche Bundesbank Research Seminar. The paper especially benefited from valuable comments by Tobias Adrian, Alessandro Beber, Pasquale Della Corte, Christian Freund, Arne Halberstadt, Philipp Kolberg, Christoph Memmel, Emanuel Moench, Ingmar Nolte, Mark Salmon, Elvira Sojli, and Wing Wah Tham. We gratefully acknowledge data provided by Fabian Baetje and financial support by the German Research Foundation (Deutsche Forschungsgemeinschaft DFG). The usual disclaimer applies. Discussion Papers represent the authors' personal opinions and do not necessarily reflect the views of the Deutsche Bundesbank or its staff.

†Christoph Fricke, Deutsche Bundesbank, Financial Stability Department, Wilhelm-Epstein-Strasse 14, 60431 Frankfurt am Main, Germany, tel: +49 (69) 9566-2359, fax: +49 (69) 9566-2551, mailto: christoph.fricke@bundesbank.de

‡Lukas Menkhoff, Kiel Institute for the World Economy and University of Kiel, 24100 Kiel, Germany, tel: +49 (431) 8814 216, mailto: lukas.menkhoff@ifw-kiel.de

1 Introduction

The term structure of interest rates mostly shows the "normal" shape. This means that long-term bonds deliver higher interest rates than short-term bonds. Consequently, holding long-term bonds usually yields higher returns over the short-term than holding short-term instruments directly. These excess returns from holding long-term bonds compensate for risk. Thus they reflect "bond risk premia" which are related to the expected excess return (see Almeida, Graveline, and Joslin, 2011; Ludvigson and Ng, 2009).

The explanation of bond risk premia has made great progress during the last years. A common approach for detecting risk premia determinants is the identification of variables which are related to expected excess returns. Proofing a linkage between expected excess returns and any variable is mainly indirect by identifying variables with predictive power for bond excess returns. Despite the complex set of determinants for bond excess returns, these returns can be predicted to quite some extent. Forecasting ability is derived, in particular, from combinations of forward rates and options (Cochrane and Piazzesi, 2005; Almeida and Vincente, 2009; Kessler and Scherer, 2009; Sekkel, 2011) or from information contained in macroeconomic factors (Ludvigson and Ng, 2009). Additional, Wright and Zhou (2009) show that recessions and financial crises influence the forecasting ability of bond excess returns. However, predictability is far from perfect, which implies that large parts of bond risk premia are still not well understood. This motivates to split bond excess returns into two components, i.e. the predictable part that is to be expected, and the remaining part that results from unexpected developments.

Whereas predictability has been examined comprehensively, the analysis of the unexpected component of bond excess returns is rather new to the best of our knowledge. In order to address this issue we rely on the recently proposed term structure model of Adrian, Crump, and Moench (2013). This model has the advantage, from our perspective, that it disaggregates the bond excess returns into two components: the first component is the expected excess return which can be understood as the regular term premium. Thus the second component captures innovations according to the model. Whatever we may learn about these innovations provides a hint how to improve the model. Thus, what may influence these unexpected returns?

Obviously, macro factors do not seem to be the first choice in this respect, as their explanatory power is largely focused on the expected excess returns. In addition to this argument, the development of many macro variables is to some extent sluggish over time. Therefore, we propose to integrate financial condition variables into the set of independent variables. Financial condition variables, e.g. financial stress indices, capture information beyond macro factors, in particular information of a shorter-term nature, and may also be forward-looking (Cardarelli, Elekdag, and Lall, 2011). These variables should differ from macro variables of financial origin, such as money and interest rates, and instead cover information about behavior of professionals and its outcomes. Our coverage of such financial condition variables is necessarily explorative, i.e. we cover a broader set of interesting variables in order to learn about their relevance. These variables about financial conditions incorporate position-taking by market professionals, measures of financial stress, order flow as an indicator of risk shifting and liquidity in the bond market. The exact definition and earlier use of these variables is described below.

We consistently find across bonds with different maturities that the expected part of bond excess returns is explained by macro factors, the most important being those from the real side of the economy, i.e. cyclical output and employment. This result fits nicely into the literature (see Cooper and Priestley, 2009; Joslin, Priebsch, and Singleton, 2014; Duffee, 2011). We go beyond this literature by examining the unexpected component of the bond excess returns - here, the indicators of financial conditions seem to be more important. In detail, we obtain significant coefficients for one variable on position-taking, financial stress and order flow, respectively. Overall and simply put, expected bond excess returns seem to be explained mainly by dynamics of the real economy, whereas financial conditions dynamics explain innovations in these excess returns.

Our study proceeds in the following way. First, we apply the Adrian et al. (2013) model to the standard set of U.S. government zero coupon bonds provided by the Federal Reserve (Gurkaynak, Sack, and Wright, 2007). We examine the period October 1998 until December 2012. Although the bond data and macro factors would be available for a longer time period, other explanatory variables do not start until the 1990s, such as primary dealers' position data which have been available since 1994 and, in particular, the order flow time series starting at the end of 1998. Despite possible disturbance from the recent financial crisis, our results largely mirror the results of Adrian et al. (2013), indicating the usefulness of the approach and data.

As the second step we go beyond earlier work by explaining the two main components of the Adrian et al. (2013) model on bond excess returns. These components are expected excess returns and innovations to excess returns, i.e. unexpected excess returns. Potentially explanatory variables are derived from the literature. In accordance with earlier studies, we start with a set of macroeconomic factors. However, in order to be able to interpret these factors, we allocate the underlying macro variables ex ante to five categories. The categories are derived from Ludvigson and Ng (2009) and represent (i) output, (ii) employment, (iii) orders, (iv) money and (v) prices. This ex ante allocation of macro variables allows us to gain economic interpretation at the cost of statistical power. By contrast, most studies generate factors by a statistical process which increases statistical power at the cost of economic interpretation.

As a second group of explanatory variables, we consider seven variables indicating financial conditions of various kinds. The intuition here is that not just macroeconomic factors but also higher frequency behavior and decisions of financial professionals may have an influence on bond risk premia. We hypothesize that bond excess returns increase with less position-taking by market professionals, less overall financial stability, stronger order flow into bonds and less liquidity (Adrian, Covitz, and Liang, 2013). Three of these variables represent position-taking by financial professionals by considering issuance of financial paper and proxies for broker-dealer leverage. Two other variables represent financial stress: the Cleveland financial stress index and the National Financial Condition Index. Moreover, we consider order flow of the five-year U.S. bond future contract as a proxy for the flight-to-quality phenomenon, the investors' demand shift between risky and less risky assets (Baur and Lucey, 2009). Finally, we control for a standard measure of illiquidity in the bond market (Amihud, 2002).

Our approach is different from most of the literature. This difference results from a new focus. Whereas recent research on bond risk premia has focused on the prediction of these excess returns, and thus covers expected excess returns, we are also interested in the excess return innovations. By construction, innovations will not be well explained by the same determinants as the expected part of excess returns. Moreover, innovations reflect changes which are difficult to capture by sluggish macro variables; this motivates to expand the set of potentially interesting influences to variables informing about financial behavior of professionals. As this is new in this context, we propose a set of seven financial condition variables. We find that some of these variables are indeed related to unexpected excess returns, so that we contribute overall to a more comprehensive understanding of bond risk premia than before.

This paper is organized in five more sections. Section 2 explains the Adrian et al. (2013) term structure model and shows results of our application. Section 3 introduces in more detail the data used. Results are shown and discussed in Section 4, robustness issues are presented in Section 5. Section 6 concludes.

2 Term structure modeling and estimation

This section introduces briefly the Adrian et al. (2013) term structure model.[1] The model offers an intuitive decomposition of one-month excess returns into an expectation term and an (unexpected) innovation term. The log excess return on a bond with maturity n, $rx_{t+1}^{(n)}$, is the bond holding return minus the one-period interest rate, $r_t^{(1)}$:

$$rx_{t+1}^{(n)} = lnP_{t+1}^{(n-1)} - lnP_t^{(n)} - r_t^{(1)}, \tag{1}$$

with $lnP_{t+1}^{(n-1)}$ as the log price of a zero coupon bond at time t and a maturity of $n-1$. Expected excess returns are based on the contemporaneous information set, which is represented by a set of so-called pricing factors. These factors are commonly derived from the term structure of interest rates (see e.g. Cochrane and Piazzesi, 2005; Joslin et al., 2014). Unexpected excess returns, namely return innovations, are driven by the innovations of the pricing factors.

The model is built in a three-step procedure. In the first step, we derive the pricing factors' innovations from the error terms of the following VAR(I)-representation of the pricing factors:

$$X_{t+1} = \mu + \Phi X_t + \nu_{t+1} \ , \tag{2}$$

with X_t representing the pricing factors which are extracted by a principal component analysis from the Gurkaynak et al. (2007) zero coupon yields with maturities of n={3,6, . . . ,18,24,. . . ,120} months. By demeaning the pricing factors, we set the intercept term μ to zero. ν_{t+1} captures the model's error terms, which can be interpreted as the pricing factors' innovations at time $t+1$. The second step relates pricing factors and their innovations to excess returns:

$$rx_{t+1}^{(n-1)} = \underbrace{\beta^{(n-1)\prime}(\lambda_0 + \lambda_1 X_t)}_{\text{Expected return}} - \underbrace{\frac{1}{2}(\beta^{(n-1)\prime}\Sigma\beta^{(n-1)} + \sigma^2)}_{\text{Convexity adjustment}} + \underbrace{\beta^{(n-1)\prime}\nu_{t+1}}_{\text{Return innovations}} + \underbrace{e_{t+1}^{(n-1)}}_{\text{Return pricing error}} . \tag{3}$$

Σ represents the variance-covariance matrix of the pricing factors' innovations ν which are derived from equation (2). σ is defined as $\sigma^2 = trace(EE')/NT$. E is a matrix of residuals

[1] We provide a comprehensive description of the model in the Appendix.

which are derived from regressing excess returns on a constant, lagged pricing factors and their contemporaneous innovations. We compute the factor loadings β and price of risk parameters λ_0 and λ_1 at equation (3) via ordinary least squares and cross-sectional regressions (see Adrian et al., 2013). In the third step, we derive market prices of risk from a three-step OLS–estimator via which excess returns are decomposed into an expectation and an innovation term. Following Adrian et al. (2013) we use a model specification with five spanned term factors (instead of often used 3 or 4 factors). This model selection is based on three objective measures which all underline a better performance of the five factor model. Briefly, we discuss the five factor case for pricing excess returns.[2]

First, we present model-implied and regression-based betas of the five factor model at Figure 1. The estimated betas show smaller deviations from their implied values. *Second*, we follow Almeida et al. (2011) and estimate a modified R^2 statistic for expected excess returns:

$$R_n^2 = 1 - \frac{mean[(rx_{t+1}^{(n)} - \mathbb{E}_t[rx_{t+1}^{(n)}])^2]}{var[rx_{t+1}^{(n)}]}\,. \tag{4}$$

Figure 2 reveals that the R^2s decrease from 20% for the maturity of six months to 15% for ten-year bonds but are always higher than for the three factor case. *Third*, we analyze the model fit by comparing model-implied and observed interest rates. The five factor model reveals smaller deviations for one-, two-, five- and ten-year bonds which underline the good fit of the model. Thus, we obtain a term structure model with five factors.

