Corporate Bond Risk Premia

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This Version: January 14, 2013

Abstract

This paper investigates the risk premia of U.S. corporate and Treasury bonds. Using excess return regressions, two risk factors are derived from yield and macroeconomic data: a priced term risk factor and a priced credit risk factor explain half of the variation in one-year corporate and Treasury excess returns. The information of the term risk factor is not represented by major yield characteristics but is a hidden risk factor whereas the credit risk factor is not hidden. The term risk premium is earned primarily for exposure to inflation and the yield level and the credit risk premium is earned for an exposure to real growth and the credit spread level. The regression results are usefull for the specification of the market prices of risk in affine credit term structure models: The two-factor representation of the risk premium suggests a rank restriction on the market prices of risk and an additional pricing factor to capture the hidden property of term risk.

EFM Classification: 340, 550

Keywords: bond excess returns, credit risk, economic drivers, affine model, hidden factors.

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1 Introduction

Understanding risk premia in fixed income markets is of pivotal importance for investors, regulators and central bankers. Bond yields represent expected future yields as well as risk premia for taking credit and term risk.

Investors are interested in the expected excess returns of investment strategies, their risk and cyclicality with the business cycle. Regulators' and central bankers' interst in the term structure of Treasury and corporate bond yields is to extract forward looking information about the business cycle development. A prerequesite for the use of yield curve data as a business cycle indicator is the understanding of term and credit risk premium contained in yields in order to filter the expectations about perceived future monetary policy and future corporate defaults net of the risk compensation. Term premia in the Treasury bond market are intensively studied, as well as their implications for yield curve modelling both in the finance and macroeconomic literature.[1] Corporate lending conditions have gained the attention of policymakers in the course of the recent financial crisis.[2] Credit spreads are used to measure the acceleration effect of credit conditions for the business cycle. However, there is little research on credit risk premia, the interaction of credit and term risk and on their joint relation to the business cycle.

This is the first paper to jointly investigate the term and credit risk premia of U.S. corporate and Treasury bonds, the role of the business cycle for risk premia and the implications for the specification of the market prices of risk in affine credit term structure models. Three research questions are in the center of interest:

First, what are the joint determinants of risk premia in Treasury and corporate bond markets and are there linear combinations of the determinants that explain risk premia for a wide spectrum of credit qualities and maturities? In the Treasury market, the tent-shaped factor of Cochrane and Piazzesi (2005) predicts Treasury bond excess returns for maturities up to

[1]See literature review in section 2 for the risk premium literature and Rudebusch (2010) for a review of the macro-finance literature of the Treasury yield curve.

[2]Roger and Vlcek (2012) provide a literature survey of dynamic stochastic general equilibrium models with financial imperfections.

five years and thereby provides evidence for a one-dimensional risk factor in the Treasury market. To the best of my knowledge, this is the first paper to study the dimension of risk premia in the Treasury and corporate bond market in a joint approach. I find that excess returns are driven by three one-year average forward rates and three one-year junk-investment-grade forward credit spreads, both with maturity in one, three and five years. They explain about half of the excess return variation. Two factors that are linear combinations of the six forwards have virtually the same explanatory power than the unrestricted model. The first factor represents the term risk, the average excess return of all ratings with increasing impact on longer maturities. The second factor distinguishes bonds from the high-yield and the investment grade sector and will be called credit risk factor. Adding industrial production growth contributes to the predicition of junk bond excess returns.

The second research question is whether the return forecasting credit risk factor or the term risk factor are hidden from the term structures. Hidden factors do not represent major characteristics of the cross section of the yields (e.g. level, slope, credit spread) although they are important determinants of expected excess returns i.e. bond risk premia.[3] I find a hidden term risk factor which is consistent with the Treasury bond risk premia literature. The credit risk factor can be replaced by a linear combination of the first to third yield principal components and is therefore not hidden from the cross section of yields.

The third research question covers the implications of the aforementioned results for the specification of affine term structure models. The two dimensional risk premium imposes a rank restriction on the market price of risk. The presence of a risk factor hidden from the cross section of yields implies to increase the number of factors in a dynamic term structure model beyond the dimension suggested by the cross section alone. Finally, I extend the analysis of Cochrane and Piazzesi (2008) to the corporate sector in order to

[3]The term "hidden" is used in the sense of Cochrane and Piazzesi (2005), (2008) or Duffee (2011) and does *not* imply that the factors are completely unobservable. It means that the hidden factors represent no yield characteristics like level, slope and credit spread that are used to characterize the major cross section characteristics of yields.

study for which factor the time varying market price of risk is earned: The term risk factor is primarily earned for exposure to inflation and the yield level. The credit risk factor is earned for exposure to real economic growth and the credit spread level.

A technical contribution is the construction of a new balanced panel of corporate zero bond excess returns from yield curves and rating migrations for a wide spectrum of maturities and credit qualities.[4] The new balanced panel contains the excess returns of representative corporate zero bonds of each rating and is the corporate equivalent to excess returns derived from the Treasury zero bond yield curve. Therefore, it allows for a direct comparison of this paper's results on term and credit risk premia to the findings of the literature on the Treasury term risk premium.

The remainder of the paper is structured as follows: After a review of the related literature in section 2, section 3 describes the data and the construction of the new balanced panel of corporate bond excess returns. Section 4 investigates the financial drivers of risk premia before hidden factors are studied in section 5. Section 6 covers the business cycle relation of excess returns. Robustness tests are in section 7. Section 8 focuses on the implications for affine term structure models. Section 9 concludes.

2 Related Literature

This paper extends the analysis of risk premia from the Treasury market to the corporate sector, so a review of the Treasury literature is in order. Starting with financial variables to test the expectations theory of the Treasury term structure with a single forward rate in Fama and Bliss (1987) or yield spreads in Campbell and Shiller (1991)[5], one linear combination of five forward rates by Cochrane and Piazzesi (2005) is considered to capture all information in the cross section of yields and explains Treasury bond excess

[4] The literature on corporate bond risk premia usually uses bond indices or individual (coupon) bond prices whereas Treasury risk premia are usually investigated based on interpolated zero bond yield curves.

[5] Campbell and Shiller (1991) predict yield changes but the yield spread was used afterwards to predict excess returns.

returns with an R^2 of up to 44%. Recently, factors unrelated to the Treasury yield curve are found to contain explanatory power for Treasury bond excess returns beyond the cross section of the Treasury yield curve: Macroeconomic variables of Ludvigson and Ng (2009) or liquidity measures of Fontaine and Garcia (2012) as well as investor heterogeneity proxies of Buraschi and Whelan (2010). These studies of Treasury bond risk premia have in common, that one or two financial and/or economic factors drive Treasury bond excess returns i.e. risk premia. Given that the cross-section of Treasury yields is usually described by three factors (e.g. Litterman and Scheinkman (1991) or Duffee (2002)) the dimension of the Treasury risk premium is lower than the dimension of the processes necessary to describe the cross section of yields.

The explanatory power for Treasury bond excess returns of non-yield data as well as the fact that the tent shaped factor of Cochrane and Piazzesi (2005) is not covered by the classical Treasury yield curve factors level, slope and curvature implies the existence of risk factors that are hidden from the Treasury term structure. In a consistent affine term structure model with a one-dimensional market price of risk, Duffee (2011) finds evidence for factors partially hidden from the Treasury term structure. Cochrane and Piazzesi (2005) derive a specification of the market price of risk consistent with their regression results. In a subsequent paper, Cochrane and Piazzesi (2008) use their return forecasting factor as observed but hidden factor in an estimated affine term structure model. The return forecasting factor is the only factor driving the market price of risk. Their time varying risk premium is a compensation for an exposure to the persistent level of the yield curve. These findings allow Cochrane and Piazzesi (2008) to reduce the number of risk process parameters in a four-factor model from 20 to 2. The relation of the Treasury risk premium to a level effect is consistent with the findings of Radwanski (2010) and Cieslak and Povala (2010). Both papers relate the Treasury term risk premia to inflationary trends that are closely related to the level of the yield curve. This paper uses standard techniques from the Treasury literature in a joint study of corporate and Treasury bonds and provides a robustness check for the findings in the default-free market.

In the corporate bond sector, there is only little current research compared to the Treasury market. Fama and French (1989) study the joint determinants of corporate bond and equity risk premia from 1927 onwards based on individual bonds. Three factors – the dividend price ratio, the Treasury slope and a credit spread – have explanatory power for excess returns of stocks, Treasury and corporate bonds with an R^2 of about 30%. The variables are interpreted as financial indicators of the business cycle and the expected excess return is found to be countercyclical. In a consecutive paper, Fama and French (1993) use Treasury and corporate bond indices and more detailed stock market data. Their major finding is an indirect effect of bond market factors on excess stock returns through the stock market risk premium: Even in the presence of other stock market factors, bond factors have a significant impact on stock excess returns whereas the stock market factors loose explanatory power for excess bond returns if bond factors are included. The origin of common variation of excess returns is therefore identified in the bond market. Their bond risk factors correspond to major characteristics of the cross section of yields: The Treasury slope and a credit spread. They are not hidden. Krishnan et al. (2008) predict credit spreads of single firms and find predictive power of firm specific and macroeconomic factors. However this impact is not robust to the inclusion of Treasury term structure or credit spread data. This finding is similar to Collin-Dufresne et al. (2001), who find aggregate data dominates firm specific data. The paper most closely related to this study is Cheng and Kitsul (2008): They investigate holding period returns of investment grade corporate bond and Treasury bond indices from 1976 to 2006 for two maturity clusters each. They find both Treasury forward rates as well as six macroeconomic variables contain predictive power of holding period bond returns with an R^2 of about 60%. In contrast to these studies I extend the cross section of the bond data set as well as the explanatory variables in particular for the junk bond sector.

The investigation of corporate excess returns is closely related to the default event risk premium. The default event risk premium is a compensation for investors if individual firm defaults are not diversifiable and therefore the *event* of a default carries a risk premium. In the case of non-diversification, the risk neutral expected loss measured by the credit spread exceeds the real expected loss and the holding period excess return of a corporate bond is positive on average. Giesecke et al. (2010) studies a long history of U.S. corporate bonds from 1866 to 2008 and find an average credit spread (153 BP) in excess of the average loss (75 BP) which indicates the existence of a default event risk premium. Yu (2002) theoretically decomposes the yield spread into different components one of which is the default event risk premium without an empirical study. Empirical studies of the event risk premium compare *ex ante* the implied risk neutral loss rate to expected (real) default losses. Driessen (2005) uses firm specific corporate bond data and proxies the expected loss by rating agency information whereas Amato and Luisi (2006) use expected default frequencies (EDF) of Moody's KMV model in a macro-finance setting. In both papers the credit spread is on average about twice as large as the expected loss similar to Giesecke et al. (2010). However, after correcting for tax and liquidity effects, there is no clear indication for the existence of a default event premium in Driessen (2005). In contrast to the default event premium literature, I take an *ex post* view by studying the determinants of realized bond excess returns.

3 Data

This paper studies holding period excess bond returns. In a portfolio context, an excess holding period return is the return of an investor that invests in a Treasury or corporate bond over a period shorter than the bond's maturity and funds this investment by a riskfree loan for the holding period. A τ_H year holding period excess return of a bond F_t^{j,τ_n} with a credit quality j and a remaining maturity of τ_n years at the beginning of the holding period in t is defined as

$$rx_{t+\tau_H}^{j,\tau_n} \quad = \quad rh_{t+\tau_H}^{j,\tau_n} - y_t^{T,\tau_H}. \tag{1}$$

y_t^{T,τ_H} is the yield of a default-free Treasury (T) zero bond that matures at the end of the holding period τ_H years from now. The holding period return

$rh^{j,\tau_n}_{t+\tau_H}$ of zero bond F^j_{t,τ_n} between t and $t+\tau_H$ is

$$rh^{j,\tau_n}_{t+\tau_H} = \frac{1}{\tau_H} log\left(\frac{F^{j,\tau_n-\tau_H}_{t+\tau_H}}{F^{j,\tau_n}_t}\right). \quad (2)$$

It is possible to split the excess return into a credit risk premium $rx^{j-T,\tau_n}_{t+\tau_H}$ and the well-known (Treasury) term premium $rx^{T,\tau_n}_{t+\tau_H}$:[6]

$$rx^{j,\tau_n}_{t+\tau_H} = \underbrace{\left(rh^{j,\tau_n}_{t+\tau_H} - rh^{T,\tau_n}_{t+\tau_H}\right)}_{rx^{j-T,\tau_n}_{t+\tau_H}} - \underbrace{\left(rh^{T,\tau_n}_{t+\tau_H} - y^{T,\tau_H}_t\right)}_{rx^{T,\tau_n}_{t+\tau_H}} \quad (3)$$

I will use two datasets: A balanced panel of holding period returns based on yield curves called "Migration Dataset" as well as a bond "Index Dataset". In addition, macroeconomic variables and yield curve data is used to construct explanatory variables.

This study covers a rather short history starting in June 1992 and ending in December 2006. The start is dictated by the availability of interpolated corporate yield curves to construct the balanced excess return panel and the explanatory variables. The end is set prior to the onset of the subprime crisis to make results comparable to existing literature on Treasury term risk premia. The holding period is equal to one year.

Yield Curve Data I use Bloomberg par yield curves constructed from Treasuries and from senior unsecured corporate bonds of the manufacturing industry. Corporate bonds are available for Bloomberg Composite Ratings AAA to B–. Due to the availability of rating migrations, I use full letter ratings only. Bloomberg's option adjusted par yields of senior unsecured bonds from the manufacturing industry are transformed to continuously compounded zero bond yields for each rating class j by the piecewise constant forward rate bootstrapping approach of Fama and Bliss (1987).

Zero bonds with remaining maturities from two to ten years with annual

[6] A bar indicates average excess return of each category j: $\bar{rx}^j_{t+\tau_H} = \sum_{\tau_n} rx^{j,\tau_n}_{t+\tau_H}$. If rating index j is missing, it refers to the average of all ratings.

spacing are considered. In total, there are 63 yield time series: 9 maturities from each of the 7 credit qualities. Figure 1 contains a time series plot of selected yields in Panel A and credit spreads in Panel B. A principal component analysis of the cross section of yields and credit spreads in Table 1 showns a strong comovement of yields since more than 98 % of all 63 yields' variance is explained by three principal components. The principal component loadings in Figure 2 provide a standard interpretation: The first yield principal component in the upper left panel is negatively related to all yields and is the *level*. The second yield principal component in the mid-left is a *credit* indicator that loads positive on junk bond yields and negatively on investment grade yields. It is closely related to the first credit spread principal component in the upper right panel with a correlation of 0.949. The third yield principal component in the lower right panel is a *slope* factor with negative impact on the short end and positive impact on the long end. The magnitude of the opposite effect on the long and short end increases with higher credit quality and is highest for Treasuries. The major characteristics of the yield curve are summarized in the vector of the first to third yield principal components

$$pcy_t = \begin{pmatrix} level_t & credit_t & slope_t \end{pmatrix}' \tag{4}$$

The term premium within each rating class (Panel A, column "T“ to "B") is well described by 2 principal components that describe more than 99 % of the yield variance.