3 Data

This section reports on the estimation and interpretation of monthly data which are related to the U.S. macro factors and financial condition variables. The data sets cover the period between 10/1998 and 12/2012, i.e. more than 14 years.

3.1 Estimation of macroeconomic factors

We compute latent macroeconomic factors from the Ludvigson and Ng (2009) data set. The data set consists of 132 time series. These variables are transformed such to ensure stationarity. Any detected seasonality is corrected by an X11-ARIMA process (see Marcellino, 2003). We follow Ludvigson and Ng (2009) and subdivide the data set into five broader categories: (i) output (in the following abbreviated by F^{output}), (ii) employment and working hours ($F^{empl.}$), (iii) orders and housing (F^{orders}), (iv) money, credit and finance (F^{MCF}) and (v) prices (F^{prices}). We try to achieve a clear economic interpretation of the macroeconomic factors by extracting the first principal component out of each category. These factors can either be pro- or countercyclical. This might complicate the interpretation of the factors' effects on excess return components. Therefore, we transform each factor such that it exhibits a countercyclical pattern, i.e. a higher factor value reflects an improvement of the economic environment. Whereas the procedure here is

[2] In keeping with Adrian et al. (2013), we also compare the observed and model-implied average interest rate and the standard deviation of interest rates. For the sake of brevity we do not discuss them, as both moments are better described by the five factor model.

largely standard, the broad consideration of financial condition variables is new and thus requires more attention.

3.2 Financial condition variables

Financial condition variables aim to cover measures of risk-related behavior of financial professionals and its outcomes. Our variables cover four areas, i.e. position-taking by financial professionals, financial stress indices as well as the bond future market's order flow and an illiquidity measure. We detrend the balance sheet data by computing monthly growth rates (Adrian, Moench, and Shin, 2010). Overall, we cover the above mentioned four areas by seven financial condition variables:

Position-taking by financial professionals.

(i) *Financial paper issuance*: The issuance of financial commercial paper is (in addition to repos) an important refinancing instrument in the wholesale market for financial intermediaries, equally for banks and the shadow banking sector (see Adrian et al., 2010). The inclusion of this variable ensures that the balance sheet activities of financial intermediaries are captured quite broadly and also more broadly than by the balance sheet data of primary dealers discussed below. This measure does not only cover the risk-taking ability of financial institutions but also their financing of the real economy. It is thus unclear ex ante whether the change in financial paper issuance is negatively related to the bond risk premium or positively. In the first case, which is ex ante expected to dominate, a low level of financial paper issuance would reflect a cautious stance of financial intermediaries due to a higher risk aversion which might coincide with a higher risk premium. In the second case of a positive relation, the reason may be either that financial intermediaries take risk in order to make money or that they refinance their booming customer business.

(ii) *Net financing of primary dealers*: Primary dealers play an important role for the financial system as they are marginal providers of credit (see Adrian et al., 2010). As their balance sheets are valued "mark to market", changes in dealers' balance sheets can be interpreted as financing constraints in the financial system. An inverse measure of financing constraints is leverage, the ratio of total assets to book equity. A monthly time series cannot be derived from quarterly available balance sheet data. Therefore, we follow Adrian and Fleming (2005) and proxy the broker dealers' leverage by their financing transactions. The balance sheet data of the primary dealers are provided by the Federal Reserve Bank of New York.[3] The data set includes information about the amount of fixed income securities used (securities out) and received (securities in) in financing transactions, such as repos. The primary dealers' *net financing* is defined as securities in minus securities out.

(iii) *Net positions of primary dealers*: We also calculate the primary dealers' *net positions*, which is net financing corrected by forward positions. In contrast to net financing, net positions of primary dealers take into account that open positions can be offset by adequate forward positions. In this case, net financing would be just a crude measure for dealer risk-taking behavior. As leverage behaves procyclically (Adrian et al., 2010), we expect in general that more open positions signal more risk-taking, and that this occurs with lower risk premia. However, as with financial paper issuance, larger open positions may indicate greater risk appetite, which then may be positively related to risk premia.

[3]See Adrian and Fleming (2005) for a comprehensive discussion of the data set.

Two financial stress indices. Financial conditions can refer to various financial stress indices. Financial stress is not restricted to volatility, such as measured by the VIX-index, but may also influence spreads in financial markets. Therefore, we use two broader financial stress index, the *Cleveland Financial Stress Index* and the *adjusted Chicago Fed's National Financial Conditions Index*. The former index can be seen as a pure market-based indicator. The latter indicator is based on both market spreads and liquidity-based indicators and thus delivers a broader picture of the financial system.

(i) *Cleveland Financial Stress Index (CFSI)*: The CFSI is composed of 16 indicators. These indicators measure market spreads and market dynamics which are related to credit, equity, foreign exchange, funding, real estate and securitization markets. The weight of each indicator in the index is computed dynamically. This method ensures a flexible index which captures the most relative market dynamics.

(ii) *The adjusted Chicago Fed's National Financial Conditions Index (ANFCI)*: The Chicago Fed's National Financial Conditions Index (NFCI) subsumes the U.S. financial conditions in money markets, debt and equity markets, and the traditional and shadow banking systems. Financial conditions are related to economic conditions. However, as we are purely interested in the effect of the financial conditions, we consider the adjusted NFCI (ANFCI), which represents financial conditions corrected for economic conditions.

Due to their construction, we expect that an increase in financial stress indices goes along with a higher bond risk premium.

Order flow. Order flow is the difference between buy- and sell-side initiated trading and can therefore be seen as the trade imbalance of an asset. For our analysis we use the order flow of "on-the-run" U.S. five-year bond future contracts, which have a significant price impact on all U.S. Treasury bond futures (see Brandt and Kavajecz, 2004). We approximate the "on-the-run" bond future by using a daily "auto roll" procedure. This procedure compares the trading volume of all traded five-year bond futures and considers the one with the highest trading volume in the data sample. The Lee and Ready (1991)-algorithm is applied to this data set for modeling if the trade was buyer- or seller-initiated. Therefore, we compare trade prices with the available bid and ask price and code order flow to be buyer-initiated if the trade price is equal or above the ask price and vice versa. Then, order flow is aggregated on a monthly basis.

The economic interpretation of the order flow here is that it represents the net shift in and likely out of more risky markets, such as stock markets. Thus, an increase in order flow means a shift into bond markets and out of more risky stock markets. It is expected that order flow is positively related to bond risk premia.

Illiquidity measure. The consideration of illiquidity is motivated by Li, Wang, Wu, and He (2009), who reveal that illiquidity appears to be an additional pricing factor for U.S. bond excess returns. Therefore, we calculate a monthly liquidity measure based on the trading data set of the five-year bond future. Due to the multiplicity of liquidity, a clear identification of an adequate liquidity measure is challenging. In this paper, liquidity is measured as the monthly average of the daily Amihud (2002) "price impact - volume" ratio. Goyenko, Holden, and Trzcinka (2009) show that this measure is an adequate proxy for monthly illiquidity conditions. This ratio is defined as

$$illiquidity_t = \frac{|r_t|}{volume_t} \tag{5}$$

where r_t is the daily return of the five-year Treasury bond future and $volume_t$ is the contract's trading volume at day t.

The expected relation of this measure to bond risk premia is positive as the measure is in effect calibrated as a measure of illiquidity.

3.3 Correlation structure of the variables

In order to provide an empirical description of relations between our 12 variables of interest, we measure coefficients of correlation. Table 1 shows the correlation structure of the five macroeconomic and seven financial condition variables in four directions: (i) the first column of coefficients reports correlations between our 12 variables of interest with expected excess returns; these coefficients are mostly positive, four of these coefficients are larger than 0.1 and statistically significant, and three of these larger ones refer to macro factors. The positive sign results from the definition of variables: macro factors are defined here as countercyclical variables, which implies that we tend to expect a positive correlation with excess returns. The same largely applies to the interpretation of the financial condition variables. (ii) The second column reports coefficients with excess return innovations; here, the financial condition variables show higher coefficients than the macro factors. (iii) The coefficients within the group of macro factors are almost always positive and within the group of the first four factors the size is always above 0.33 and coefficients are significant at the 1% level. It is only the fifth factor, i.e. prices, that is sometimes negatively correlated, but except for the relation to the fourth factors, the size of these coefficients is small. (iv) The coefficients within the group of financial condition variables have positive and negative signs and are mostly rather small, i.e. below 0.2 and mostly even below 0.1. It is only the coefficient between the two stress indicators that stands out with a size of 0.4. This indicates that the financial condition variables capture different aspects of the market state, which is welcome in our explorative approach.

Overall, the correlation matrix provides a first intuitive picture about the role of possible determinants of excess returns. Unlike this matrix, however, the later regressions analyze lagged variables to explain expected excess returns and the approach is strictly multivariate. Therefore, results may differ from the descriptive correlations provided here.

4 Determinants of excess returns

This section presents our results in explaining bond excess returns, disaggregated into expected excess returns (Section 4.1) and excess return innovations (Section 4.2). We analyze in both cases bonds with a maturity of two, five and ten years, and in addition a constructed mean return which is an equally weighted average return of bonds with a maturity between three months and ten years. Moreover, all coefficients and standard errors of the following regressions are block bootstrapped (see Politis and Romano, 1994, and Politis and White, 2004).

4.1 Explaining expected excess returns

In the regressions explaining expected excess returns we rely on the full set of possible determinants discussed and described in the above data section (Section 3). These variables come from two different groups, i.e. the group of five macroeconomic factors and the group of seven financial condition variables. The consideration of macro factors has become standard procedure in this literature and thus one can expect that these variables show an ability to explain expected excess returns. In contrast to macro factors, the consideration of financial condition variables is less explored.

At Table 2 we present regressions separated for the four maturities being considered, and for each maturity there are three regressions (Panels A to C respectively) which contain as exogenous variables the macro factors (Panel A), the financial condition variables (Panel B) and finally the full set of variables (Panel C). The regression of Panel C is as follows:

$$\begin{aligned}\mathbb{E}_t[rx_{t+1}^{(n)}] = \alpha + \beta_1 F_t^{output} + \beta_2 F_t^{empl.} + \beta_3 F_t^{orders} + \beta_4 F_t^{MCF} + \beta_5 F_t^{prices} + \\ + \beta_6 Fin.\ Paper_t + \beta_7 Net\ financing_t + \beta_8 Net\ positions_t + \beta_9 CFSI_t + \\ + \beta_{10} ANFSI_t + \beta_{11} OF_t + \beta_{12} illiquidity_t + \epsilon_{t+1}\,.\end{aligned} \tag{6}$$

$\mathbb{E}_t[rx_{t+1}^{(n)}]$ represents the expected excess return between time t and t+1 of a bond with maturtiy n and is derived from equation (3). The exogeneous variables are the macro factors (F_t) and financial variables as they are described in Section 3. Three main lessons appear from Table 2: first, the explanatory power of the regressions in Panel C, considering all RHS variables, is considerable, with a level of R^2s of between 18% and 24%. This shows that the full set of variables has relevance for explaining expected excess returns.

Second, this explanatory power is overwhelmingly driven by macro factors. Regressions in Panel A provide about 70% or more of the total explanation, measured by the R^2. When we look at the contribution from financial condition variables, they increase explanatory power somewhat but mainly statistically, and there is only a weak systematic impact. This impact stems from Net positions, the only consistently significant variable. The positive coefficient sign indicates that the primary dealers taking these positions may aim for higher returns from higher risk premia.

Within the group of macro variables there is a clear hierarchy, which provides the third lesson. As each variable is included in eight regressions, and neglecting the possibly different importance of these regressions, both Factor 1 and Factor 2 are statistically significant in all these regressions. Thus, output and employment, i.e. real economy variables, are most important for understanding expected bond excess returns. Further, the coefficients show that a worsening real economy is related to higher bond risk premia. By contrast, Factor 3 (housing and manufacturing orders) is just one time significant and Factor 5 (prices) only two times. Between the important and rather unimportant factors ranges Factor 4 (money, finance), which is four times significant, and these three cases all occur in Panel C-regressions, i.e. when financial conditions are considered.

The dominant role of the real economy factors fits nicely into the literature. The importance of employment and output is also found, for example, by Ludvigson and Ng (2009), who show that these two factors account for nearly half of the forecasting power for bond excess returns. This forecasting power stems from the countercyclical behavior of bond excess returns (Ludvigson and Ng, 2009; Cochrane and Piazzesi, 2005). This is exactly the same pattern documented by our Table 2.

4.2 Explaining excess return innovations

After having discussed determinants of expected excess returns we now turn to the second component of the Adrian et al. (2013) model, i.e. unexpected excess returns. Interestingly, the pattern of explanation is very different in this section from the preceding one. When we focus on excess return innovations of equation (3), $\beta^{(n-1)\prime}\nu_{t+1}$, often different variables than before become statistically significant. In particular, and that is the main message here, innovations are not related to macro factors but to contemporaneous changes in financial condition variables. In short, whenever these variables indicate specific market conditions, the risk premium is higher. The identification of such market conditions provides a first intuition about relevant forces in understanding short-term influences on bond risk premia. Full results are shown in Table 3, which we will discuss now in more detail.

The structure of this table resembles Table 2 in Section 4.1 above. Again, we can draw three main lessons: first, explanatory power here is even higher than before and R^2s range between 20% and 42%. Second, this explanatory power is almost exclusively driven by financial condition variables. Their R^2s make up for between more than 80% and even more than 100% of the total adj. R^2s. That means the contemporaneous macro factors do not really help to understand bond excess return innovations. This holds despite the fact that several of these macro factors turn statistically significant, but R^2s in the respective regressions of Panels A are rather low.

Third, the relative importance of the seven financial condition variables differs quite a lot. Measuring relative importance by the occurrence of significant coefficients in the set of eight regressions each, the dominating variables are three variables which are also statistically significant. This is (1) the change in broker-dealer Net positions, (2) the change in the Cleveland financial stress index (CFSI) and (3) order flow (OF). The respective positive coefficient signs mean that bond risk premia increase with (1) position-taking by broker-dealers, (2) the degree of financial stress and (3) with positive order flow, indicating a tendency to buy bonds and thus a demand shift towards - less risky - bonds and out of other instruments such as stocks. Whereas the second and third variables indicate higher riskiness in the markets, which fits with higher bond risk premia, the first sign of the first variable, position-taking by broker-dealers, is somewhat surprising. However, this may be due to some ambivalence in interpreting broker-dealer behavior: possibly, they take more positions to make more money, at least on average.

In contrast to these variables, there are four other financial condition variables which do not seem to matter in joint regressions as presented in Table 3: the change in financial paper issuance, the change in broker-dealer net financing as well as the change of the NFCI (national financial condition index) and the change in liquidity conditions are hardly ever significant (except for the financial paper issuance which is statistically significant in one regression).

5 Robustness tests

This section discusses the robustness of the derived results in three ways. First, we apply the Bauer, Rudebusch, and Wu (2012) bootstrap algorithm in the Adrian et al. (2013) model for accounting for a potential small sample bias in the term structure estimation.

Second, we recalculate the regressions with shorter samples to account for the financial crisis of 2007 and 2008. Third, the approach of Adrian et al. (2013) considers pricing factors which are based on interest rates. We provide results here by substituting these pricing factors by the Cochrane and Piazzesi (2008) pricing factors.

5.1 Small-sample bias-correction

Term structure estimations rely on high persistent interest rates which might bias the estimation of expected excess returns / term premia. As Bauer et al. (2012) point out, this small sample bias problem might lead to term premia which reveal (i) a lower variation overall and (ii) a lower variation with the business cycle. Thus, one might be concerned that our term premium estimations might be influenced by the small sample bias. We address this issue by applying the Bauer et al. (2012) small-sample bias bootstrap for deriving the term structure model parameters. Consistent with Bauer et al. (2012), expected excess returns are now more volatile than under the previous specification of the term structure model. Table 4 shows the results for small-sample bias-corrected expected and unexpected excess returns. Our results do not qualitatively diverge in qualitative terms from the results of Section 4. The same set of macro factors and financial variables explains expected and unexpected excess returns which have been identified above in Section 4.

5.2 Subsample analysis

In this section we run the same regressions as in Section 4 above, but for two shorter samples. First, we exclude data after October 2008 because the quantitative easing of the Federal Reserve started then. Second, we stop even earlier, i.e. in December 2006, to ensure that results are not influenced by potentially unusual effects due to the financial crisis starting in 2007.

Excluding the quantitative easing period. The full sample analyzed above falls in the period during which the Fed announced and conducted its quantitative easing period from November 2008 onwards. The quantitative easing program aims for a synthetic reduction of the term premium (Christensen and Rudebusch, 2012). Whether the Fed is successful or not, an intervention in the bond market is at least ongoing which directly influences our price of interest, the term or bond risk premium. Therefore, our findings might be distorted by the intervention period of the Fed. Accordingly, we address this concern by shortening the sample until October 2008.

The new results presented in Table 5 are qualitatively similar to the results for the full sample given in Tables 2 and 3. However, there is one major difference, as the explanation of the expected excess return is now clearly better than before. The R^2 increases for the full specification shown in Panel 3 from 20.4% to 23.6%. This improvement is driven by both groups of variables: the R^2 of Panel A specification considering just five macro factors improves from 16.6% to 22% and the R^2 of the Panel B-specification considering seven financial condition variables improves slightly from 2.3% to 3.8%. If one looks at the relative importance in joint estimation, however, Panel C in Table 5 shows that only one macro factor contributes significantly to the overall explanatory power, that is the second factor covering employment. By contrast the financial condition variables become insignificant in the joint estimation.

Turning to the explanations of excess return innovation, i.e. the lower half of Table 5, there are again a few changes compared to the estimation of the full sample. The R^2s are mainly smaller, and a similar list of variables is significant in both sets of specifications. What seems noteworthy is the improvement of the R^2 of the specification with macro factors only (Panel A). The R^2 increases from 1% in the full sample analysis (Table 3) to more than 8%. The higher explanatory power of the macro factors seems to be plausible, as the period with the heaviest financial turmoil is excluded. In the joint estimation shown in Panel C, however, the change in the CFSI index and order flow dominates, whereas only macro factor 4 remains marginally significant.

Overall, the exercise with the pre-quantitative easing subsample rather strengthens the result because it shows that the impact of macro factors was stronger before the unusual policy interventions. By contrast, there is no visible influence of the crisis on the explanation of excess return innovations.

Excluding the financial crisis period. The beginning of the financial crisis can be seen as a potential structural break point, as volatility increased sharply and the financial paper issuance collapsed. These developments might be drivers of the importance of the financial variables documented above. We control for this possibility by excluding the whole financial crisis period. We shorten the sample until December 2006 to ensure that no crisis effect is covered by the time series.