Forward rates f and forward credit spreads fs are constructed from the yield curve and will be used as explanatory factors:

$$f_{t,\tau_F}^{j,\tau} = \frac{\tau}{\tau_F} y_t^{j,\tau} - \frac{\tau - \tau_F}{\tau_F} y_t^{j,\tau-\tau_F} \tag{5}$$

$$fs_{t,\tau_F}^{j,\tau} = f_{t,\tau_F}^{j,\tau} - f_{t,\tau_F}^{T,\tau} \tag{6}$$

Subscript τ is the maturity of the forward and τ_F its time to maturity. To shorten the notation, τ_F is skipped if it is equal to one year.

Migration Dataset The construction of a balanced panel of holding period returns based on corporate yield curves needs to take into account a change in the credit quality during the holding period. A fraction $q_{t+\tau_H}^{jj'}$ of all bonds with initial rating j at time t changes its rating to j' during the holding period. From the holding period return definition in equation (2) follows:[7]

$$rh_{t+\tau_H}^{j,\tau_n} = \frac{\tau_n}{\tau_H} y_t^{j,\tau_n} + \frac{1}{\tau_H} log \left(\sum_{j'=1}^{J} q_{t+\tau_H}^{jj'} e^{-(\tau_n-\tau_H)\cdot y_{t+\tau_H}^{j',\tau_n-\tau_H}} \right). \quad (7)$$

Annual rating migration fractions $q_{t+\tau_H}^{jj'}$ are from Moody's. These migrations are available from 1998 on an annual basis for whole letter ratings.[8] Prior to 1998 I use the historical averages up to 1998. A fraction $w_{t+\tau_H}^{j}$ of ratings are withdrawn each year. The migrations of the respective rating class are upscaled by $1/(1 - w_{t+\tau_H}^{j})$ such that the migration fractions add up to one.[9] The withdrawal-adjusted average migration rates from 1920 to 2011 are in Table 2.

In the case of default ($j' = D$) I use recovery of market value:

$$e^{-(\tau_n-\tau_H)\cdot y_{t+\tau_H}^{D,\tau_n-\tau_H}} = REC_{t+\tau_H} e^{-\tau_n \cdot y_t^{j,\tau_n}}. \quad (8)$$

The annual recovery rate of senior unsecured bonds $REC_{t+\tau_H}$ is from Moody's (2012) as well. A time-series plot of the recovery rate is depicted in Figure 3 together with the rating drift, which is defined as the relative difference of up and downgrades. Recovery is positively related to the rating drift and procyclically related to the business cycle. Thus there are more downgrades and defaults in the NBER recessions (1990/91, 2001 and 2007/09) and in case of a default during a recession, investors suffer a larger loss than during a boom. Therefore, excess returns are likely to covary with the business cycle as well.

[7]This nests the Treasury return ($q_{t+\tau_H}^{TT'} = 1$): $rh_{t+\tau_H}^{T,\tau_n} = \frac{\tau_n}{\tau_H} y_t^{T,\tau_n} - \frac{\tau_n-\tau_H}{\tau_H} y_{t+\tau_H}^{T,\tau_n-\tau_H}$

[8]Annual reports are publicly available from 1993 onwards. The latest report is Moody's (2012). Moody's report of 2003 does not contain a migration matrix.

[9]This adjustment is suggested in Moody's (2008) for the adjustment of transition matrices.

Ratings below B have no equivalent Bloomberg yield data. At the end of the holding period, all non-defaulted bonds that end up below B are assigned to composite rating (C). To proxy yields of rating (C), the historical average loss given default up to t, $(1-\overline{REC}_t)$ and the average historical probability of default $\overline{PD}_t$ are used to approximate the spread between (C) and B rated bonds:[10]

$$y_t^{(C),\tau_n} = y_t^{B,\tau_n} + \frac{(\overline{PD}_t^{(C)} - \overline{PD}_t^{B})(1-\overline{REC}_t)}{\tau_H}. \tag{9}$$

Although equation (9) is based on real probabilities instead of risk neutral ones I make no (default event) risk adjustment since the correction for liquidity and taxes, which is important for the difference between corporate and Treasury bonds, plays a minor role between two corporate rating classes.

Figure 1 contains in panel C a time series plot of the selected one-year excess returns $rx_{t+\tau_H}^{j,\tau_n}$ and in panel D the credit risk premium $rx_{t+\tau_H}^{j-T,\tau_n}$. Summary statistics are in Table 3. The average excess return increases with maturity and decreases with credit quality up to BB. Rating B has a lower average realized excess return than BB. Riskiness of excess returns in terms of the standard deviation increases with longer maturity and lower credit quality.

The principal component analysis of one-year excess returns $rx_{t+\tau_n}^{j,\tau_n}$ and credit risk premia $rx_{t+\tau_H}^{j-T,\tau_n}$ in Table 5 and Figure 4 provide some intuition about the dimension of the risk process. The term risk within each rating (Tab. 5, Panel A, column "T" to "B") is well-described by one factor as in Cochrane and Piazzesi (2005). If all ratings are jointly considered, more than 95% of all excess returns' ($rx_{t+\tau_H}^{j,\tau_n}$) variance is explained by the first and second principal component (Tab. 5, Panel A, "all"). The loadings of the excess return principal components ($rx_{t+\tau_H}^{j,\tau_n}$) are in the upper row of Figure 4. The first principal component in the upper left panel shows an increasing impact in absolute terms for longer maturities irrespective of the rating. The

[10] A wide bar indicates historical averages. Duffie and Singleton (1999) show that under a recovery of market value, the instananeous credit spread is the risk neutral expected loss.

second factor in the upper right panel loads negatively on excess returns of junk bonds and positively on investment grade bonds. All other excess return principal components (not displayed) only contribute marginally and have no easily interpretable loading pattern. Credit risk premia $rx_{t+\tau_H}^{j-T,\tau_n}$ are more homogenous compared to the raw excess returns: The first factor alone captures more than 85% of the total cross sectional variation (Tab. 5, Panel B, "all").

The advantage of this dataset compared to the data used in the existing literature is its wide range of maturities and credit qualities in particular for the junk bond sector. However, some limitations of the data remain: In addition to non-availability of $q_{t+\tau_H}^{jj'}$ before 1998 and a (C) yield curve, the migrations contain financial institutions, non-financial corporates and regulated utilities, out of which only the second group corresponds to the Bloomberg corporate yield curve data such that sector specific events distort the results.[11] Furthermore, recovery is found to be higher for speculative grade bonds, but no rating-specific annual recovery data is available.

Index Database Bond indices of Bank of America Merril Lynch (BofA) are available on Bloomberg. Master indices for investment grade and junk bond ratings as well as Treasury bonds (T) summarize all bonds from each credit category. There are maturity subindices for Treasuries and investment grade corporate bonds. High-yield bond ratings BB, B and (C) are only available from December 1996 onwards without maturity segmentation. Bond indices are face-value weighted total return indices of bonds with a remaining maturity of more than one year. Rebalancing at month-end excludes all bonds that do not coincide with the (sub)index' requirements. Cash-flows received during the month are held as cash in the index to the next rebalancing.

Comparing the selection of excess return time series of the two datasets in Figure 1 Panel C to F shows comparable time-series characteristics. The

[11] e.g. Moody's (2012) calls 2011 the "year of sovereign risk" with a stronger impact on financial institutions, so using these downgradings for the manufacturing industry's yield data are exagerated.

mean and standard deviation of BofA excess returns in Table 4 are comparable to the migration dataset in Table 3 in particular the lower excess return for B and (C) compared to BB. Within a rating class, the indices are slighly less homogenous in terms of variance explained by principal components (Panel C of Table 5) but still more than 95% of the return variance of the maturity subindices of rating j is explained by the first principal component.

Correlations of the holding period returns[12] of the Migration dataset and the Bank of America "Master" indices are in Table 6 Panel A. The BofA Master indices have a high correlation to the average migration $\bar{rh}^j$ of comparable credit quality. However, migration $\bar{rh}^{BB}$ is more closely related to Master BofA investment grade returns than to junk bond data such that the junk-investment grade border is not properly fitted.[13]

The potential problems in the construction of the Migration database are not relevant for the bond indices but for junk bonds the history is shorter and no maturity subindices are available. Therefore the Index Database is used for robustness checks in section 7.2.

Macro Data and other Financial Data I use the annual growth rate industrial production g as a real indicator and annual consumer price inflation π as a nominal indicator.

The relation of realized corporate bond excess returns and the business cycle (Tab. 6, Panel B) is driven by the opposed effects of the procyclcal riskless rate and the countercyclical credit risk: The sum of both is clearly negative for investment grade bonds. For junk bonds, the correlation is close to zero but still negative. For BofA excess returns and for Migration credit risk premia $\bar{rx}^{j-T}$ (not displayed) there is a positive correlation with g for low quality bonds.[14] The relation of excess returns to inflation is negative, consistent with increasing yields as a consequence of higher inflation.

[12]Holding period returns are used to avoid spurious correlations in rx due to the identical short rate.

[13]There is probably a term effect since the average maturity of the indices may deviate from the maturity of the average Migration $\bar{rx}^j$ of 6 years.

[14]In the economic upturn investment grade bonds loose , $corr(g, \bar{rx}^{AAA-T}) = -0.53$, whereas junk bonds gain, $corr(g, \bar{rx}^{B-T}) = 0.19$, in the Migration Dataset.

Finally, the Treasury slope ($y^{5Y} - y^{3M}$) and Moody's $Baa - Aaa$ spread are simple financial indicators as in Fama and French (1989) and (1993). All data is from the Federal Reserve Economic Database (FRED).

4 Determinants of Bond Risk Premia

4.1 Methodology

This section estimates holding period excess return regressions

$$rx^{j,\tau_n}_{t+\tau_H} = \alpha^j_n + \beta^j_n X^o_t + \sigma^j_n \varepsilon_{t+\tau_H} \quad (10)$$

to study which observable variables X^o_t determine the holding period risk premium for bonds with different credit quality j and maturity τ_n.

Parameter estimation is challenging in the presence of autocorrelated and persistent regressors with overlapping data. The monthly spaced one-year excess returns induce a MA(12) structure in the error terms. In line with the literature, I use an OLS approach with the heteroscedasticity and autocorrelation consistent standard errors of Newey and West (1987) with 18 lags.[15] The discussion usually refers to a significance level of 5% if not stated otherwise.

The primary dataset is the Migration dataset, the BofA Index dataset is used to cross check the results in section 7.2. The contribution of this paper is the joint investigation of term and credit risk. So it would be desirable to include all 63 excess returns from the Migration dataset into the analysis. Since a table including all results is quite expensive in terms of space and reading time, I only report the regressions of average excess return of each rating $\bar{rx}^j$ for the Migration dataset. I will refer to selected maturity specific results in the text.

[15] e.g. Cochrane and Piazzesi (2005) or Ludvigson and Ng (2009). Other estimation methods from the literature are inappropriate in the current setting: Bootstrapping the underlying bond data as in Cochrane and Piazzesi (2005) is infeasible since the large panel of corporate bonds induces a curse of dimensionality in the yield VAR estimation. Consistent estimators like Campbell and Yogo (2006) or Stambaugh (1999) are only available for the univariate setting.

4.2 Yield Curve Factors

The determinants of term and credit risk are studied first with rating-specific explanatory variables to determine a benchmark. In a second step joint explanatory varables for all ratings are used to construct two factors that determine term and credit risk for bonds irrespective of rating and maturity.

Rating Specific Cochrane and Piazzesi (2005): Following Cochrane and Piazzesi (2005), the information about term risk of Treasury bonds in the Treasury term structure is best summarized by five one-year Treasury forwards. To capture credit risk, rating-specific one-year forward credit spreads are added in a similar fashion for corporate bond returns. This yields a corporate version of the unrestricted Cochrane and Piazzesi (2005):

$$rx_{t+\tau_H}^{j,\tau_n} = \alpha_n^j + \beta_{n,1}^j f_t^T + \beta_{n,2}^j fs_t^j + \sigma_n^j \varepsilon_{t+\tau_H} \quad (11)$$

with

$$f_t^T = \begin{pmatrix} y_t^{T,1} & f_t^{T,3} & f_t^{T,5} \end{pmatrix}' \quad (12)$$

$$fs_t^j = \begin{pmatrix} cs_t^{j,1} & fs_t^{j,3} & fs_t^{j,5} \end{pmatrix}' \quad (13)$$

The two and four year forwards are skipped to reduce multicolinearity as in Cochrane and Piazzesi (2008). $\beta_{n,1}^j$ and $\beta_{n,2}^j$ are the corresponding parameter vectors with n and j referring to the excess return characteristics. The regressors f_t^T and fs_t^j are used for all bonds of rating class j independent of their maturity τ_n. Table 7 contains the results of the rating-specific Cochrane and Piazzesi (2005) model.

A tent-shaped pattern of Treasury forwards f^T, that is observed in the Treasury market, is not present for low quality bonds. Treasury forwards are jointly significantly different from zero at the 5 % significant level in a $\chi^2(3)$ test in column $p(f^T)$, except for BB. However, individual parameter significance is distorted by multicollinearity in particular for Treasuries for which not a single forward rate is individually significantly different from zero.[16]

Turning to forward credit spreads, there is a pronounced tent-shaped pattern. The three-year forward credit spread is individually significantly positive. The sum of the three parameters in $\beta^j_{n,2}$ is positive for all ratings and the three forward credit spreads are jointly significantly different from zero in the $\chi^2(3)$ test at the 5% level of column $p(fs^T)$. In the abscence of a default event risk premium, the credit spread is just a compensation for expected losses and has no systematic impact on excess returns and the $p(fs^T)$-test provides evidence for a default event risk premium.

The explanatory power in terms of R^2 is 30% for Treasury bonds and increases to more than half of the excess return's variance for junk bonds. For all ratings, the six explanatory variables are jointly significant at the 1 % level. The parameter values increase with larger maturities, the R^2 increases for long-maturity Treasuries, with decreases for short-maturity corporate bonds.

Auxiliary results show that regressors that are specific to the rating and maturity of the dependent variable inspired by Fama and Bliss (1987) provide inferior explanatory power but support the evidence against the expectation hypothesis and for the presence of a default event risk premium. The main lesson from the rating specific approaches are that there is predictability of excess returns with financial variables not only for Treasuries but also for corporate bonds.

Moody's Credit Spread Adjusted Model: The corporate Cochrane and Piazzesi (2005) regressions are uninformative about the risk process that *jointly* drives all maturities and rating classes due to the rating-specific regressors. Moody's junk-investment grade spread $\bar{cs}^M = Baa - Aaa$ used by Fama and French (1989) and (1993) is a common measure of the overall credit risk level. It will be used together with the Treasury forwards f^T which are

[16]There are two sources of multicolinearity: First between forward credit spread and Treasury forwards with equivalent maturity, since both contain the same long term Treasury forward. Second, the same yield is contained in two adjacent forwards and the interpolation of the cross section may induces a high correlation of all yields.

supposed to capture the term risk.

$$rx_{t+\tau_H}^{j,\tau_n} = \alpha_n^j + \beta_{n,1}^j f_t^T + \beta_{n,2}^j \bar{cs}^M + \sigma_n^j \varepsilon_{t+\tau_H} \quad (14)$$

The results of this credit spread augmented Cochrane and Piazzesi (2005) are in Table 8. The impact of Moody's $Baa - Aaa$ spread is significantly positive. The Treasury forwards are jointly significantly different from zero, providing further evidence for a default event premium, but their tent-shape disappears. Comparing the explanatory power of the credit spread augmented model to the rating specific corporate Cochrane and Piazzesi (2005) model in Table 7 gives two major findings: First, the junk-investment grade credit spread is helpful for the prediction of excess returns of bonds with the highest credit quality.[17] The excess returns of bonds with low credit quality are better captured by the rating-specific model. The latter finding can be either explained by the actual need for rating specific information or by the information in the term structure of forward credit spreads.

Unrestricted Forward Model: The unrestricted forward model uses term structure information for both foward rates and forward credit spreads. The rating specific forward spreads in the corporate Cochrane and Piazzesi (2005) approach (11) are replaced by the average junk-investment grade forward spreads $fs^{JI,n}$. Since multicollinearity is a particular problem for the Treasury forwards, the Treasury forwards f^T are replaced by the average forwards $\bar{f}$. The maturities 1, 3, and 5 year forwards are unchanged. The unrestricted joint model is given by

$$rx_{t+\tau_H}^{j,\tau_n} = \alpha_n^j + \beta_{n,1}^j \bar{f}_t + \beta_{n,2}^j fs_t^{JI} + \sigma_n^j \varepsilon_{t+\tau_H} \quad (15)$$

The parameter estimates for all j-n-combinations of the Migration dataset are depicted in Figure 5 and 6, the average excess return results are in Table 9. Average forward rates observe a tent shape and are jointly significantly different from zero at the five percent level except for B rated bonds. Indi-

[17]For the two-year Treasury bond, the R^2 nearly doubles from 21.61 to 41.01%.

vidually, the one- and three year average forwards have the most impact.

Junk-investment grade forward credit spreads observe a tent shape as well. They are jointly insignificantly different from zero for high quality bonds in particular for those with a high time to maturity although the three year forward credit spread is individually significantly larger than zero except for Treasuries. Credit information in average forward rates $\bar{f}$ is sufficient to capture credit risk of high quality bonds such that the information in the junk and investment grade spreads fs^{JI} has no significant influence on these excess returns in the $\chi^2(3)$ test in column $p(fs^{JI})$. For rating T to A, excess returns are better captured in terms of R^2 by average forwards $\bar{f}$ alone (not displayed) compared to the rating-specific Cochrane and Piazzesi (2005) model in Table 7 and the credit spread augmented model in Table 8.

These six financial variables (and a constant) are able to explain more than half of the average excess return variation ($\bar{rx}^j$) in Table 9. R^2 is higher than for the simple credit spread augmented Cochrane and Piazzesi (2005) regressions in Table 8 for all j-n-combinations of the Migration dataset. The *term structure* of credit spreads and not only the level of credit spreads contains important information about the risk premium of corporate and Treasury bonds. Compared to the rating-specific Cochrane and Piazzesi (2005) model in Table 7, the explanatory power is higher except for B for which the R^2 of the rating specific benchmark is five percentage points higher.

Due to the pattern of the coefficients and the high explanatory power, the choice of the explanatory variables seems to be reasonable to construct joint risk factors in the next step.

Restricted Forward Model: Excess returns move jointly to a large extend (Table 5) and the unrestricted coefficients share a common pattern for different credit qualities (Figures 5 and 6). Therefore the unrestricted excess return prediction for each j-n-combination

$$E_t(rx^{j,\tau_n}_{t+\tau_H}) = \alpha^j_n + \beta^j_{n,1}\bar{f}_t + \beta^j_{n,2}fs^{JI}_t. \qquad (16)$$

is used for the factor construction. The idea of the factor construction is to extract the major patterns of α_n^j and $\beta_{n,1}^j$. This is done by a principal component analysis of the expected excess returns (16) with the method of of Cochrane and Piazzesi (2008). All 63 j-n-excess returns from the Migration dataset from Figure 5 and 6 are included in the factor construction and *not* the rating averages of Table 9. The risk factors Z_t correspond to the first and second principal component of the unrestricted demeaned expected returns $E_t(rx_{t+\tau_H}^{j,\tau_n}) - \sum_t E_t(rx_{t+\tau_H}^{j,\tau_n})$ from equation (16):

$$\begin{aligned} Z_t = \begin{pmatrix} Z_t^\tau \\ Z_t^c \end{pmatrix} &= \Gamma_{1:2} \left[E_t(rx_{t+\tau_H}^{j,\tau_n}) - \frac{1}{T} \sum_t E_t(rx_{t+\tau_H}^{j,\tau_n}) \right] \\ &= \Gamma_{1:2} \begin{pmatrix} \beta_1 & \beta_2 \end{pmatrix} \begin{pmatrix} \bar{f}_t - \frac{1}{T} \sum_t \bar{f}_t \\ fs_t^{JI} - \frac{1}{T} \sum_t fs_t^{JI} \end{pmatrix} \end{aligned} \tag{17}$$

$\Gamma_{1:2}$ are the two eigenvectors associated with the largest eigenvalues of the variance-covariance matrix of $E_t(rx_{t+\tau_H}^{j,\tau_n}) - \frac{1}{T} \sum_t E_t(rx_{t+\tau_H}^{j,\tau_n})$ of the Migration dataset. The parameters are given by

$$\Gamma_{1:2} \begin{pmatrix} \beta_1 & \beta_2 \end{pmatrix} = \begin{pmatrix} 28.90 & -54.96 & -2.48 & 13.44 & -40.03 & 5.12 \\ -0.67 & 14.53 & -4.81 & -2.84 & -3.36 & -2.22 \end{pmatrix}$$

The tent shaped pattern for Z^τ of average forward and junk investment grade spread from the unrestricted regressions is inverted. Z^c is negatively related to junk investment rade forward credit spreads. The loadings of the *expected* excess returns in the lower row of Figure 4 have a similar shape than the loadings of *realized* excess returns in the upper row: The first principal component Z_t^τ captures the broad level of all expected excess returns, if expected excess returns are high, the factor is small. Its increasing impact for longer maturities qualifies Z_t^τ as a term risk factor. The second factor Z_t^c distinguishes between junk and investment grade bonds, a high factor value decreases the expected excess return on junk bonds and increases the expected excess return on investment grade bonds. Z_t^c is a credit risk factor. Z_t^τ explains 82.87 % of the expected excess return variance, Z_t^c explaines 14.59 % and the joint explanatory power of the remaining factors is only

2.54%.

To check whether the restrictions induces a loss of explanatory power, the two factors Z_t^τ and Z_t^c are used as explanatory variables:

$$rx_{t+\tau_H}^{j,\tau_n} = a_n^j + b_n^j Z_t + \sigma_n^j \varepsilon_{t+\tau_H} \tag{18}$$

Both factors in Table 10 are significantly different from zero, except for the factor that separates junk and investment grade ratings Z^c, which has no significant impact on BBB. The R^2 has the same magnitude than the unrestricted model in Table 9. As in Cochrane and Piazzesi (2005) for the Treasury market, the restricted model of the risk premium is able to recover the explanatory power of the unrestricted model.

5 Hidden Factors

Three yield principal components pcy_t are sufficient to describe the yield curves as they explain 98.43% of cross-sectional yield variance (Table 1) whereas the remaining 60 principal components explain the remaining 1.57%. Are the factors Z_t^τ and Z_t^c represented by pcy_t or are they hidden from the cross section of yields?

There are no hidden factors in case the yield principal components have the same or higher explanatory power for excess returns than Z_t^τ and Z_t^c:

$$rx_{t+\tau_H}^{j,\tau_n} = \alpha_n^j + \beta_{n,y}^j pcy_t + \sigma_n^j \varepsilon_{t+\tau_H} \tag{19}$$

The yield principal components in rows (19) of Table 13 observe an R^2 between 37% and 49%. For all rating averages, the two factors Z^τ and Z^c in Table 10 have a higher R^2 than the first three principal components. The factors pcy_t that describe more than 98% of yields' cross sectional variance have less predictive power for the excess returns than a linear combination of 6 forward and spot rates. There are hidden factors in the yield curves.

The number of hidden factors still needs to be determined. The second test is to investigate how well the yield principal components are able to explain the yield forecasting factors:

$$Z_t^h = \delta_0^h + \delta_y^h pcy_t + \varepsilon_t^h \tag{20}$$

Table 12 provides indication for the credit risk factor Z_t^c to be not hidden, since only three percent of its variation cannot be explained by pcy_t. In contrast, more than 20% of the term risk factor Z_t^τ variation cannot be captured pcy_t.

Although there is indication for a hidden term risk factor, the ultimate decision whether a factor is hidden can only be judged based on the loss of explanatory power for excess returns when a factor is skipped and replaced by the yield characteristics pcy_t: Factor Z_t^h is hidden, if the R^2 of an excess return regression *without* Z_t^h but including the yield curve characteristics pcy_t and the other factor Z_t^i is as high as the R^2 of the restricted model (18) in Table 10. The model to be estimated is

$$rx_{t+\tau_H}^{j,\tau_n} = a_0^i + b_Z^i Z_t^i + \gamma_y^i pcy_t + \sigma_n^j \varepsilon_{t+\tau_H} \tag{21}$$

Parameter indices j and n are skipped here. Table 13 contains the results for the exclusion of Z^c in (21 a): Looking at the R^2 first, the combination of Z^τ and the three pcy_t are able to achieve a similar fit than both Z. Z^τ is highly significant whereas the hypothesis of joint insignificant principal components cannot be rejected by the χ^2-test for some ratings. Therefore the credit risk information of Z^c can be replaced by the cross section of yields and Z^c is not hidden. In contrast to the credit risk factor Z^c, skipping Z^τ leads to a lower R^2 in line (21b) of Table 13. The impact of Z^c on junk bonds and BBB is insignificantly different from zero. The term risk factor Z^τ cannot be replaced by the yield principal components and is a hidden factor.

Restricted Financial Model: Replacing Z_t^c by three principal components increased the number of free parameters. Therefore a single linear combination of $\gamma_y^i pcy_t$ is derived from the unrestricted regressions parameters γ_y^i in equation (21a) with the principal component methodology that was used to construct Z^τ and Z^c. The first principal component of demeaned

$\gamma_y^i pcy_t$ is called Z_t^y:

$$Z_t^y = \Gamma^y \cdot \gamma_y^\tau \cdot pcy_t = \begin{pmatrix} 1.10 & 3.20 & 2.60 \end{pmatrix} pcy_t. \tag{22}$$

Γ^y is the eigenvector of the largest eigenvalue of $\gamma_y^\tau pcy_t$. γ_y^τ is the parameter vector including all j-n-combinations referring to the yield principal components of equation (21a) including Z_t^τ but not Z_t^c. Table 11 shows a high correlation between Z_t^y and Z_t^c. Hardly surprising, the correlation of Z_t^y with observable yield characteristics is larger in absolute values than for Z_t^c. The fit of the restricted financial model

$$rx_{t+\tau_H}^{j,\tau_n} = a_n^j + b_{n,1}^j Z_t^\tau + b_{n,2}^j Z_t^y + \sigma_n^j \varepsilon_{t+\tau_H} \tag{23}$$

in Table 14 shows that the restriction does not reduce predictive ability in terms of R^2 compared to Table 13. Compared to the credit risk factor Z^c derived from forwards in Table 10, the observable yield characteristics combined in Z^y are effectively able to replace Z^c.

Summarizing the results from yield curve factor models, credit information is not only important for corporate bond risk premia but also for Treasury bond risk premia. This provides evidence for a default event premium and against the expectation hypothesis of the Treasury term structure. In-sample, the explanatory power with R^2 of about 50% is larger than found in the Treasury literature (in a different sample period). The term premium factor Z^τ is hidden from the cross section of yields which is in line with a hidden term risk factor in the Treasury market.

6 Risk Premia and the Business Cycle

This section studies whether business cycle indicators have a significant impact on risk premia beyond the financial variables from the previous section. The role of business cycle indicators is considered by the inclusion of industrial production growth g and inflation π in the financial model (23). The macro augmented financial model is given by

$$rx^{j,\tau_n}_{t+\tau_H} \;=\; a^j_n + b^j_{n,1} Z^\tau_t + b^j_{n,2} Z^y_t + c^j_n \begin{pmatrix} g_t & \pi_t \end{pmatrix}' + \sigma^j_n \varepsilon_{t+\tau_H} \tag{24}$$

Table 15 contains the results. The coefficients and significant levels of Z^τ and Z^y are unchanged by the inclusion of the macro variables. Inflation has only little explanatory power. Industrial production growth has an impact on the excess return of junk bonds but not of investment grade bonds. Good economic conditions i.e. high current growth, increases the expected excess returns of junk bonds which is well in line with a structural credit risk model. The R^2 of investment grade bonds is left broadly unchanged whereas the fit of junk bond excess returns increases by about 10 percentage points.