Table 6 reports the results which are qualitatively comparable to our earlier findings. The macro factors explain about 20% of expected excess returns. This again is a small increase on the sample up to October 2008 (Panel A). The macro factor which covers employment is once more highly significant. Interestingly, the R^2 of the financial variables also increases up to 7.5% in Panel B. This change is caused by the greater importance of the "financial paper" variable. The negative sign of the "financial paper" variable suggests the following interpretation: a drop in financial paper issuance, thus a worsening of the refinancing conditions of broker-dealers, occurs with an increase of the term premium. However, considering the set of financial condition variables in addition to the macro factors (Panel C) does not substantially increase the R^2 of Panel A.

Turning to the return innovations, changes of the macro factors are more important compared to results of the whole sample. The R^2 of almost 12% is even higher compared to the results when the quantitative easing period is excluded (Panel A). In contrast, the financial variables lose some of their explanatory power (Panel B). However, the change of financial conditions (CFSI) and order flow remain the main determinants of return innovations. This finding also holds when the macro factors are added to the regression (Panel C).

5.3 Variation of the term structure pricing factors

This section addresses the concern that findings may depend on the kind of pricing factors. In a sense, each consideration of pricing factors is somewhat specific and it is not clear ex ante that results are definitely independent of this issue. Thus we substitute the pricing factors taking in the Adrian et al. (2013) model by those from Cochrane and Piazzesi

(2008).[4] In contrast to the Adrian et al. (2013) pricing factors, the Cochrane and Piazzesi (2008) factors are computed from forward rates instead of from interest rates. This modification means that we substitute interest rates for expected future interest rates (forward rates).[5] Table 7 reveals a high correlation of the Adrian et al. (2013) model's pricing factors and those from Cochrane and Piazzesi (2008). However, this correlation structure seems to be mainly driven by the computation of the Cochrane and Piazzesi (2008) pricing factors which are based on interest rates for calculating forward spreads. The pairwise comparison of the factors, that is the comparison of the Adrian et al. (2013) i'th factor with the Cochrane and Piazzesi (2008) i'th factor, reveals a decrease of the correlation from the first to the fifth pricing factor. Thus, although there is indeed some similarity between the pricing factors, we achieve a sufficient variation in the pricing factors.

Results on this robustness exercise are given in Table 8. This table has the same structure as Table 5 discussed in the section above. However, what is different here is that the results are almost identical to the earlier results from Tables 2 and 3. Obviously, the information contained in interest rates and forward rates leads to very similar term premiums in the Adrian et al. (2013) term structure model. We see this finding as a confirmation of our results which do not seem to be driven by the choice of pricing factors.

6 Conclusion

This study is motivated by the fact that the variation of bond excess returns can be explained to roughly 20% by expected bond excess returns (Almeida et al., 2011). These expected excess returns, representing bond risk premia, have been explained in several studies by macro factors. The economic intuition is that risk premia depend on macro conditions, in particular that signs of a business cycle expansion tend to increase excess returns. This is what we also find in our data. However, 80% of the bond excess returns remain unexplained which leaves room for more research.

We go beyond earlier studies by considering two new elements in the empirical approach: first, expanding the explanation of bond excess returns to a decomposition into an expected and an unexpected component, and, second, complementing macro factors by financial condition variables. The expected excess returns reflect the bond risk premia as they are usually examined in the literature, and where macro factors have explanatory and even predictive power. However, explaining the unexpected component of excess returns, i.e. their innovations, is new to the literature. We implement our approach by applying the recently suggested term structure model of Adrian et al. (2013).

Regarding the extension of considered influences on the term structure, we have to follow an explorative approach and thus rely on a broader set of financial condition variables. These variables should provide additional information to macro factors, in particular about risk-related behavior of financial professionals and measures of risk-related outcomes. These variables include position-taking by financial professionals, financial

[4] We provide a comprehensive description of the Cochrane and Piazzesi (2008) pricing factors in the Appendix.

[5] See Cochrane and Piazzesi (2008) for a detailed discussion on the commonalities of interest rates and forward rates.

stress indicators, order flow and illiquidity. Interestingly, these variables do not help much in understanding expected excess returns, indicating that the term structure is mainly driven by macro factors and not by financial conditions.

When it comes to explaining excess return innovations, however, the picture reverses. Now, macro factors do not explain much anymore, whereas financial conditions are very useful in understanding unexpected changes in bond risk premia. The intuition of this result seems to make sense, as macro factors have a longer-term impact on risk premia and might thus be incorporated into expected excess returns. By contrast, short-term influences are more diverse and thus financial conditions have a clearer relation to innovations in bond excess returns. If we look at the coefficient signs in these regressions we see that tentatively "worse", i.e. more risky, market conditions go hand in hand with higher bond risk premia and may thus signal an economic downturn. Unfortunately, we cannot assess from our approach whether financial instability does really drive bond risk premia, although such a statement would be consistent with our results.

If we leave out the time period of the recent crisis, i.e. limiting the analysis either until the end of 2006 or until October 2008 (to just exclude the Fed's quantitative easing), explanatory power is even better regarding expected excess returns. This is driven by a higher explanatory power of both, macro factors and now also to a smaller degree by financial conditions. This provides motivation to examine in further research whether financial condition variables may be seen as pricing factors of the term structure, complementing the set of macro factors.

References

Adrian, T., D. Covitz, and N. Liang (2013). Financial stability monitoring. *Federal Reserve Bank of New York Staff Reports 601.*

Adrian, T., R. K. Crump, and E. Moench (2013). Pricing the term structure with linear regressions. *Journal of Financial Economics 110*(1), 110–138.

Adrian, T. and M. J. Fleming (2005). What financing data reveal about dealer leverage. *Federal Reserve Bank of New York Current Issues in Economics and Finance 11*(3).

Adrian, T., E. Moench, and H. S. Shin (2010). Macro risk premium and intermediary balance sheet quantities. *IMF Economic Review 58*(1), 179–207.

Almeida, C., J. J. Graveline, and S. Joslin (2011). Do interest rate options contain information about excess returns? *Journal of Econometrics 164*(1), 35–44.

Almeida, C. and J. Vincente (2009). Are interest rate options important for the assessment of interest rate risk? *Journal of Banking and Finance 33*(8), 1376–1387.

Amihud, Y. (2002). Illiquidity and stock returns: Cross-section and time-series effects. *Journal of Financial Markets 5*(1), 31–56.

Bauer, M. D., G. Rudebusch, and J. C. Wu (2012). Correcting estimation bias in dynamic term structure models. *Journal of Business & Economic Statistics 30*(3), 454–467.

Baur, D. G. and B. M. Lucey (2009). Flights and contagion - An empirical analysis of stock-bond correlations. *Journal of Financial Stability 5*(4), 339–352.

Brandt, M. W. and K. A. Kavajecz (2004). Price discovery in the U.S. Treasury market: The impact of orderflow and liquidity on the yield curve. *Journal of Finance 59*(6), 2623–2654.

Cardarelli, R., S. Elekdag, and S. Lall (2011). Financial stress and economic contractions. *Journal of Financial Stability 7*(2), 78–97.

Christensen, J. H. and G. D. Rudebusch (2012). The response of interest rates to US and UK quantitative easing. *The Economic Journal 122*(564), F385–F414.

Cochrane, J. H. and M. Piazzesi (2005). Bond risk premia. *American Economic Review 95*(1), 138–160.

Cochrane, J. H. and M. Piazzesi (2008). Decomposing the yield curve. *Working paper, University of Chicago*.

Cooper, I. and R. Priestley (2009). Time-varying risk premiums and the output gap. *Review of Financial Studies 22*(7), 2801–2833.

Duffee, G. R. (2011). Information in (and not in) the term structure. *Review of Financial Studies 24*(9), 2895–2934.

Goyenko, R., C. W. Holden, and C. A. Trzcinka (2009). Do liquidity measures measure liquidity? *Journal of Financial Economics 92*(2), 153–181.

Gurkaynak, R., B. Sack, and J. H. Wright (2007). The U.S. Treasury yield curve: 1961 to the present. *Journal of Monetary Economics 54*(8), 2291–2304.

Joslin, S., M. Priebsch, and K. J. Singleton (2014). Risk premiums in dynamic term structure models with unspanned macro risks. *Journal of Finance 69*(3), 1197–1233.

Kessler, S. and B. Scherer (2009). Varying risk premia in international bond markets. *Journal of Banking and Finance 33*(8), 1361–1375.

Lee, C. M. C. and M. J. Ready (1991). Inferring trade direction from intraday data. *Journal of Finance 46*(2), 733–46.

Li, H., J. Wang, C. Wu, and Y. He (2009). Are liquidity and information risks priced in the Treasury bond market? *Journal of Finance 64*(1), 467–503.

Ludvigson, S. C. and S. Ng (2009). Macro factors in bond risk premia. *Review of Financial Studies 22*(12), 5027–5067.