Macroeconomic variables have increased the number of risk factors as it did the principal components in equation (21). The macro variables have a significant impact on junk bonds only, so I will derive a joint factor for the macro variables and *pcy* with the usual method: First an unrestricted regression for the variables that are supposed to form the factor (*pcy*, g, and π) is estimated

$$rx^{j,\tau_n}_{t+\tau_H} \;=\; a^j_n + b^j_n Z^\tau_t + \gamma_M \begin{pmatrix} pcy'_t & g_t & \pi_t \end{pmatrix}' + \sigma^j_n \varepsilon_{t+\tau_H} \tag{25}$$

Then a principal component analysis of $\gamma_M \begin{pmatrix} pcy'_t & g_t & \pi_t \end{pmatrix}'$ leads to the eigenvector Γ^M associated with the highest eigenvalue. The macro-credit factor is given by

$$Z^M_t \;=\; \Gamma^M \cdot \gamma_M \cdot \begin{pmatrix} pcy'_t & g_t & \pi_t \end{pmatrix}' \tag{26}$$

with

$$\Gamma^M \cdot \gamma_M \;=\; \begin{pmatrix} 1.75 & 4.89 & 2.90 & 4.51 & 2.79 \end{pmatrix} \tag{27}$$

The attempt to replace Z^τ by a linear combination of *pcy*, g and π yields a lower R^2 compared to Table 15 or 16. The hidden property of term risk cannot is robust to the inclusion of business cycle variables.

The correlations in Table 11 show a high comovement between the financial factor Z_t^y and the macro-credit factor Z_t^M. The relation of Z_t^M to yield curve characteristics is lower than for Z_t^y but surprisingly Z_t^M has a lower correlation with g_t than the financial factor Z_t^y. Finally, Z_t^M and Z_t^τ are the explanatory variables in a restricted macro model:

$$rx_{t+\tau_H}^{j,\tau_n} = a_n^j + b_n^j Z_t^\tau + b_n^j Z_t^M + \sigma_n^j \varepsilon_{t+\tau_H} \quad (28)$$

Comparing the results for the restricted model (28) in Table 17 with the macro augmented financial model (24) in Table 15 reveals that there is only a small loss of explanatory power in the Migration dataset. Treasuries have a drop in R^2 of 3 percentage points to 47.79%, investment grade corporate bonds R^2 of 60% and junk bonds about 60%.

Overall, the inclusion of macro variables is helpful for the predicition of excess returns of low quality bonds at the cost of a minor loss of predictive ability of high-quality bonds. Real business conditions are important determinants of the junk bond risk premia. In a joint model for all rating classes, the inclusion of macroeconomic variables seems to be justified.

7 Robustness

7.1 Measurement Error

In the Treasury literature, one is usually concerned about measurement errors stemming from the common dependence of regressors and dependent variables on time t yield information. If there are measurement errors in time t-yields, they can cause spurious excess return predictability. The average forwards $\bar{f}$ of junk investment grade spreads fs^{JI} are less prone to the impact of single yield's measurement error compared to Treasury forwards in the Treasury market studies or rating-specific forward credit spreads in the corporate Cochrane and Piazzesi (2005) approach. However, measurement error remains a potential concern in the Migration dataset as well.

Using lagged explanatory variables eliminates the impact of time t measurement errors as long as these are not serially correlated. Table 18 contains the R^2 for the unrestricted forward model (15) and the corporate Cochrane and Piazzesi (2005) model (11). There is no loss of explanatory power using lagged regressors compared to the results neither for the unrestricted forward model in Table 9 nor for the rating-specific benchmark model in Table 7. The imposition of restrictions does not change this result. Measurement errors are not responsible for the predictive power in the current setting.

7.2 Bank of America Dataset

The Bank of America Index dataset provides the opportunity to test whether the factors Z^i that are derived from the Migration dataset in section 4.2 to section 6 are representative for economy-wide bond risk premia or whether they just capture idiosyncratic characteristics of the Migration dataset maybe stemming from the problems in their construction from yield and rating agency data. In addition, it constitutes another test for measurement errors, since the Index excess returns are not constructed from the yield curve.

In this section I reestimate the regressions from the previous sections with the BofA Index excess returns as dependent variables. The explanatory factors Z_t^τ, Z_t^c, Z_t^y and Z_t^M are the ones derived from the Migration dataset, i.e. they are unchanged and only their loadings b_n^j and constant a_n^j are fitted to the Index dataset. Table 19 contains the results. The column header provides reference to the Table number "Tab ." and the equation number "(.)" of the Migration dataset.

Consider the unrestricted forward model and the two benchmark models in the last three columns first: About half of the excess return variation is explained by the six forwards and forward spreads - a magnitude broadly comparable to the Migration dataset. Only at the threshold between investment grade and junk bond rating, the R^2 is below 50% (BBB and BB). It is difficult to distinguish between junk and investment grade sector in th BofA dataset based on information from the Migration dataset. This is in line with the holding period return correlations in Table 6. Only for the junk bond Master indices "J", the simple "Moody's" credit spread augmented Cochrane and Piazzesi (2005) provide a superior fit than the unrestricted model. Compared to the corporate Cochrane/Piazzesi approach "CP" the unrestricted forward model has a higher R^2 except for the BB index.

The financial factor model in Panel A observes not only an increase in the loadings of the term risk factor Z^τ as in Table 14 but a change in sign for junk bond ratings although the positive coefficients are only marginally significant for (C).[18] The credit risk factor Z^y parameters have a similar pattern than their Migration counterparts: They get larger with decreasing credit quality and the impact is significantly different from zero except for ratings at the threshold between junk nd investment grade bonds. The fit in terms of R^2 compared to the "Unrestr." column is comparable for investment grade bonds but worse for junk bonds, in particular for BB for which the R^2 drops from 48.77% to 22.01%. Again, the fitting of the threshold between investment grade and junk bonds is worse.

The macro-credit factor Z^M in Panel B induces an increase in the explanatory power for junk bonds. The R^2 in Table 17 is now of comparable magnitude to the Migration dataset for all ratings and the deficits in fitting BBB and BB are removed. The coefficients of the macro-financial factor Z^M are increasing for lower credit qualities and are significantly different for all ratings again except for A and BBB. The coefficient of the term risk factor Z^τ is significantly negative only for investment grade bonds. In comparison to the financial model in Panel A, the macro model works better for junk bonds whereas the financial model has an advantage for high quality corporate bonds.

Overall, the results of the Bank of America Index dataset are broadly in line with the results from the Migration dataset, although the credit risk factors Z^c and Z^y have trouble to fit the threshold between investment grade and junk bonds in the BofA dataset if no macro data is used. This might be caused by the construction of the factors by Migration data: Five investment grade or Treasury ratings are combined with only two junk bond ratings such

[18]The restricted forward model (10) with Z^c gives the same economic results than the financial factor model and can be skipped.

that the fit of high quality bonds has a higher weight in the construction of the factors than differences in credit quality. The high increase in R^2 induced by the macro-credit factor Z^M underlines the importance of macroeconomic information for low quality bond risk premia.

8 Affine Models

Following the regression result in the previous sections, the time variation of the market price of risk depends on two linear combinations of forwards, yield principal components and macroeconomic variables. This section illustrates the regression implied consequences for affine term structure modelling and finally for which factor exposure the time varying risk premia are earned for.

An affine term structure model is characterized by K factors in vector X_t that drive the cross-section of yields and risk premia of the bond markets for all maturities and credit qualities. The real world dynamics of the factors are given by a vector autoregressive process:

$$X_{t+\Delta t} = \nu + \Phi X_t + \Sigma \varepsilon_{t+\Delta t} \tag{29}$$

Disturbances ε are iid multivariate standard normal. The factors X_t can be macroeconomic variables or latent processes. In this class of models, the market price of risk processes are affine, too:

$$\lambda_t = \lambda_0 + \lambda_X X_t \tag{30}$$

Technically spoken, the goal of this section is to derive implications for the parameters of the market price of risk λ_0 and λ_X from the excess return regression results.

The details of affine bond pricing models are not relevant for this analysis except that the model can be derived from the stochastic discount factor. The expected excess return is determined by the covariation of the excess return with the factor surprises and the the market price of risk[19]

$$E_t(rx^{j,\tau_n}_{t+\Delta t}) + \frac{1}{2}var_t(rx^{j,\tau_n}_{t+\Delta t}) \quad = \quad cov_t(rx^{j,\tau_n}_{t+\Delta t}, \varepsilon'_{t+\Delta t}\Sigma')\,(\lambda_0 + \lambda_X X_t)\,. \quad (31)$$

The left hand side expectation is $\alpha^j_n + \beta^j_n X_t$ and the variance $(\sigma^j_n)^2$ from the restricted regression (23) or (28). β^j_n contains restrictions from the factor constructions that are discussed below. The conditional covariance is time-constant in the Gaussian setting and the matching principle yields a relation between excess return regression coefficients and the market price of risk parameters:

$$\alpha^j_n + \frac{1}{2}(\sigma^j_n)^2 \quad = \quad cov_t(rx^{j,n}_{t+\Delta t}, \varepsilon'_{t+\Delta t}\Sigma')\lambda_0 \qquad (32)$$

$$\beta^j_n \quad = \quad cov_t(rx^{j,n}_{t+\Delta t}, \varepsilon'_{t+\Delta t}\Sigma')\lambda_X \qquad (33)$$

The regression coefficients and the covariance are specific to the holding period: The data frequency Δt of the VAR must equal the holding period τ_H of the regression. This might contradict the usual quartely or monthly VARs that are used in the affine term structure literature.

The presence of latent factors turns X_t and $\varepsilon_{t+\Delta t}$ to unobservable variables. Therefore the time series process (29) and the excess return regression parameters α^j_n and β^j_n cannot be estimated from observable data as well as the covariance term in (31). However, latent factors are usually highly correlated with yield principal components. In order to gain some intuition for the origin of the risk premium without a specification of a dynamic term structure model, I carry on with the hidden term rsik factor Z^τ_t and the yield principal components as proxies for the latent yield factors:[20]

$$X_t \approx X^o_t = \begin{pmatrix} Z^\tau_t & pcy'_t \end{pmatrix}' \qquad (34)$$

For the macro-credit specification, industrial production growth and inflation

[19]See appendix A.1 and Cochrane and Piazzesi (2008).

[20]Appendix A.2 discusses the conditions and potential inconsistencies if observable data replaces latent factors.

are added to the factor vector:

$$X_t \approx X_t^o = \begin{pmatrix} Z_t^\tau & pcy_t' & g_t & \pi_t \end{pmatrix}' \tag{35}$$

The estimation of the observable equivalent of (29) with demeaned X_t^o at data frequency τ_H is carried out with OLS:

$$X_{t+\tau_H}^o = \Phi X_t^o + \varepsilon_{t+\tau_H}^o \qquad \text{with} \qquad \varepsilon_{t+\tau_H}^o \sim N(0, V^o). \tag{36}$$

Given the one-year holding period, the time-series contains only 14 observations. Therefore I estimate the factor processes independently, such that only one parameter per factor has to be estimated. The monthly frequency yields twelve estimates for Φ from which I use the simple average to construct $\varepsilon_{t+\tau_H}^o$.[21] The errors are used to determine the covariances with excess returns $C_{\tau_H}^{j,n} = cov_t(rx_{t+\tau_H}^{j,n}, (\varepsilon_{t+\tau_H}^o)')$. The parameter mapping from equations (32) and (33) is

$$\alpha_n^j + \frac{1}{2}\sigma_n^j = C_{\tau_H}^{j,n}\lambda_0 \tag{37}$$

$$\beta_n^j = C_{\tau_H}^{j,n}\lambda_X \tag{38}$$

Section 4 provides evidence for only two linear combinations to represent the market price of risk. Therefore a rank restriction on λ_X can be imposed:

$$\lambda_X = \underset{(K\times 2)}{\lambda_l} \; \underset{(2\times K)}{\lambda_r} = \begin{pmatrix} \lambda_1 & \lambda_2 \end{pmatrix} \lambda_r \tag{39}$$

λ_l contains the loadings of the two factors in column vectors λ_1 and λ_2. λ_r contains the structural relation between the factors. Z_t^τ is included in X_t^o whereas Z_t^y and Z_t^M are linear combinations of pcy_t and maybe g_t and π_t:

$$\lambda_r = \begin{pmatrix} 1 & 0_{K-1\times 1} \\ 0 & \Gamma^i \cdot \gamma_i \end{pmatrix} \tag{40}$$

[21]The average autoregressive matrix used for the calculation is given by

$$\Phi = diag(\; 0.319 \quad 0.041 \quad 0.340 \quad 0.579 \quad 0.636 \quad 0.229 \;).$$

Index i is either y for the financial factor Z_t^y for which the restriction is given by $\Gamma^y\gamma_y$ in equation (22) or $i = M$ if macro variables are included for which the restriction $\Gamma^M\gamma_M$ is given by equation (26). The only free parameters are in the loading matrix λ_l. The rank restriction and the restricted excess return parameters are used to split the mapping of β_n^j into two parts

$$\begin{aligned} \beta_n^j &= C_{\tau_H}^{j,n}\lambda_l\lambda_r && (41) \\ \begin{pmatrix} b_{n,1}^j & b_{n,2}^j\Gamma^i\gamma_i \end{pmatrix} &= C_{\tau_H}^{j,n}\begin{pmatrix} \lambda_1 & \lambda_2\Gamma^i\gamma_i \end{pmatrix} && (42) \end{aligned}$$

to recover the two-factor structure of the excess return regression:[22]

$$\begin{aligned} b_{n,1}^j &= C_{\tau_H}^{j,n}\lambda_1 && (43) \\ b_{n,2}^j &= C_{\tau_H}^{j,n}\lambda_2 && (44) \end{aligned}$$

λ_0, λ_1 and λ_2 are identical for all j and n. Equations (43), (44) and (37) can be interpreted as cross sectional regressions to estimate the constant of the market price of risk λ_0, the first column λ_1 and the second column λ_2 of the loading matrix. The dependent variables a_n^j, $b_{n,1}^j$, and $b_{n,2}^j$ are explained by the covariance $C_{\tau_H}^{j,n}$.[23] Table 20 contains the OLS estimates of λ_0, λ_1 and λ_2 as well as associated absolute t-values. The numerical values of λ are not informative, but the significance levels indicate for which factors the time varying risk premium is earned for. Both the Migration dataset and the BofA maturity subindices of investment grade ratings are used.

Migration Dataset: All parameters of the 63 combinations of j and n from Figure 5 and 6 are used to estimate the market price of risk parameters. The results are in Panel A of Table 20. Consider the financial model with dynamics of Z^τ and *pcy* for one-year excess returns ($\tau_H = 1$) in the left block

[22] $\Gamma^i\gamma_i$ is eliminated by postmultiplicating the second block with $(\Gamma^i\gamma_i)'[\Gamma^i\gamma_i(\Gamma^i\gamma_i)']^{-1}$:

$$b_{n,2}^j = b_{n,2}^j\Gamma^i\gamma_i(\Gamma^i\gamma_i)'[\Gamma^i\gamma_i(\Gamma^i\gamma_i)']^{-1}$$

[23] The graphical approach of Cochrane and Piazzesi (2008) in a one hidden factor setting is not feasible with the large number of j-n-combinations.

of Panel A first. The constant λ_0 and the market price of risk associated to term risk λ_1 have a significant entry for the *level*. The unconditional mean as well as the compensation for the term risk Z^τ is earned for an exposure to *level* risks. In addition, term risk premia are also earned for exposure to term factor itself and to *slope*. The relation of the term risk to the *level* is consistent with the findings of Cochrane and Piazzesi (2008) in the Treasury market and supports the specification of the market price of (term) risk in Duffee (2011). The credit risk factor Z^y has an impact on risk premia through the credit factor itself.

Adding macroeconomic variables to the model in the right block of Panel A allows to investigate the economic sources of the risk premia. The unconditional market price of risk has no significant entry for macroeconomic variables but all financial variables turn out to be significant. The term risk is related to output growth, inflation, and *level*. The significant entries in the financial model in Panel A for Z^τ and *slope* are not present anymore. The relation of term risk to inflation is a finding similar to Radwanski (2010) and Cieslak and Povala (2010) in a different setting. The irrelevance of the slope for the term premium is discussed in Cochrane and Piazzesi (2008). The remuneration of term risk for exposure to real business risk and credit spread exposure is novel but in line with economic intuition.

Bank of America Investment Grade Indices: I use the 36 maturity specific subindices from investment grade ratings in Table 4 to estimate the parameters in Panel B. The results for the term premium support the major findings for the term risk: It is primarily related to the *level* and macroeconomic variables. In the financial model in the left block of Panel B, the *level* is the only relevant variable, *slope* and Z^τ are not significantly different from zero. The results for credit risk factors Z^y and Z^M derived from the Migration dataset are different in the BofA dataset: All variables seem to be relevant except for the *slope* in the macro-credit model n the right block of Panel B. However the Bank of America Index Database only comprises data from the investment grade sector.

Summarizing the result of the impact channel study, the findings of the relation of term risk to *level* and inflation and the irrelevance of the *slope* for the term premium are in line with existing research on the Treasury term premium. The relation of credit risk to the real business cycle conditions is in line with economic intuition. However, some caution is warranted in particular for the constant and the role of credit risk in the BofA dataset. In a consistent affine term structure model, a flexible specification of the market price of risk processes is highly recommended.

9 Conclusion

This paper is the first empirical study of the joint determinants and the dimension of term and credit risk premia. I extend the literature on Treasury bond premia to the corporate sector in order to improve our understanding of credit and term risk premia. Two linear combinations of yield and macroeconomic variables are priced risk factors. The credit risk factor is represented by major yield curve characteristics in contrast to the term risk factor that is hidden.

A key finding for all specifications and datasets is the superior performance of restricted models with joint factors compared to *un*restricted rating-specific benchmarks: The general credit conditions seem to be more important for a bond's return than information specific to the bond's credit quality in particular for bonds with the highest credit quality. This implies for finance and macroeconomics to aggregate information for an econometric and an economic reason: Given the true model is in fact a two risk factor model, the average forwards are less distorted by measurement errors or liquidity differences than rating specific data. The economic explanation is based on the business cycle dynamics. High quality bond yields reflect primarily the central bank's decisions about the riskless short rate which depends on the stance of the business cycle. A growing literature provides evidence for the superior information in credit data for the business cycle compared to Treasury yield data. Hence, credit information has explanatory power for future growth which is an important determinant of future central bank key rates and finally the high quality bond yield.[24]

The results from this paper deliver valuable intuition for the specification of an affine credit term structure model: The two risk factor structure suggests a rank restriction on the market price of risk and the hidden factor property suggests an additional factor of an affine model. These restrictions reduce the number of parameters in an affine credit term structure model which may facilitate its estimation. In addition, I find the term risk premia are compensations for exposure to *level* and inflation risk whereas credit risk is a compensation for real growth risk and *credit* spread level risk. All term risk findings are in line with the Treasury bond excess return literature.

Overall, the regression results and their implications for affine models improves our understanding of expected future interest rates and risk premia which is necessary to base well-founded investment strategies or policy decisions on yield curve data.

A Appendix

A.1 Expected Excess Return and Market Price of Risk

The step length Δt of the VAR (29) is equal to the holding period $\tau_H = \Delta t$. The log stochastic discount factor (SDF) is given by

$$m_{t,t+\Delta t} = -y_t^{T,\Delta t} - \frac{1}{2}\lambda_t'\Sigma\Sigma'\lambda_t - \lambda_t'\Sigma\varepsilon_{t+\Delta t} \tag{45}$$

The conditional expectation and the conditional variance are given by:

$$\begin{aligned} E_t(m_{t,t+\Delta t}) &= -E_t(y_t^{T,\Delta t}) - \frac{1}{2}E_t(\lambda_t'\Sigma\Sigma'\lambda_t) - E_t(\lambda_t'\Sigma\varepsilon_{t+\Delta t}) \\ &= -y_t^{T,\Delta t} - \frac{1}{2}\lambda_t'\Sigma\Sigma'\lambda_t \qquad (46) \\ var_t(m_{t,t+\Delta t}) &= var_t(-y_t^{T,\Delta t} - \frac{1}{2}\lambda_t'\Sigma\Sigma'\lambda_t - \lambda_t'\Sigma\epsilon_{t+\Delta t}) \\ &= \lambda_t'\Sigma\Sigma'\lambda_t \qquad (47) \end{aligned}$$

[24] See Mueller (2008), Speck (2010) or Dewachter et al. (2012) for affine credit term structure models that investigate the feedback of financial conditions on the business cycle.

For a excess return over a Δt period follows:

$$
\begin{aligned}
1 &= E_t\left(e^{m_{t,t+\Delta t}+rh^{j,n}_{t,t+\Delta t}}\right)\\
0 &= E_t\left(m_{t,t+\Delta t}+rx^{j,n}_{t,t+\Delta t}+y^{T,\Delta t}_t\right)+\frac{1}{2}var_t\left(m_{t,t+\Delta t}+rx^{j,n}_{t,t+\Delta t}\right)\\
0 &= E_t(rx^{j,n}_{t,t+\Delta t})+\frac{1}{2}var_t(rx^{j,n}_{t,t+\Delta t})-cov_t(rx^{j,n}_{t,t+\Delta t},\varepsilon'_{t+\Delta t}\Sigma')\,(\lambda_0+\lambda_X X_t)
\end{aligned}
$$

If the holding period is equal to the time step of the VAR, the mapping from regression parameters to market prices of risk is straightforward since $E_t(.)$ and $var_t(.)$ are given by the regression and the conditional one-period covariance is time invariant due to the Gaussian innovation.

A.2 Affine Models and Forecasting Factor

This appendix covers the distinction between observable variable processes and latent factors. Principal components as well as yields or the forwards underlying potential forecasting factor are measurements rather than factors in an affine term structure model:

$$
\begin{aligned}
Y_t &= A+BX_t+v_t && (48)\\
pcy_t &= \Gamma(Y_t-\bar{Y}) && (49)
\end{aligned}
$$

Y_t is a vector of zero bond yields. $\bar{Y}$ is the yield average and Γ the eigenvector(s) associated with the principal components. A and B contain the restrictions of no-arbitrage.

Hamilton and Wu (2010) derive for their minimum chi squared estimation approach a mapping from the observable X^o_t process (36) parameters to the latent X_t factor process parameters of (29). For the financial model, assuming zero measurement error $v_t = 0$, substitute (49) and (48) into (36). Solve for the latent variables X_t yields the latent factor dynamics as a function of the observable factor VAR:

$$X_{t+1} = \underbrace{(\Gamma B)^{-1}\left[\nu^o + (\Phi^o - I)\Gamma(A - \bar{Y})\right]}_{\nu} \quad (50)$$

$$\underbrace{(\Gamma B)^{-1}\,\Phi^o\Gamma B}_{\Phi}\, X_t + \underbrace{(\Gamma B)^{-1}\,\Sigma^o}_{\Sigma}\,\varepsilon_{t+1} \quad (51)$$

Unless the additional restriction $X^o_{t+1} = X_t$ is imposed, the observable counterpart can differ from the latent factors.

$$X^o_{t+1} = pcy_t = \Gamma(Y_t - \bar{Y}) \quad (52)$$

$$= \Gamma\left(A + BX_t + v_t\right) \quad (53)$$

$$= \Gamma(A - \bar{Y}) + \Gamma B X_t + \Gamma' v_t. \quad (54)$$

Three requirements have to be met for $X^o_t = X_t$: First the measurement errors v_t have to be tiny. However, the assumption of no measurement error is critical in the light of hidden factors: What is considered to be a minor measurement error in the cross section of yields may turn out to be an important hidden factor for expected excess returns. Therefore in the model specification process, the dimension of the factor process may not solely be determined from the cross section of yields. Second, $I_K = \Gamma B$ which is not problematic from a parameter-restrictions count since there are K^2 free parameters in λ_K that is used to construct B. Third, $0 = \Gamma'(A - \bar{Y})$ imposes K restrictions which can be met by the K free parameters in λ_0 that determine A.

From a mathematical perspective it is possible to construct market prices of risk such that the observed variables coincide with the factors (see also Cochrane and Piazzesi (2005) section III. B). From an economic perspective, the restrictions on λ_X that are necessary to set $X^o_t = X_t$ may conflict with the rank restriction on the risk premia in section 4. A restriction to rank rk reduces the number of parameters by $rk \cdot (K - rk)$ and there are not enough free parameters to ensure $X^o_t = X_t$.

So why do I carry on with $X^o_t \approx X_t$ despite these shortcomings? The estimation of an unrestricted affine term structure model is challenging and

I hope the approximation errors are small enough to get further insights into the structure of the market price of risk. These insights might be helpful in the specification and estimation of a consistent dynamic credit term structure model.

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Table 1: **Yield and Credit Spread Variance Explanation**

Variance explained by the 1st to 5th principal component in percent. "all" summarizes all bond yields or spreads including Treasuries. "IG" indicates all corporate investment grade time series, "J" all corporate junk bond time series. "T" to "B" are the variance explained of principal components that are calculated from all maturities of the rating class.

Panel A: Yield variance explained.

	all	IG	J	T	AAA	AA	A	BBB	BB	B
1	83.57	94.59	94.81	94.97	95.33	95.29	95.45	95.22	96.61	97.49
2	12.36	4.63	2.63	4.89	4.51	4.57	4.39	4.58	2.92	2.04
3	2.50	0.53	1.42	0.08	0.08	0.07	0.07	0.10	0.27	0.31
4	0.63	0.05	0.70	0.03	0.04	0.03	0.05	0.04	0.11	0.08
5	0.36	0.04	0.22	0.01	0.02	0.02	0.03	0.03	0.05	0.04

Panel B: Credit spread variance explained

	all	IG	J		AAA	AA	A	BBB	BB	B
1	87.60	89.10	91.14		88.08	92.14	93.33	95.16	94.67	93.40
2	5.76	5.07	5.19		5.95	3.11	3.30	3.47	4.59	5.93
3	3.58	1.67	2.30		2.18	1.59	1.48	0.61	0.39	0.40
4	0.85	1.07	0.73		1.41	1.17	0.58	0.25	0.19	0.15
5	0.74	0.69	0.30		1.16	0.87	0.51	0.20	0.08	0.06

Table 2: **Average Moody's Annual Rating Migration 1920-2011**

Average migration in percent. Column header is start of year rating j. End of period rating j' name is in in the first row. Source: Withdrawal-adjusted rating migration from Exhibit 25 of Moody's (2012).

	AAA	AA	A	BBB	BB	B	(C)	D
AAA	90.40	1.27	0.08	0.04	0.01	0.01	0.00	0.00
AA	8.53	89.83	3.06	0.30	0.09	0.05	0.03	0.00
A	0.87	7.81	89.93	4.75	0.53	0.17	0.08	0.00
BBB	0.17	0.79	5.92	88.26	6.68	0.66	0.13	0.00
BB	0.03	0.18	0.74	5.34	82.84	6.56	0.72	0.00
B	0.00	0.04	0.13	0.85	7.68	81.43	6.60	0.00
(C)	0.00	0.01	0.04	0.16	0.73	6.94	71.79	0.00
D	0.00	0.07	0.10	0.30	1.43	4.19	20.65	100.00

Table 3: **Migration Excess Return Statistics**

1-year excess returns' mean and *(standard deviation)* in percent.

j	$rx^{j,2}$	$rx^{j,3}$	$rx^{j,4}$	$rx^{j,5}$	$rx^{j,6}$	$rx^{j,7}$	$rx^{j,8}$	$rx^{j,9}$	$rx^{j,10}$
T	0.600	1.023	1.515	1.721	2.348	2.568	2.790	2.923	2.907
	(1.394)	*(2.707)*	*(3.778)*	*(4.726)*	*(5.619)*	*(6.454)*	*(7.302)*	*(8.018)*	*(8.579)*
AAA	0.910	1.424	1.998	2.216	2.748	2.919	3.233	3.275	3.551
	(1.459)	*(2.783)*	*(3.998)*	*(4.890)*	*(5.846)*	*(6.588)*	*(7.329)*	*(8.127)*	*(8.851)*
AA	0.962	1.442	2.004	2.205	2.777	2.945	3.210	3.273	3.495
	(1.470)	*(2.807)*	*(3.952)*	*(4.847)*	*(5.865)*	*(6.623)*	*(7.352)*	*(8.110)*	*(8.873)*
A	1.143	1.719	2.256	2.473	3.111	3.275	3.503	3.542	3.693
	(1.497)	*(2.819)*	*(3.770)*	*(4.599)*	*(5.651)*	*(6.393)*	*(7.063)*	*(7.773)*	*(8.699)*
BBB	1.306	1.796	2.267	2.442	3.032	3.128	3.188	3.279	3.383
	(1.446)	*(2.650)*	*(3.672)*	*(4.529)*	*(5.580)*	*(6.397)*	*(7.140)*	*(7.891)*	*(8.553)*
BB	2.264	2.809	3.351	3.698	4.195	4.329	4.774	5.086	5.594
	(2.294)	*(3.410)*	*(4.493)*	*(5.266)*	*(6.013)*	*(6.707)*	*(7.467)*	*(8.304)*	*(9.420)*
B	0.783	1.131	1.526	1.561	1.669	1.597	1.671	1.665	1.832
	(3.384)	*(4.511)*	*(5.558)*	*(6.505)*	*(7.727)*	*(8.860)*	*(9.726)*	*(10.604)*	*(11.671)*