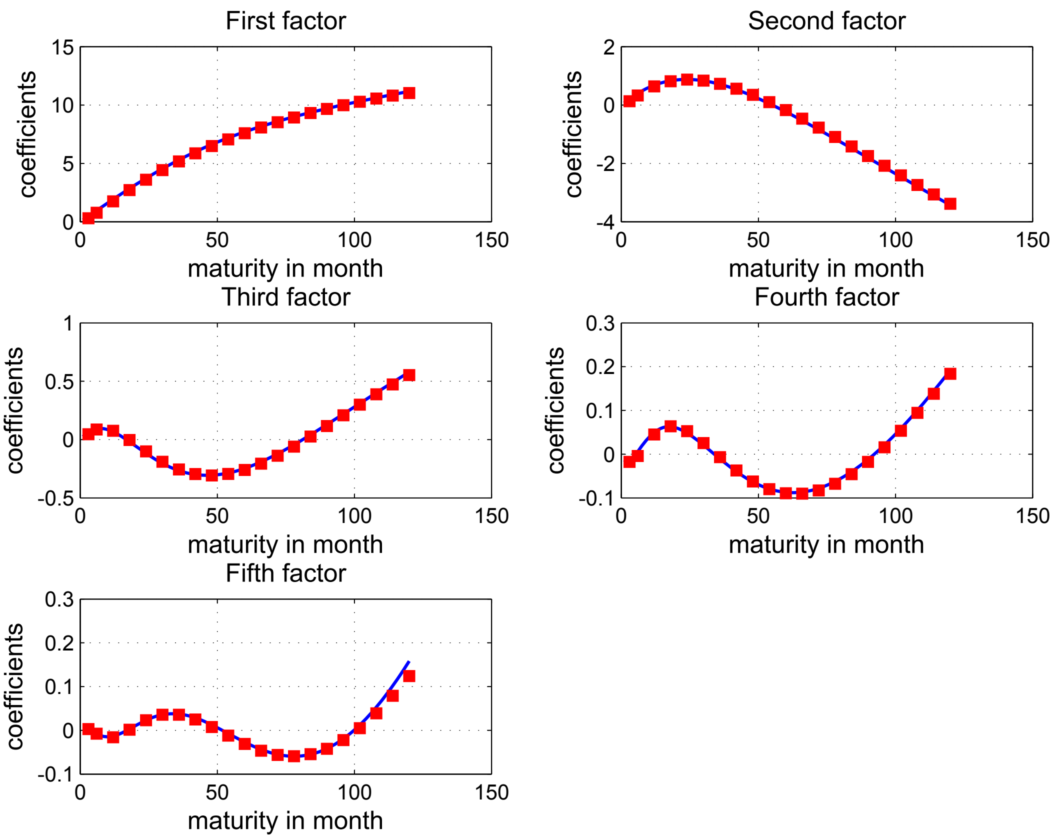
Marcellino, M. (2003). Macroeconomic forecasting in the Euro Area: Country specific versus area-wide information. *European Economic Review 47*(1), 1–18.

Politis, D. N. and J. P. Romano (1994). The stationary bootstrap. *Journal of the American Statistical Association 89*(428), 1303–1313.

Politis, D. N. and H. White (2004). Automatic block-length selection for the dependent bootstrap. *Econometric Reviews 23*(1), 53–70.

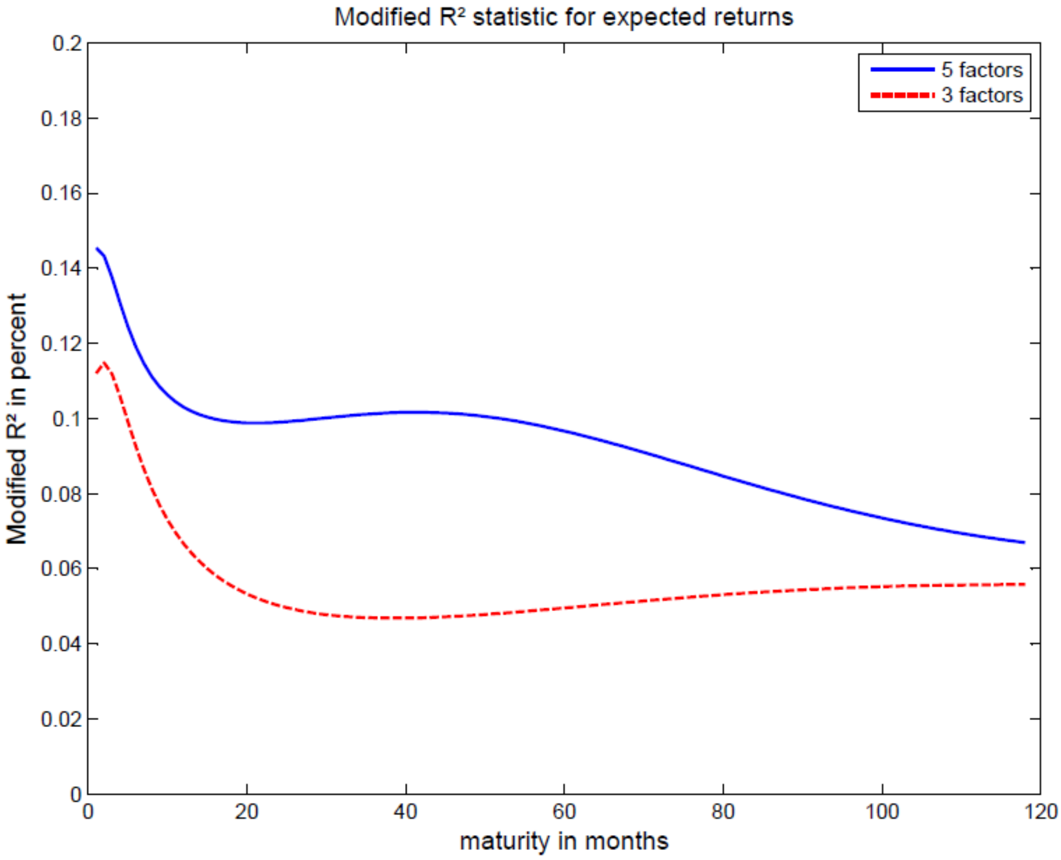
Sekkel, R. (2011). International evidence on bond risk premia. *Journal of Banking and Finance 35*(1), 174–181.

Wright, J. H. and H. Zhou (2009). Bond risk premia and realized jump risk. *Journal of Banking and Finance 33*(12), 2333–2345.



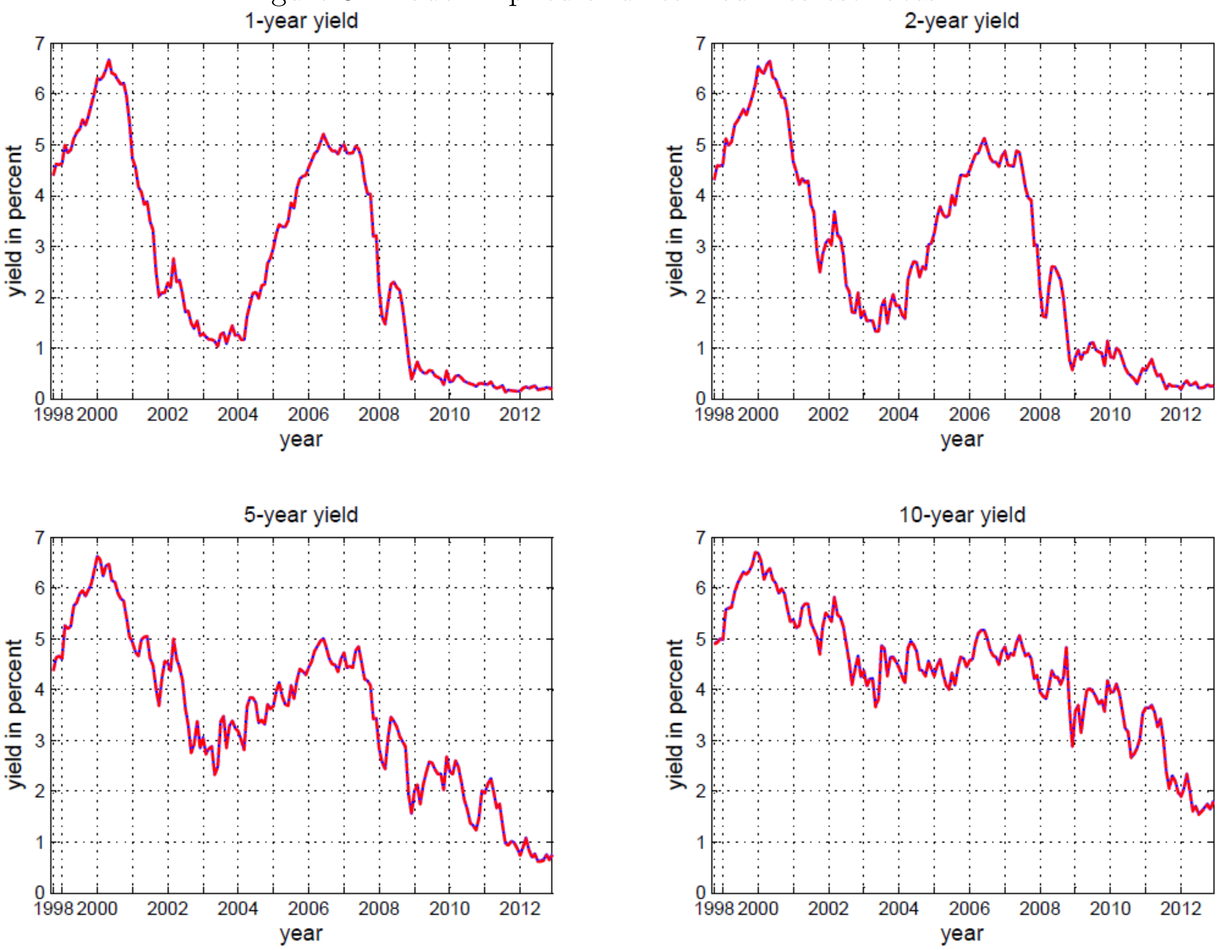
Note: These figures compare the regression coefficients $\beta^{(n)}$ from equation (3) with the term structure model implied coefficients. The blue line represents the regression coefficients for all considered maturities n=$\{1, \ldots, 120\}$. The red data points show the recursive estimated B_n coefficients.

Figure 2: Explanatory R^2s of expected excess returns for excess returns.



Note: This figure shows the Almeida et al. (2011) R^2 statistics for expected excess returns (see equation (4)). These R^2s reveal the share of bond excess returns which belongs to the expected return in the Adrian et al. (2013) term structure model. The R^2s for the model with five (three) pricing factors is represented by the blue (red-dashed line).

Figure 3: Model-implied and realized interest rates



Note: These figures compare the model-implied interest rates from the Adrian et al. (2013) term structure model with realized interest rates. The blue line represents the regression coefficients for all considered maturities n=$\{1, \ldots, 120\}$. The red-dashed data points show the recursive estimated B_n coefficients.

Table 1: Correlation matrix

variables	$exp.rx_t$	$inno-vations_t$	F_t^{output}	$F_t^{empl.}$	F_t^{orders}	F_t^{MCF}	F_t^{prices}	$Fin. Paper_t$	$Net\ fin._t$	$Net\ pos._t$	$CFSI_t$	$adj. NFSI_t$	OF_t	$illi-quidity_t$
$exp.\ rx_t$	1.00													
$innovations_t$	0.00	1.00												
F_t^{output}	0.10	0.03	1.00											
$F_t^{empl.}$	0.38***	0.03	0.68***	1.00										
F_t^{orders}	0.20**	0.06	0.61***	0.63***	1.00									
F_t^{MCF}	0.18**	0.14*	0.33***	0.37***	0.48***	1.00								
F_t^{prices}	-0.04	-0.10	0.11	0.00	-0.02	-0.23***	1.00							
$Fin.\ Paper_t$	-0.01	0.05	-0.01	-0.10	0.01	-0.19**	0.08	1.00						
$Net\ fin._t$	0.03	0.04	0.05	0.03	0.03	-0.01	-0.05	-0.06	1.00					
$Net\ pos._t$	0.17**	0.07	-0.01	0.00	-0.01	-0.08	0.02	-0.07	-0.06	1.00				
$CFSI_t$	0.05	0.26***	0.36***	0.45***	0.28***	0.24***	0.06	-0.15**	0.04	-0.01	1.00			
$ANFSI_t$	0.08	0.02	0.40***	0.42***	0.45***	0.39***	0.00	-0.16**	-0.12	-0.08	0.40***	1.00		
OF_t	0.03	0.29***	0.09	0.13	0.06	0.00	-0.12	0.04	0.11	0.06	0.04	0.08	1.00	
$illiquidity_t$	-0.01	-0.04	-0.05	-0.01	0.00	0.02	-0.05	0.06	0.01	0.05	-0.01	0.13*	0.00	1.00

Note: This table shows the correlation structure of average expected/unexpected excess returns, $exp.ret/innovations$, the Ludvigson and Ng (2009) macroeconomic factors, F, and financial condition variables. $Fin.Paper$ represents the financial paper issuance, $Netfin.$ / $Netpos.$ the net financing / net positions of primary dealers, $CFSI$ / $ANFSI$ the FED Cleveland Financial Stress Indicator / the adjusted Chicago FED's National Financial Conditions Index , OF the five-year U.S. bond future contract's order flow, $illiquidity$ the Amihud (2002) liquidity measure.

Table 2: Explaining expected excess returns

	expected excess returns					
	maturity					
	2-year			**5-year**		
Variable	**Panel A**	**Panel B**	**Panel C**	**Panel A**	**Panel B**	**Panel C**
intercept	0.441**	0.441*	0.437**	1.633**	1.742*	1.650**
F_{t-1}^{output}	0.335**		0.292**	1.120**		0.996**
$F_{t-1}^{empl.}$	0.567***		0.734***	2.256***		2.640***
F_{t-1}^{orders}	0.023		0.067	0.309		0.357
F_{t-1}^{MCF}	-0.257		-0.326*	-0.600		-0.718
F_{t-1}^{prices}	0.033		0.060	0.133		0.254
$Fin.\ Paper_{t-1}$		-0.055	0.004		-0.514	-0.337
$Net\ financing_{t-1}$		0.017	0.005		0.063	0.047
$Net\ positions_{t-1}$		0.171*	0.183**		0.559*	0.561*
$CFSI_{t-1}$		-0.222	-0.415**		-0.596	-1.252*
$ANFSI_{t-1}$		0.209	0.004		0.701	0.100
OF_{t-1}		0.015	-0.016		0.236	0.107
$illiquidity_{t-1}$		-0.029	-0.016		-0.215	-0.187
adj. R^2	15.2%	1.5%	22.9%	13.5%	1.5%	18.4%
	maturity					
	10-year			**mean**		
Variable	**Panel A**	**Panel B**	**Panel C**	**Panel A**	**Panel B**	**Panel C**
intercept	2.979**	3.103*	2.979**	1.460**	1.516*	1.455**
F_{t-1}^{output}	2.126**		2.064**	1.018**		0.905**
$F_{t-1}^{empl.}$	4.793***		4.821***	2.037***		2.309***
F_{t-1}^{orders}	0.738		0.890	0.254		0.346
F_{t-1}^{MCF}	-1.426		-1.123	-0.568		-0.652
F_{t-1}^{prices}	0.144		0.153	0.092		0.175
$Fin.\ Paper_{t-1}$		-1.171*	-0.791		-0.437	-0.276
$Net\ financing_{t-1}$		-0.273	-0.243		-0.002	-0.017
$Net\ positions_{t-1}$		1.074*	1.132**		0.514*	0.517**
$CFSI_{t-1}$		0.197	-0.896		-0.384	-0.952*
$ANFSI_{t-1}$		1.993	1.285		0.722	0.213
OF_{t-1}		0.490	0.235		0.195	0.103
$illiquidity_{t-1}$		0.446	0.417		-0.060	-0.050
adj. R^2	21.6%	9.0%	24.3%	16.6%	2.3%	20.4%

Note: This table reports regression results of two-year, five-year, ten-year and average expected excess returns on an intercept, lagged values of macro factors, $F_{i,t-1}$. *Fin. Paper* represents the financial paper issuance, *Net financing* / *Net positions* the net financing / net positions of primary dealers, *CFSI* / *ANFSI* the FED Cleveland Financial Stress Indicator / the adjusted Chicago FED's National Financial Conditions Index , *OF* the five-year U.S. bond future contract's order flow, *illiquidity* the Amihud (2002) liquidity measure. Regression coefficients and standard errors are block-bootstrapped with 10,000 bootstrap samples. The 10% (5%, 1%) significance level is marked with a * (** / ***).

Table 3: Explaining excess return innovations

	excess return innovations					
	maturity					
	2-year			**5-year**		
Variable	**Panel A**	**Panel B**	**Panel C**	**Panel A**	**Panel B**	**Panel C**
intercept	0.348	0.353	0.359*	0.913	0.965	1.002
ΔF_t^{output}	-0.132		-0.091	-0.468		-0.250
$\Delta F_t^{empl.}$	0.258		-0.107	2.288*		0.734
ΔF_t^{orders}	0.476**		0.313	1.518*		0.661
ΔF_t^{MCF}	-0.980***		-1.052***	-0.755		-0.900
ΔF_t^{prices}	0.295*		0.208	0.702		0.241
$\Delta Fin.\ Paper_t$		-0.107	0.069		0.074	0.136
$\Delta Net\ financing_t$		0.035	0.030		0.633	0.609
$\Delta Net\ positions_t$		0.239	0.292*		1.344***	1.431***
$\Delta CFSI_t$		2.088***	2.004***		11.647***	11.331***
$\Delta ANFSI_t$		0.389	-0.051		0.381	0.022
OF_t		0.595***	0.642***		2.460***	2.348***
$\Delta illiquidity_t$		0.199	0.243		0.741	0.780
adj. R^2	4.9%	15.8%	19.8%	1.0%	34.0%	32.6%
	maturity					
	10-year			**mean**		
Variable	**Panel A**	**Panel B**	**Panel C**	**Panel A**	**Panel B**	**Panel C**
intercept	1.698	1.851	1.824	0.845	0.909	0.884
ΔF_t^{output}	-1.956		-1.414	-0.513		-0.365
$\Delta F_t^{empl.}$	4.744*		0.787	1.988*		0.500
ΔF_t^{orders}	1.891		-0.237	1.228*		0.493
ΔF_t^{MCF}	6.200**		5.896***	-0.034		-0.228
ΔF_t^{prices}	0.723		-0.516	0.586		0.169
$\Delta Fin.\ Paper_t$		2.861**	1.567		0.323	0.312
$\Delta Net\ financing_t$		1.638	1.622		0.565	0.518
$\Delta Net\ positions_t$		3.246***	2.940***		1.217***	1.276***
$\Delta CFSI_t$		28.402***	28.355***		10.828***	10.621***
$\Delta ANFSI_t$		-1.813	0.305		0.169	-0.039
OF_t		4.516***	4.255***		2.196***	2.117***
$\Delta illiquidity_t$		0.839	0.643		0.580	0.608
adj. R^2	5.5%	40.4%	42.1%	1.0%	36.6%	35.0%

Note: This table shows regression results of two-year, five-year, ten-year and average excess return innovations on standardized values of changes of macro factors $\Delta F_{i,t}$. *Fin. Paper* represents the financial paper issuance, *Net financing* / *Net positions* the net financing/ net positions of primary dealers, *CFSI* / *ANFSI* the FED Cleveland Financial Stress Indicator / the adjusted Chicago FED's National Financial Conditions Index, *OF* the five-year U.S. bond future contract's order flow, *illiquidity* the Amihud (2002) liquidity measure. Regression coefficients and standard errors are block-bootstrapped with 10,000 bootstrap samples. The 10% (5%, 1%) significance level is marked with a * (** / ***).