Table 4: **BofA Index Excess Return Statistics**

1-year excess returns' mean and *(standard deviation)* in percent. "Master" is the index for all maturities of a rating. Empty entries indicate no available data. The sample period June 1992 to December 2006 for all data except for "BB", "B" and "(C)", that start in December 1996.

j	Master	1-3Y	3-5Y	5-7Y	7-10Y	10-15Y	15+Y
IG	2.590	1.437	2.114	2.653	2.755	3.127	3.447
	(4.919)	*(1.921)*	*(3.431)*	*(4.596)*	*(5.626)*	*(6.297)*	*(7.088)*
J	3.296						
	(7.946)						
T	1.810	0.616	1.416	1.876	2.167	2.726	3.601
	(4.258)	*(1.603)*	*(3.638)*	*(4.599)*	*(5.779)*	*(5.959)*	*(8.258)*
AAA	2.485	1.249	1.999	2.717	2.614	3.113	3.586
	(4.845)	*(1.907)*	*(3.585)*	*(4.684)*	*(5.887)*	*(6.261)*	*(6.783)*
AA	2.461	1.370	2.078	2.710	2.844	2.915	3.559
	(4.948)	*(1.945)*	*(3.559)*	*(4.761)*	*(5.835)*	*(6.662)*	*(7.354)*
A	2.559	1.424	2.121	2.785	2.737	3.116	3.521
	(4.844)	*(1.914)*	*(3.505)*	*(4.818)*	*(5.731)*	*(6.636)*	*(7.190)*
BBB	2.635	1.419	2.121	2.563	2.748	3.399	3.390
	(5.148)	*(2.168)*	*(3.566)*	*(4.824)*	*(5.628)*	*(6.263)*	*(7.184)*
BB	2.643						
	(6.255)						
B	1.374						
	(9.193)						
(C)	1.325						
	(17.911)						

Table 5: **Excess Return Variance Explanation**

Variance explained by the 1st to 5th principal component in percent. "IG" indicates all corporate investment grade time series, "J" all junk bond time series. "IG" in Panel C is not the variance percentage explained of the six investment grade maturity specific subindices in the first row of Table 4 but refers to the 24 maturity specific corporate investment grade subindices from ratings AAA to BBB in Table 4.

				Panel A: Excess return $rx^{j,\tau_n}_{t+\tau_H}$						
	all	IG	J	T	AAA	AA	A	BBB	BB	B
1	78.83	96.75	89.81	97.85	97.91	98.10	97.99	97.79	96.38	96.95
2	16.78	1.76	6.99	1.85	1.75	1.61	1.68	1.83	2.91	2.32
3	1.54	0.91	1.68	0.18	0.18	0.16	0.18	0.23	0.44	0.48
4	1.15	0.13	0.84	0.05	0.08	0.06	0.07	0.06	0.16	0.15
5	0.54	0.12	0.32	0.03	0.03	0.02	0.03	0.04	0.07	0.05
				Panel B: Credit risk premium $rx^{j-T,\tau_n}_{t+\tau_H}$						
	all	IG	J		AAA	AA	A	BBB	BB	B
1	85.52	73.79	90.28		86.02	87.55	87.71	92.24	93.70	95.89
2	5.42	13.62	5.04		6.19	6.07	6.28	4.77	4.67	3.11
3	3.51	3.60	2.72		3.56	2.58	3.09	1.49	1.16	0.64
4	2.03	2.37	0.87		2.04	1.93	1.04	0.58	0.23	0.19
5	0.84	1.80	0.55		0.93	0.76	0.67	0.36	0.12	0.09
				Panel C: BoA excess return of $rx^{j,\tau_n}_{t+\tau_H}$						
	all	IG	J	T	AAA	AA	A	BBB	BB	B
1		91.61		96.07	95.42	96.31	96.00	96.14		
2		4.35		3.49	3.18	2.90	3.09	2.08		
3		2.40		0.31	1.10	0.59	0.71	1.14		
4		0.57		0.08	0.19	0.14	0.12	0.32		
5		0.30		0.03	0.07	0.04	0.06	0.21		

Table 6: **Data Correlation**

Correlation of the average realized holding period return $\bar{rh}^j$ of the Migration dataset (column headers) and the realized holding period return of the Bank of America "Master" indices in Panel A. Panel B contains the correlation of the Migration *excess* returns $\bar{rx}^j$ with selected financial and economic indicators.

	$\bar{rh}^T$	$\bar{rh}^{AAA}$	$\bar{rh}^{AA}$	$\bar{rh}^A$	$\bar{rh}^{BBB}$	$\bar{rh}^{BB}$	$\bar{rh}^B$
Panel A: Bank of America Index Holding Period Return							
T	0.985	0.966	0.964	0.951	0.921	0.663	0.311
AAA	0.976	0.985	0.984	0.977	0.960	0.769	0.443
AA	0.973	0.981	0.979	0.973	0.954	0.758	0.424
A	0.963	0.981	0.981	0.979	0.971	0.806	0.499
BBB	0.828	0.854	0.851	0.858	0.907	0.884	0.673
BB	0.027	0.091	0.085	0.097	0.243	0.583	0.609
B	-0.201	-0.136	-0.133	-0.104	0.048	0.473	0.837
(C)	-0.287	-0.205	-0.204	-0.169	-0.012	0.460	0.837
Panel B: Macroeconomic and Financial Indicators							
	$\bar{rx}^T$	$\bar{rx}^{AAA}$	$\bar{rx}^{AA}$	$\bar{rx}^A$	$\bar{rx}^{BBB}$	$\bar{rx}^{BB}$	$\bar{rx}^B$
g	-0.322	-0.404	-0.398	-0.393	-0.378	-0.348	-0.043
π	-0.265	-0.299	-0.300	-0.295	-0.223	-0.160	-0.241
$y^T_{5Y} - y^T_{3M}$	-0.049	0.050	0.061	0.116	0.124	0.286	0.343
FFR	-0.265	-0.369	-0.381	-0.419	-0.444	-0.582	-0.598
Aaa - FFR	0.148	0.249	0.261	0.310	0.303	0.404	0.371
Baa - FFR	0.170	0.274	0.285	0.330	0.312	0.400	0.360
Baa - Aaa	0.233	0.312	0.313	0.304	0.223	0.185	0.114

Table 7: **Corporate Cochrane and Piazzesi (2005)**

Corporate Cochrane and Piazzesi (2005) regressions with selected maturities from equation (11). $p(.)$ are the probabilities of a $\chi^2(3)$ test for blockwise insignificance of all Treasury forwards or all forward credit spreads. Constants are included in the estimation but not displayed. Absolute t-values in brackets and p-values are based on Newey and West (1987) standard errors with 18 lags. R^2 in percent.

	$y^{T,1}$	$f^{T,3}$	$f^{T,5}$	$cs^{j,1}$	$fs^{j,3}$	$fs^{j,5}$	R^2	$p(f^T)$	$p(fs^j)$
$\bar{rx}^T$	-2.034	3.680	0.415				29.69	0.00	
	[1.242]	*[1.026]*	*[0.141]*						
$\bar{rx}^{AAA}$	-2.743	3.948	0.700	0.952	5.629	1.385	32.61	0.00	1.03
	[1.681]	*[0.942]*	*[0.195]*	*[0.250]*	*[3.268]*	*[0.738]*			
$\bar{rx}^{AA}$	-2.788	4.004	1.088	-0.567	7.759	1.249	40.34	0.00	0.00
	[2.316]	*[1.281]*	*[0.384]*	*[0.159]*	*[5.088]*	*[0.944]*			
$\bar{rx}^A$	-1.658	2.610	1.152	2.012	4.023	-0.102	39.15	0.03	0.82
	[1.434]	*[0.933]*	*[0.402]*	*[0.510]*	*[2.561]*	*[0.083]*			
$\bar{rx}^{BBB}$	-2.289	2.610	2.470	-2.654	5.945	0.436	44.57	0.00	0.04
	[2.133]	*[0.988]*	*[1.181]*	*[0.891]*	*[3.420]*	*[0.352]*			
$\bar{rx}^{BB}$	-1.193	0.687	3.147	-0.912	5.940	-1.177	56.03	5.86	0.00
	[2.102]	*[0.399]*	*[1.874]*	*[0.585]*	*[3.206]*	*[1.100]*			
$\bar{rx}^B$	-3.768	2.836	2.534	-2.649	5.798	0.015	52.30	2.12	1.31
	[3.076]	*[1.030]*	*[1.236]*	*[1.231]*	*[2.530]*	*[0.013]*			

Table 8: **Credit Spread-Augmented Cochrane and Piazzesi (2005)**

Credit spread augmented Treasury forward regression (14). $\bar{cs}^M$ is Moody's Baa-Aaa spread. $p(.)$ are the probabilities of the blockwise χ^2 test for insignificance of all variables or for the three Treasury forwards. Absolute t-values in brackets and p-values are based on Newey and West (1987) standard errors with 18 lags. R^2 in percent.

	$y^{T,1}$	$f^{T,3}$	$f^{T,5}$	$\bar{cs}^M$	R^2	$p(all)$	$p(f^T)$
$\bar{rx}^T$	-0.567	1.940	1.958	10.810	38.18	0.00	0.00
	[0.466]	*[0.730]*	*[0.857]*	*[2.341]*			
$\bar{rx}^{AAA}$	-0.253	1.253	2.367	13.504	36.89	0.00	0.00
	[0.179]	*[0.403]*	*[0.905]*	*[2.788]*			
$\bar{rx}^{AA}$	-0.338	1.242	2.399	13.000	36.23	0.00	0.00
	[0.235]	*[0.393]*	*[0.902]*	*[2.718]*			
$\bar{rx}^{A}$	-0.380	1.047	2.627	13.623	40.93	0.00	0.00
	[0.283]	*[0.361]*	*[1.087]*	*[3.172]*			
$\bar{rx}^{BBB}$	-0.002	-0.241	3.599	15.378	45.64	0.00	0.00
	[0.002]	*[0.100]*	*[1.759]*	*[3.441]*			
$\bar{rx}^{BB}$	0.654	-3.519	5.581	18.014	48.43	0.00	0.01
	[0.862]	*[1.651]*	*[2.848]*	*[4.562]*			
$\bar{rx}^{B}$	-0.905	-2.449	4.555	16.905	46.18	0.00	0.50
	[0.800]	*[0.926]*	*[2.060]*	*[2.998]*			

Table 9: **Unrestricted Forward Model**

Unrestricted regressions from equation (15). $p(.)$ are the probabilities of blockwise $\chi^2(3)$ test for insignificance of all average forwards $\bar{f}$ or all forward credit spreads fs^{JI}. Absolute t-values in brackets and p-values are based on Newey and West (1987) standard errors with 18 lags. R^2 in percent.

	$\bar{y}^1$	$\bar{f}^3$	$\bar{f}^5$	$cs^{JI,1}$	$fs^{JI,3}$	$fs^{JI,5}$	R^2	$p(\bar{f})$	$p(fs^{JI})$
$\bar{rx}^T$	-3.398	7.727	-0.336	-1.893	3.742	-0.540	50.75	0.00	35.67
	[4.486]	*[4.946]*	*[0.369]*	*[1.338]*	*[1.696]*	*[0.555]*			
$\bar{rx}^{AAA}$	-3.234	7.764	-0.547	-1.629	4.259	-0.448	51.99	0.00	23.88
	[3.484]	*[4.608]*	*[0.583]*	*[1.197]*	*[1.935]*	*[0.465]*			
$\bar{rx}^{AA}$	-3.333	7.802	-0.522	-1.610	4.181	-0.415	51.88	0.00	25.01
	[3.649]	*[4.723]*	*[0.558]*	*[1.174]*	*[1.909]*	*[0.417]*			
$\bar{rx}^{A}$	-3.335	7.408	-0.249	-1.331	3.961	-0.452	55.74	0.00	15.20
	[3.860]	*[4.600]*	*[0.281]*	*[1.031]*	*[1.994]*	*[0.494]*			
$\bar{rx}^{BBB}$	-3.041	6.321	0.304	-1.206	4.489	-1.134	53.89	0.00	3.14
	[3.878]	*[3.939]*	*[0.320]*	*[0.838]*	*[2.168]*	*[1.405]*			
$\bar{rx}^{BB}$	-2.362	4.116	0.950	-0.681	5.952	-1.254	58.51	0.16	0.00
	[3.237]	*[2.288]*	*[0.659]*	*[0.370]*	*[2.835]*	*[1.216]*			
$\bar{rx}^{B}$	-3.964	3.946	0.953	-1.150	5.157	0.308	47.48	5.28	0.51
	[2.675]	*[1.318]*	*[0.383]*	*[0.458]*	*[1.982]*	*[0.165]*			

Table 10: **Restricted Forward Model**

Excess return regressions on Z_t of equation (18). Absolute t-values based on Newey and West (1987) standard errors with 18 lags in brackets. R^2 in percent.

	const	Z^τ	Z^c	R^2
$\bar{rx}^T$	2.044	-0.106	0.110	50.64
	[2.851]	*[6.574]*	*[3.864]*	
$\bar{rx}^{AAA}$	2.475	-0.115	0.077	51.52
	[3.235]	*[6.989]*	*[2.692]*	
$\bar{rx}^{AA}$	2.479	-0.116	0.073	51.51
	[3.232]	*[7.102]*	*[2.616]*	
$\bar{rx}^A$	2.746	-0.118	0.058	55.39
	[4.011]	*[8.194]*	*[2.303]*	
$\bar{rx}^{BBB}$	2.647	-0.116	0.029	53.49
	[4.315]	*[9.580]*	*[1.017]*	
$\bar{rx}^{BB}$	4.011	-0.125	-0.110	56.65
	[5.935]	*[7.226]*	*[2.123]*	
$\bar{rx}^B$	1.493	-0.116	-0.251	47.13
	[1.108]	*[5.496]*	*[2.758]*	

Table 11: **Factor Correlation**

Correlation of the risk premium factors Z^τ, Z^c, Z^y and Z^M to other factors and to financial and economic indicators.