Table 4: Small-sample bias-corrected expected excess returns and innovations

	average expected excess return		
Variable	**Panel A**	**Panel B**	**Panel C**
intercept	1.830**	1.823*	1.869***
F_{t-1}^{output}	0.905*		0.756
$F_{t-1}^{empl.}$	2.141***		2.379***
F_{t-1}^{orders}	0.622		0.570*
F_{t-1}^{MCF}	-0.834		-0.983
F_{t-1}^{prices}	0.168		0.277
$Fin.\ Paper_{t-1}$		-0.722*	-0.507
$Net\ financing_{t-1}$		0.010	-0.012
$Net\ positions_{t-1}$		0.530	0.560*
$CFSI_{t-1}$		-0.185	-0.861
$ANFSI_{t-1}$		0.331	-0.283
OF_{t-1}		0.159	0.075
$illiquidity_{t-1}$		-0.032	-0.004
adj. R^2	14.8%	1.1%	18.0%
	average excess return innovations		
Variable	**Panel A**	**Panel B**	**Panel C**
intercept	1.063	1.110	1.178
ΔF_t^{output}	-0.832		-0.573
$\Delta F_t^{empl.}$	2.565*		0.664
ΔF_t^{orders}	1.402		0.305
ΔF_t^{MCF}	1.252		1.039
ΔF_t^{prices}	0.683		0.114
$\Delta Fin.\ Paper_t$		0.834	0.571
$\Delta Net\ financing_t$		0.824	0.838
$\Delta Net\ positions_t$		1.711***	1.674***
$\Delta CFSI_t$		15.004***	14.812***
$\Delta ANFSI_t$		-0.454	-0.175
OF_t		2.602***	2.403***
$\Delta illiquidity_t$		0.682	0.677
adj. R^2	2.0%	38.6%	37.5%

Note: This table reports regression results of expected and unexpected excess returns on macroeconomic and financial condition variables. The excess return components are derived from the Adrian et al. (2013) term structure model with small-sample bias-corrected model parameters (see Bauer et al., 2012). The table shows the average expected and unexpected excess return, which is computed from bonds with a maturity of $n = 3, 4, \ldots, 120$ months. F (ΔF) represents (changes of) the Ludvigson and Ng (2009) macroeconomic factors. $Fin.\ Paper$ represents the financial paper issuance, $Net\ financing$ / $Net\ positions$ the net financing / net positions of primary dealers, $CFSI$ / $ANFSI$ the FED Cleveland Financial Stress Indicator / the adjusted Chicago FED's National Financial Conditions Index, OF the five-year U.S. bond future contract's order flow, $illiquidity$ the Amihud (2002) liquidity measure. Regression coefficients and standard errors are block-bootstrapped with 10,000 bootstrap samples. The 10% (5%, 1%) significance level is marked with a * (** / ***).

Table 5: Analysis of the subsample of 1998 to 2008

	average expected excess return		
Variable	**Panel A**	**Panel B**	**Panel C**
intercept	1.007***	1.010*	1.015***
F_{t-1}^{output}	0.192		0.174
$F_{t-1}^{empl.}$	1.308***		1.403***
F_{t-1}^{orders}	-0.039		-0.103
F_{t-1}^{MCF}	-0.390		-0.468
F_{t-1}^{prices}	-0.122		-0.065
$Fin.\ Paper_{t-1}$		-0.744**	-0.278
$Net\ financing_{t-1}$		-0.054	-0.144
$Net\ positions_{t-1}$		0.396*	0.255
$CFSI_{t-1}$		0.060	-0.497
$ANFSI_{t-1}$		-0.044	0.221
OF_{t-1}		-0.034	-0.100
$illiquidity_{t-1}$		-0.216	-0.184
adj. R^2	22.0%	3.8%	23.6%

	average excess return innovations		
Variable	**Panel A**	**Panel B**	**Panel C**
intercept	0.722	0.692	0.649
ΔF_{t}^{output}	-0.365		-0.605
$\Delta F_{t}^{empl.}$	3.114		0.869
ΔF_{t}^{orders}	-6.505*		-1.479
ΔF_{t}^{MCF}	-4.075***		-2.050*
ΔF_{t}^{prices}	-0.600		-0.492
$\Delta Fin.\ Paper_{t}$		-0.113	-0.213
$\Delta Net\ financing_{t}$		0.223	0.250
$\Delta Net\ positions_{t}$		0.020	0.058
$\Delta CFSI_{t}$		9.841***	8.825***
$\Delta ANFSI_{t}$		-0.234	-1.550
OF_{t}		2.842***	2.716***
$\Delta illiquidity_{t}$		0.938	0.701
adj. R^2	8.3%	31.4%	30.8%

Note: This table reports regression results of average bond excess returns on macroeconomic and financial condition variables. The sample ends 12/2008 for excluding the quantitative easing period of the Federal Reserve Bank. The average is computed from bonds with a maturity of $n = 3, 4, \ldots, 120$ months. F (ΔF) represents (changes of) the Ludvigson and Ng (2009) macroeconomic factors. $Fin.\ Paper$ represents the financial paper issuance, $Net\ financing$ / $Net\ positions$ the net financing / net positions of primary dealers, $CFSI$ / $ANFSI$ the FED Cleveland Financial Stress Indicator / the adjusted Chicago FED's National Financial Conditions Index, OF the five-year U.S. bond future contract's order flow, $illiquidity$ the Amihud (2002) liquidity measure. Regression coefficients and standard errors are block-bootstrapped with 10,000 bootstrap samples. The 10% (5%, 1%) significance level is marked with a * (** / ***).

Table 6: Analysis of the subsample of 1998 to 2006

	average expected excess return		
Variable	**Panel A**	**Panel B**	**Panel C**
intercept	1.170**	0.793	1.148**
F^{output}_{t-1}	-0.173		-0.155
$F^{empl.}_{t-1}$	1.438***		1.389***
F^{orders}_{t-1}	0.202		0.250
F^{MCF}_{t-1}	-0.566		-0.557
F^{prices}_{t-1}	0.054		0.013
$Fin.\ Paper_{t-1}$		-0.630*	-0.321
$Net\ financing_{t-1}$		-0.255	-0.239
$Net\ positions_{t-1}$		0.302	0.127
$CFSI_{t-1}$		-0.173	-0.412
$ANFSI_{t-1}$		-0.581	-0.301
OF_{t-1}		-0.081	-0.234
$illiquidity_{t-1}$		-0.093	-0.093
adj. R^2	20.4%	7.5%	22.7%

	average excess return innovations		
Variable	**Panel A**	**Panel B**	**Panel C**
intercept	0.392	0.622	0.518
ΔF^{output}_{t}	-0.823		-0.565
$\Delta F^{empl.}_{t}$	2.859*		1.731
ΔF^{orders}_{t}	4.138***		2.676**
ΔF^{MCF}_{t}	1.840		0.440
ΔF^{prices}_{t}	0.790		0.768
$\Delta Fin.\ Paper_{t}$		-0.717	-1.201
$\Delta Net\ financing_{t}$		0.272	0.621
$\Delta Net\ positions_{t}$		-0.126	0.258
$\Delta CFSI_{t}$		7.853***	6.448***
$\Delta ANFSI_{t}$		-1.840	-2.431
OF_{t}		3.042***	2.523***
$\Delta illiquidity_{t}$		1.038	0.912
adj. R^2	11.9%	29.0%	30.2%

Note: This table reports regression results of average bond excess returns on macroeconomic and financial condition variables. The sample ends 12/2006 for excluding the financial crisis and quantitative easing period. The average is computed from bonds with a maturity of $n = 3, 4, \ldots, 120$ months. F (ΔF) represents (changes of) the Ludvigson and Ng (2009) macroeconomic factors. $Fin.\ Paper$ represents the financial paper issuance, $Net\ financing$ / $Net\ positions$ the net financing / net positions of primary dealers, $CFSI$ / $ANFSI$ the FED Cleveland Financial Stress Indicator / the adjusted Chicago FED's National Financial Conditions Index, OF the five-year U.S. bond future contract's order flow, *illiquidity* the Amihud (2002) liquidity measure. Regression coefficients and standard errors are block-bootstrapped with 10,000 bootstrap samples. The 10% (5%, 1%) significance level is marked with a * (** / ***).

Table 7: Correlation structure of the term structure model's pricing factors

variables	X_1	X_2	X_3	X_4	X_5	x_t	$TSF_{1,t}^{CP}$	$TSF_{2,t}^{CP}$	$TSF_{3,t}^{CP}$	$TSF_{4,t}^{CP}$	$TSF_{5,t}^{CP}$
X_1	1.00										
X_2	0.00	1.00									
X_3	0.00	0.00	1.00								
X_4	0.00	0.00	0.00	1.00							
X_5	0.00	0.00	0.00	0.00	1.00						
x_t	-0,08	-0.47***	0.33***	-0.06	-0.33***	1.00					
$TSF_{1,t}^{CP}$	0.99***	-0.17**	0.01	0.01	0.01	0.00	1.00				
$TSF_{2,t}^{CP}$	-0.15*	-0.84***	0.02	0.07	0.24***	0.00	0.00	1.00			
$TSF_{3,t}^{CP}$	0.02	0.18**	0.87***	0.40***	0.17**	0.00	0.00	0.00	1.00		
$TSF_{4,t}^{CP}$	0.01	0.02	0.28***	-0.50***	-0.67***	0.00	0.00	0.00	0.00	1.00	
$TSF_{5,t}^{CP}$	0.01	0.04	0.23***	-0.71***	0.46***	0.00	0.00	0.00	0.00	0.00	1.00

Note: This table reports the correlation matrix of the term structure model's pricing factors which are derived from yields and the Cochrane and Piazzesi (2008) pricing factors.The pricing factors derived from yields are the first five principal components from interest rates with a maturity of n={3,6, ...,18,24,...,120}. X_i is the i'th principal component. The Cochrane and Piazzesi (2008) pricing factors are derived from forward rates and forward spreads. x represents the return-forecasting factor which can be interpreted as an expected excess return. TSF_i represents the i'th common component which is embedded in forward rates. For more details on the estimation of the Cochrane and Piazzesi (2008) pricing factors we refer to the Appendix. The 10% (5%, 1%) significance level is marked with a * (** / ***).

Table 8: Cochrane and Piazzesi (2008) pricing factors

	average expected excess return		
Variable	**Panel A**	**Panel B**	**Panel C**
intercept	1.463**	1.492*	1.489**
F_{t-1}^{output}	1.039***		0.899**
$F_{t-1}^{empl.}$	2.055***		2.373***
F_{t-1}^{orders}	0.260		0.368
F_{t-1}^{MCF}	-0.595		-0.689
F_{t-1}^{prices}	0.116		0.190
$Fin.\ Paper_{t-1}$		-0.471	-0.276
$Net\ financing_{t-1}$		0.013	-0.021
$Net\ positions_{t-1}$		0.527*	0.527**
$CFSI_{t-1}$		-0.402	-0.987*
$ANFSI_{t-1}$		0.655	0.231
OF_{t-1}		0.207	0.080
$illiquidity_{t-1}$		-0.079	-0.066
adj. R^2	16.6%	2.4%	20.5%

	average excess return innovations		
Variable	**Panel A**	**Panel B**	**Panel C**
intercept	0.828	0.898	0.879
ΔF_t^{output}	-0.545		-0.369
$\Delta F_t^{empl.}$	1.999*		0.542
ΔF_t^{orders}	1.297*		0.518
ΔF_t^{MCF}	-0.062		-0.216
ΔF_t^{prices}	0.597		0.161
$\Delta Fin.\ Paper_t$		0.342	0.320
$\Delta Net\ financing_t$		0.532	0.584
$\Delta Net\ positions_t$		1.235***	1.274***
$\Delta CFSI_t$		10.836***	10.634***
$\Delta ANFSI_t$		0.135	-0.067
OF_t		2.193***	2.073***
$\Delta illiquidity_t$		0.620	0.590
adj. R^2	1.0%	36.5%	34.9%

Note: This table reports regression results of average expected and unexpected bond excess returns. The average is computed from bonds with a maturity of $n = 3, 4, \ldots, 120$ months. Both excess return components are derived from the Adrian et al. (2013) term structure model with modified pricing factors, X_t. Here, the pricing factors are derived from forward rates as it is suggested by Cochrane and Piazzesi (2008). F (ΔF) represents (changes of) the Ludvigson and Ng (2009) macroeconomic factors. $Fin.\ Paper$ represents the financial paper issuance, $Net\ financing$ / $Net\ positions$ the net financing / net positions of primary dealers, $CFSI$ / $ANFSI$ the FED Cleveland Financial Stress Indicator / the adjusted Chicago FED's National Financial Conditions Index, OF the five-year U.S. bond future contract's order flow, $illiquidity$ the Amihud (2002) liquidity measure. The regression coefficients and standard errors are block-bootstrapped with 10,000 bootstrap samples. The 10% (5%, 1%) significance level is marked with a * (** / ***).

Appendix

Term structure modeling

This section provides an in-depth analysis of the Adrian et al. (2013) term structure model and of the results for the Gurkaynak et al. (2007) US zero-coupon yield curve between 10/1998 and 12/2012.

Terminology:
For the term structure analysis we use the following notations and definitions. p_t^n defines the log price of a zero-coupon bond with maturity n at time t and $y_t^{(n)}$ the implied yield of a bond which matures in month n. The log forward rate at time t for payments between period $t+n-1$ and $t+n$ is expressed as

$$f^{(n-1 \to n)} = p_t^{(n-1)} - p_t^{(n)} \tag{7}$$

and the log one-period return for holding an n-period bond is

$$r_{t+1}^{(n)} = p_{t+1}^{(n-1)} - p_t^{(n)} \,. \tag{8}$$

The difference between the holding period return in (8) and the return of a one-period bond, the yield $y_t^{(1)}$, defines the log excess return rx:

$$rx_{t+1}^{(n)} = p_{t+1}^{(n-1)} - p_t^{(n)} - y_t^{(1)} \,. \tag{9}$$

According to Ludvigson and Ng (2009) we define the average excess return for bonds with a maturity up to N months at time t, $\bar{rx}_t^{(N)}$, as:

$$\bar{rx}_t^{(N)} = \frac{1}{N-1} \sum_{n=2}^{N} rx_t^{(n)} \,. \tag{10}$$

Term structure modeling:
Here, the theoretical background of the term structure model is provided. The core elements of the model are affine structures of log bond prices to market prices of risk and of market prices of risk to the yield curve.

At the first step the dynamic of the state vector X is modeled. X is backed out from a set of zero-coupon rates with a maturity of n={3,4,. . .,120} months. The state vector follows a VAR(1)–process with the innovation term ν_{t+1} which has, conditional on X_t, a mean of zero and variance Σ:

$$X_{t+1} = \mu + \Phi X_t + \nu_{t+1} \,. \tag{11}$$

The intercept term of equation (11) is set to zero by demeaning the interest rates.

The second step relates log one-month excess returns, rx_{t+1}, to the state variables X_t and the innovation term ν_{t+1}. We write the log excess holding period return as a function of an expected return, a convexity adjustment term, return innovations which are related to ν_{t+1} and a priced error term, e_{t+1}, with variance $\widehat{\sigma}^2$:

$$rx_{t+1}^{(n-1)} = \beta^{(n-1)\prime}(\lambda_0 + \lambda_1 X_t^s) + \frac{1}{2}(\beta^{(n-1)\prime}\Sigma\beta^{(n-1)} + \sigma^2) + \beta^{(n-1)\prime}\nu_{t+1} + e_{t+1}^{(n-1)} \,. \tag{12}$$

To compute parameters we transform equation (12) to

$$rx_{t+1}^{(n-1)} = \alpha^{(n-1)} + \beta^{(n-1)\prime}\nu_{t+1} + c^{(n-1)\prime}X_t^s + e_{t+1}^{(n-1)} \,. \tag{13}$$

The coefficients of equation (13) are stacked into vector form $\widehat{\alpha} = (\widehat{\alpha}^{(1)}, \ldots, \widehat{\alpha}^{(N)})$, $\widehat{\beta} = (\widehat{\beta}^{(1)\prime}, \ldots, \widehat{\beta}^{(N)\prime})$ and $\widehat{c} = (\widehat{c}^{(1)\prime}, \ldots, \widehat{c}^{(N)\prime})$. Finally, we derive the quasi prices of risk, λ_0 and λ_1, from the following conditions:

$$\widehat{\lambda}^0 = (\widehat{\beta}'\widehat{\beta})^{-1}\widehat{\beta}'(\widehat{\alpha} + \frac{1}{2}(\widehat{B}^* vec(\widehat{\Sigma}) + \widehat{d}_e)) \tag{14}$$

$$\widehat{\lambda}^1 = (\widehat{\beta}'\widehat{\beta})^{-1}\widehat{\beta}'\widehat{c} \tag{15}$$

with $B^* = [vec(\beta^{(1)}\beta^{(1)\prime}), \ldots, vec(\beta^{(N)}\beta^{(N)\prime})]$ and $\widehat{d}_e = \widehat{\sigma}^2 i_N$. i_N is a Nx1 vector of ones.

Besides affine excess returns, log bond prices also follow affine processes which depend on the state vector X_t and an error term u_t:

$$\ln P_{t+1}^n = A_n + B_n' X_{t+1} + u_{t+1} \,. \tag{16}$$

A reformulation of (16) leads to the following restrictions for bond pricing which can be solved recursively (see Adrian et al., 2013):

$$A_n = A_{n-1} + B_{n-1}'(\mu - \lambda_0) + \frac{1}{2}(B^{(n-1)\prime}\Sigma B^{(n-1)} + \sigma^2) - \delta_0 \tag{17}$$

$$B_n' = B_{n-1}'(\Phi - \lambda_1) - \delta_1 \tag{18}$$

$$A_0 = 0; B_0' = 0 \tag{19}$$

$$\beta_n' = B_n' \,. \tag{20}$$

The starting parameters are defined as $A_1 = -\delta_0$ and $B_1 = -\delta_1$. We derive the parameters δ_0 and δ_1 from a linear projection of the log one-month interest rate, $y_t^{(1)}$, on a constant and X_t. δ_0 is the intercept coefficient and δ_1 the coefficient vector of X_t.

Cochrane and Piazzesi (2008) return-forecasting factor x:
Cochrane and Piazzesi (2008) propose forward spreads as a more appropriate candidate for forecasting excess returns one year ahead. Here, we account for the fact that the Adrian et al. (2013) model considers one-month excess returns instead of one-year ones. Therefore, we modify x_t such that it is the one-month excess return-forecasting factor. The information in forward rate spreads can be subsumed to one single term structure pricing factor, x_t. We denote the forward spread as

$$\tilde{f}_t^{(n)} = f_t^{(n)} - y_t^{(1)} \tag{21}$$

and define forward spreads for maturities with 6, 18, 24 ..., 60, 84 and 120 months.
The estimation of expected returns starts by regressing excess returns on forward spreads

$$rx_{t+1} = \alpha + \beta\tilde{f}_t + \varepsilon_{t+1} \tag{22}$$

where rx_{t+1} is the one-month ahead excess return. Let $\mathbb{E}_t[rx_{t+1}] = \beta\tilde{f}_t$ be the expected return. We derive a factor structure of expected returns by a factor analysis. Consistent with Cochrane and Piazzesi (2008) and the results above, we find a one-factor specification as sufficient. This factor picks up 99.99% of expected returns' variance and can easily be labeled as "level" factor of forward spreads.

Define x_t as the weighted function of expected returns by the factor loadings of the first principal component

$$x_t = q_r'\mathbb{E}(rx_{t+1}) = q_r'(\alpha + \beta\tilde{f}_t) = q_r'\alpha + \gamma'\tilde{f}_t \tag{23}$$

where q_r' defines the factor loadings and $\gamma' = q_r'\beta$. As β from equation (22) owns a tent-shape pattern and q_r' is in all cases positive, we derive the well-known tent-shaped function of γ' (see Cochrane and Piazzesi, 2005, 2008).

The Cochrane and Piazzesi (2008) pricing factors:

We follow Cochrane and Piazzesi (2008) and extend the set of pricing factors by constructing *level*, *slope* and *curvature* so as not to be not spanned by the return-forecasting factor. To loosen x_t from the term structure, we regress forward rates $f_t^{(n)}$ on x_t and set $n = [6, 18, 24, \ldots, 60, 84, 120]$

$$f_t^{(n)} = c + dx_t + e_t\ . \tag{24}$$

We apply a factor analysis to the residuals e_t, collect the loading of the corresponding factors $Q(:, i)$ and define the term structure factor $i = \{1, ..., 5\}$ at time t, $TSF_{i,t}^{CP}$, as

$$TSF_{i,t}^{CP} = Q(:, i)'(c + e_t) \tag{25}$$

We define the set of pricing factors in the term structure model by the Cochrane and Piazzesi (2008) return-forecasting factor x and the five forward rate factors of equation (25).