	Z^τ	Z^c	Z^y	Z^M
Z^y	-0.401	-0.898		
Z^M	-0.255	-0.787	0.825	
g	0.286	0.569	-0.646	-0.118
π	0.094	0.192	-0.245	-0.195
$y^{5Y} - y^{3M}$	-0.677	-0.219	0.528	0.430
FFR	0.307	0.788	-0.865	-0.741
$Aaa - FFR$	-0.686	-0.468	0.754	0.636
$Baa - FFR$	-0.675	-0.529	0.800	0.661
$\bar{cs}^M = Baa - Aaa$	-0.229	-0.683	0.708	0.489

Table 12: **Forward Factors and Yield Principal Components**

Regressions of three yield principal components on the financial factors Z^τ and Z^c from equation (20). R^2 in percent. Absolute t-values in brackets are based on Newey and West (1987) standard errors with 18 lags.

	const	*level*	*credit*	*slope*	R^2
Z^τ	4.889	1.462	-7.855	-10.930	78.85
	[1.795]	*[4.121]*	*[13.697]*	*[4.900]*	
Z^c	0.098	-1.349	-1.971	0.059	97.11
	[0.360]	*[64.521]*	*[22.615]*	*[0.282]*	

Table 13: **Hidden Factors**

Excess return regressions of three yield principal components of equation (19) and yield principal components combined with Z^τ in (21a) or Z^c in (21b). R^2 in percent. $p(pcy)$ is the p-value of a $\chi^2(3)$-test for joint insignificance of *level*, *credit* and *slope* in percent. Absolute t-values and p-values in brackets are based on Newey and West (1987) standard errors with 18 lags.

		const	Z^τ	Z^c	*level*	*credit*	*slope*	R^2	$p(pcy)$
$\overline{rx}^{T}$	(19)	1.673			-0.290	0.545	1.107	37.31	0.00
		[1.877]			*[4.886]*	*[2.634]*	*[2.120]*		
	(21a)	2.101	-0.117		-0.129	-0.318	-0.086	50.63	0.09
		[3.276]	*[3.401]*		*[2.405]*	*[1.191]*	*[0.130]*		
	(21b)	1.631		0.424	0.283	1.381	1.082	40.70	0.00
		[1.919]		*[2.142]*	*[1.041]*	*[3.124]*	*[2.072]*		
$\overline{rx}^{AAA}$	(19)	2.064			-0.273	0.743	0.957	38.62	0.00
		[2.224]			*[4.299]*	*[3.395]*	*[1.742]*		
	(21a)	2.503	-0.121		-0.108	-0.143	-0.270	51.96	2.99
		[3.725]	*[3.584]*		*[1.923]*	*[0.536]*	*[0.416]*		
	(21b)	2.022		0.428	0.305	1.587	0.932	41.89	0.00
		[2.278]		*[2.060]*	*[1.065]*	*[3.505]*	*[1.700]*		
$\overline{rx}^{AA}$	(19)	2.063			-0.267	0.751	1.007	38.73	0.00
		[2.213]			*[4.222]*	*[3.471]*	*[1.812]*		
	(21a)	2.498	-0.119		-0.104	-0.127	-0.208	51.77	4.29
		[3.676]	*[3.601]*		*[1.898]*	*[0.490]*	*[0.317]*		
	(21b)	2.020		0.433	0.317	1.604	0.982	42.06	0.00
		[2.264]		*[2.074]*	*[1.104]*	*[3.524]*	*[1.769]*		
$\overline{rx}^{A}$	(19)	2.312			-0.251	0.803	1.099	43.17	0.00
		[2.695]			*[4.212]*	*[4.121]*	*[2.161]*		
	(21a)	2.722	-0.113		-0.097	-0.026	-0.047	55.59	7.40
		[4.375]	*[3.704]*		*[1.975]*	*[0.109]*	*[0.078]*		
	(21b)	2.271		0.421	0.316	1.631	1.075	46.54	0.00
		[2.765]		*[2.070]*	*[1.148]*	*[3.716]*	*[2.111]*		
$\overline{rx}^{BBB}$	(19)	2.214			-0.205	0.816	1.236	41.75	0.00
		[2.741]			*[3.071]*	*[5.011]*	*[2.497]*		
	(21a)	2.612	-0.109		-0.055	0.013	0.125	53.64	60.97
		[4.718]	*[3.485]*		*[1.203]*	*[0.048]*	*[0.202]*		
	(21b)	2.182		0.322	0.229	1.449	1.217	43.75	0.00
		[2.761]		*[1.665]*	*[0.860]*	*[3.569]*	*[2.449]*		
$\overline{rx}^{BB}$	(19)	3.517			-0.048	1.198	1.263	49.02	0.00
		[4.179]			*[0.540]*	*[5.467]*	*[2.582]*		
	(21a)	3.866	-0.096		0.083	0.494	0.288	56.49	25.03
		[6.022]	*[2.433]*		*[1.718]*	*[1.247]*	*[0.480]*		
	(21b)	3.514		0.024	-0.017	1.245	1.262	49.02	0.00
		[4.168]		*[0.126]*	*[0.065]*	*[2.584]*	*[2.562]*		
$\overline{rx}^{B}$	(19)	1.015			0.185	1.316	1.645	44.95	0.01
		[0.768]			*[1.498]*	*[3.680]*	*[2.661]*		
	(21a)	1.302	-0.079		0.293	0.736	0.843	48.00	1.65
		[1.011]	*[1.657]*		*[3.111]*	*[1.313]*	*[0.995]*		
	(21b)	1.007		0.082	0.296	1.477	1.641	45.01	0.00
		[0.764]		*[0.341]*	*[0.948]*	*[2.210]*	*[2.659]*		

Table 14: **Restricted Financial Model**

Excess return regression (23) on hidden Z^{τ} and restricted yield principal components Z^{y}. R^2 in percent. Absolute t-values in brackets are based on Newey and West (1987) standard errors with 18 lags.

	const	Z^{τ}	Z^{y}	R^2
$\bar{rx}^{T}$	2.044	-0.123	-0.109	50.45
	[2.936]	*[8.490]*	*[3.745]*	
$\bar{rx}^{AAA}$	2.475	-0.128	-0.078	51.62
	[3.297]	*[8.925]*	*[2.581]*	
$\bar{rx}^{AA}$	2.479	-0.128	-0.073	51.51
	[3.295]	*[8.925]*	*[2.493]*	
$\bar{rx}^{A}$	2.746	-0.127	-0.056	55.22
	[4.084]	*[9.936]*	*[2.111]*	
$\bar{rx}^{BBB}$	2.647	-0.121	-0.027	53.43
	[4.365]	*[9.779]*	*[0.854]*	
$\bar{rx}^{BB}$	4.011	-0.108	0.106	56.10
	[5.749]	*[5.272]*	*[1.763]*	
$\bar{rx}^{B}$	1.493	-0.076	0.255	47.73
	[1.120]	*[2.810]*	*[2.638]*	

Table 15: **Macro Augmented Financial Model**

Excess return regressions on Z^{τ}, Z^{y} and macro variables of equation (24). R^2 in percent. Absolute t-values in brackets are based on Newey and West (1987) standard errors with 18 lags.

	const	Z^{τ}	Z^{y}	g	π	R^2
$\bar{rx}^{T}$	2.218	-0.124	-0.104	0.047	-0.126	50.51
	[0.793]	*[9.330]*	*[3.381]*	*[0.182]*	*[0.140]*	
$\bar{rx}^{AAA}$	2.535	-0.127	-0.081	-0.021	0.003	51.62
	[0.845]	*[10.025]*	*[2.378]*	*[0.083]*	*[0.003]*	
$\bar{rx}^{AA}$	2.440	-0.127	-0.078	-0.048	0.075	51.56
	[0.814]	*[10.179]*	*[2.270]*	*[0.185]*	*[0.076]*	
$\bar{rx}^{A}$	2.373	-0.126	-0.059	-0.041	0.197	55.32
	[0.878]	*[11.259]*	*[1.829]*	*[0.177]*	*[0.227]*	
$\bar{rx}^{BBB}$	0.962	-0.124	0.007	0.250	0.347	54.45
	[0.383]	*[10.277]*	*[0.249]*	*[1.571]*	*[0.413]*	
$\bar{rx}^{BB}$	-1.959	-0.118	0.221	0.823	1.309	65.46
	[1.028]	*[8.358]*	*[4.474]*	*[5.585]*	*[1.778]*	
$\bar{rx}^{B}$	-3.919	-0.093	0.415	1.263	0.545	59.34
	[1.423]	*[3.932]*	*[5.574]*	*[6.662]*	*[0.518]*	

Table 16: **Unrestricted Macro Model**

Excess return regressions on Z^τ, yield principal components and macro variables of equation (25). Absolute t-values in brackets are based on Newey and West (1987) standard errors with 18 lags. R^2 in percent.

	const	Z^τ	*level*	*credit*	*slope*	g	π	R^2
$\bar{rx}^T$	2.394	-0.118	-0.128	-0.311	-0.087	0.024	-0.145	50.68
	[0.864]	*[3.386]*	*[2.035]*	*[1.337]*	*[0.130]*	*[0.099]*	*[0.160]*	
$\bar{rx}^{AAA}$	2.494	-0.121	-0.107	-0.142	-0.270	0.003	-0.001	51.96
	[0.810]	*[3.527]*	*[1.616]*	*[0.609]*	*[0.415]*	*[0.014]*	*[0.001]*	
$\bar{rx}^{AA}$	2.433	-0.119	-0.107	-0.138	-0.207	-0.032	0.066	51.79
	[0.793]	*[3.521]*	*[1.664]*	*[0.603]*	*[0.316]*	*[0.130]*	*[0.067]*	
$\bar{rx}^{A}$	2.391	-0.112	-0.099	-0.037	-0.046	-0.036	0.174	55.66
	[0.858]	*[3.622]*	*[1.748]*	*[0.168]*	*[0.076]*	*[0.159]*	*[0.198]*	
$\bar{rx}^{BBB}$	0.962	-0.114	-0.015	0.116	0.125	0.248	0.329	54.59
	[0.372]	*[3.619]*	*[0.309]*	*[0.518]*	*[0.201]*	*[1.528]*	*[0.386]*	
$\bar{rx}^{BB}$	-2.394	-0.114	0.228	0.863	0.291	0.884	1.322	66.64
	[1.186]	*[3.418]*	*[4.955]*	*[3.279]*	*[0.467]*	*[7.503]*	*[1.771]*	
$\bar{rx}^{B}$	-4.341	-0.105	0.483	1.249	0.840	1.286	0.573	59.47
	[1.623]	*[2.409]*	*[4.960]*	*[3.324]*	*[0.955]*	*[6.726]*	*[0.560]*	

Table 17: **Restricted Macro Model**

Excess return regressions on Term risk factor Z^1 and macro-credit risk factor Z^M of equation (28). Absolute t-values in brackets are based on Newey and West (1987) standard errors with 18 lags. R^2 in percent.

	const	Z^τ	Z^M	R^2
$\bar{rx}^T$	2.044	-0.111	-0.075	47.79
	[3.037]	*[6.697]*	*[4.997]*	
$\bar{rx}^{AAA}$	2.475	-0.119	-0.056	50.48
	[3.434]	*[7.569]*	*[3.063]*	
$\bar{rx}^{AA}$	2.479	-0.120	-0.055	50.71
	[3.422]	*[7.708]*	*[3.049]*	
$\bar{rx}^{A}$	2.746	-0.121	-0.042	54.76
	[4.220]	*[8.828]*	*[2.513]*	
$\bar{rx}^{BBB}$	2.647	-0.117	-0.002	52.93
	[4.526]	*[9.371]*	*[0.121]*	
$\bar{rx}^{BB}$	4.011	-0.116	0.136	64.01
	[6.584]	*[7.978]*	*[4.430]*	
$\bar{rx}^{B}$	1.493	-0.099	0.268	59.27
	[1.261]	*[5.656]*	*[5.343]*	

Table 18: **Measurement Error: Lagged Regressors**

Excess return regressions with 1 to 3 lags R^2 in percent.

	A: Unrestr. forward R^2			**B:** Corporate CP R^2		
	lag=3	lag=2	lag=1	lag=3	lag=2	lag=1
$\bar{rx}^{T}$	51.46	51.36	50.83	29.56	29.57	29.49
$\bar{rx}^{AAA}$	52.49	52.43	52.04	32.70	32.63	32.45
$\bar{rx}^{AA}$	52.42	52.34	51.94	40.77	40.55	40.29
$\bar{rx}^{A}$	56.49	56.40	55.86	39.36	39.22	39.04
$\bar{rx}^{BBB}$	55.53	55.24	54.22	46.06	45.72	44.91
$\bar{rx}^{BB}$	60.71	60.18	58.89	57.69	57.25	56.42
$\bar{rx}^{B}$	49.00	48.73	47.99	54.96	54.33	53.02

Table 19: **Bank of America Dataset**

Excess return regressions of Bank of America's Master indices. Restricted factors Z^i are derived from the Migration dataset and not adapted to the BofA dataset. Constants are included in the estimation but not displayed. Sample size is June 1992 to December 2006 except for BB, B and (C) for which the sample starts in December 1996. Absolute t-values in brackets are based on Newey and West (1987) standard errors with 18 lags. R^2 in percent. The three most right columns contain the R^2 of the Unrestricted Forward Model "Unrestr.", the Moody's $\bar{cs}^M$ spread augmented Treasury model and the corporate Cochrane Piazzesi model "CP". In the column headers, "Tab ." refers to the Table of the Migration dataset, "(.)" to the test equation.

	Panel A: Financial Model Tab 14, eq (23)			**Panel B:** Macro Model Tab 17, eq (28)			Unrestr. Tab 9, (15)	Moody's Tab 8, (14)	CP Tab 7, (11)
	Z^τ	Z^y	R^2	Z^τ	Z^M	R^2	R^2	R^2	R^2
IG	-0.111	-0.028	50.42	-0.105	0.016	50.06	52.34	43.59	
	[8.464]	*[0.682]*		*[7.661]*	*[0.607]*				
J	-0.038	0.210	21.59	-0.051	0.303	46.05	27.13	32.74	
	[0.824]	*[1.612]*		*[1.598]*	*[3.981]*				
T	-0.098	-0.081	49.28	-0.089	-0.056	46.96	50.13	37.51	29.89
	[8.787]	*[3.353]*		*[7.106]*	*[4.689]*				
AAA	-0.114	-0.061	52.22	-0.106	-0.034	50.58	52.23	39.55	32.91
	[8.296]	*[2.032]*		*[7.455]*	*[1.983]*				
AA	-0.118	-0.079	53.41	-0.109	-0.047	50.95	53.68	39.23	40.04
	[9.425]	*[2.719]*		*[7.851]*	*[2.462]*				
A	-0.114	-0.041	53.78	-0.109	-0.017	52.78	54.14	40.82	35.19
	[9.808]	*[1.411]*		*[8.805]*	*[0.950]*				
BBB	-0.105	-0.002	43.76	-0.100	0.064	47.79	49.41	46.73	32.89
	[6.092]	*[0.028]*		*[5.915]*	*[1.723]*				
BB	0.018	0.197	22.01	-0.005	0.256	57.73	48.77	39.32	52.14
	[0.417]	*[1.972]*		*[0.193]*	*[6.255]*				
B	0.064	0.452	49.99	-0.010	0.395	64.24	57.39	55.56	55.74
	[1.644]	*[4.036]*		*[0.332]*	*[8.567]*				
(C)	0.142	0.895	50.60	-0.002	0.798	67.81	57.13	55.39	
	[1.904]	*[4.035]*		*[0.041]*	*[8.494]*				

Table 20: **Impact Channels of Market Price of Risk**

Estimates of the market price of risk parameters from equations (37), (43) and (44). One year holding period. Absolute t-values are based on ordinary least squares standard errors. The left block refers to the financial model with Z^τ and Z^y, the left block to the macro-financial model with Z^τ and Z^M

	Panel A: One-Year Migration rx_{t+1}^{j,τ_n}					
	λ_0	λ_1	λ_2	λ_0	λ_1	λ_2
Z^τ	-1.929	0.054	0.104	7.350	0.015	-0.004
	[0.701]	*[2.041]*	*[1.663]*	*[2.100]*	*[0.703]*	*[0.097]*
level	-2.856	-0.085	-0.036	-6.543	-0.086	0.002
	[2.425]	*[7.398]*	*[1.441]*	*[3.603]*	*[9.146]*	*[0.099]*
credit	-1.940	-0.026	-0.156	-9.269	0.028	-0.104
	[0.772]	*[1.118]*	*[2.576]*	*[2.875]*	*[1.439]*	*[2.654]*
slope	-1.242	-0.052	0.005	-10.725	0.016	0.055
	[0.450]	*[2.096]*	*[0.081]*	*[3.268]*	*[0.816]*	*[1.301]*
g				1.369	0.025	-0.023
				[0.751]	*[3.602]*	*[1.906]*
π				-1.495	0.032	0.013
				[1.119]	*[5.383]*	*[1.190]*
	Panel B: One-Year BofA Maturity Subindices rx_{t+1}^{j,τ_n}					
	λ_0	λ_1	λ_2	λ_0	λ_1	λ_2
Z^τ	6.234	-0.022	0.259	4.507	0.004	0.166
	[2.942]	*[1.106]*	*[3.808]*	*[1.871]*	*[0.213]*	*[4.328]*
level	-4.986	-0.051	-0.096	-3.681	-0.074	-0.119
	[5.364]	*[6.232]*	*[3.503]*	*[2.752]*	*[7.766]*	*[5.817]*
credit	-9.369	0.030	-0.237	-8.299	0.021	-0.148
	[5.478]	*[1.920]*	*[4.234]*	*[4.457]*	*[1.436]*	*[5.120]*
slope	-9.325	0.016	-0.150	-8.776	0.012	-0.028
	[5.136]	*[0.953]*	*[2.534]*	*[4.463]*	*[0.774]*	*[0.934]*
g				-0.245	0.019	0.075
				[0.243]	*[3.237]*	*[7.163]*
π				-1.430	0.015	0.062
				[1.350]	*[2.415]*	*[3.929]*

Figure 1: **Yield Curve and 1-Year Excess Return Data**

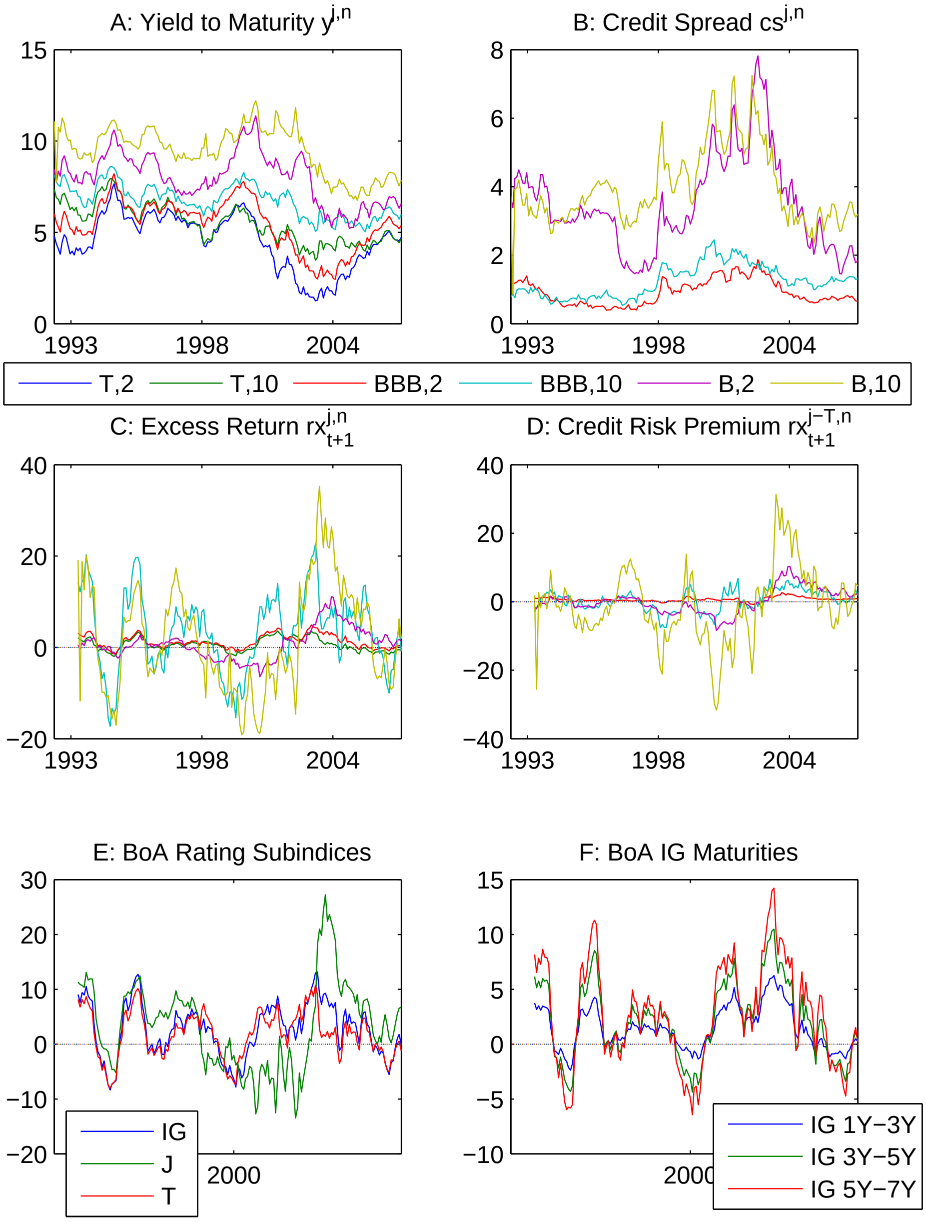

Figure 2: **Yield Principal Component**

Maturity in years on the x axis.

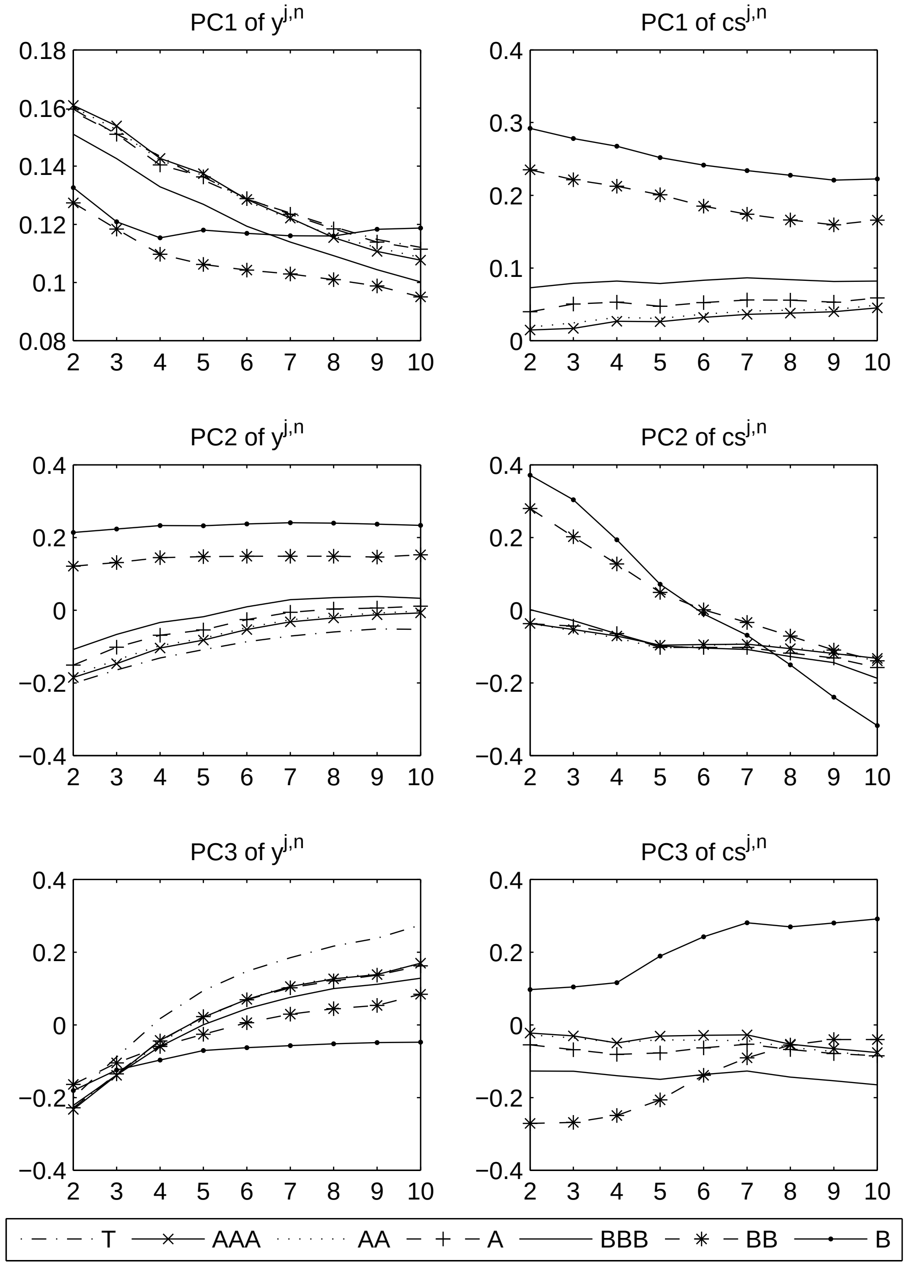

Figure 3: **Recovery and rating drift.**

Recovery is based on the trading price 30 day after default of senior unsecured bonds. Rating drift is the probability of an upgrade minus the probability of a downgrade. Displayed is an annualized drift constructed from the quarterly data in Moody's (2012): $d^{ann} = \prod_{Q=1}^{4}(1 + d^{Q})$. The correlation between Recovery and drift is 0.62.

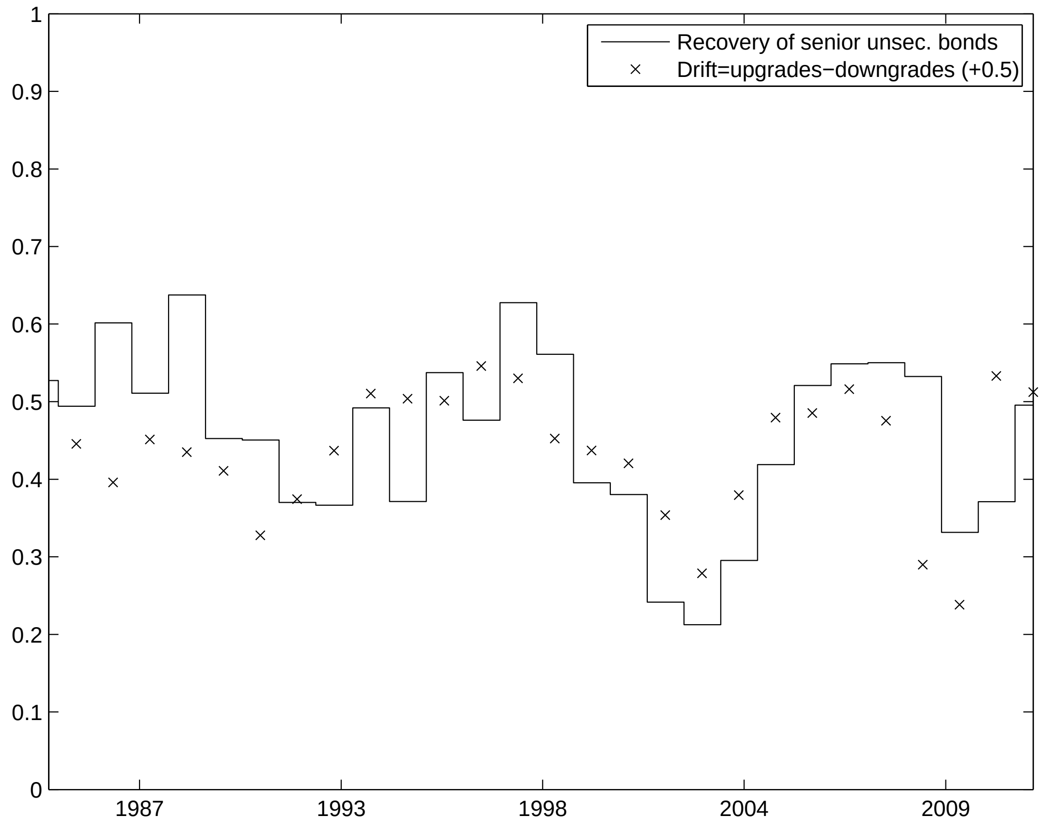

Figure 4: **Principal Component Loadings of Excess Returns**
The first row contains the loadings of realized one-year excess returns on the first and second principal component. Bond's initial maturity in years on the x axis.

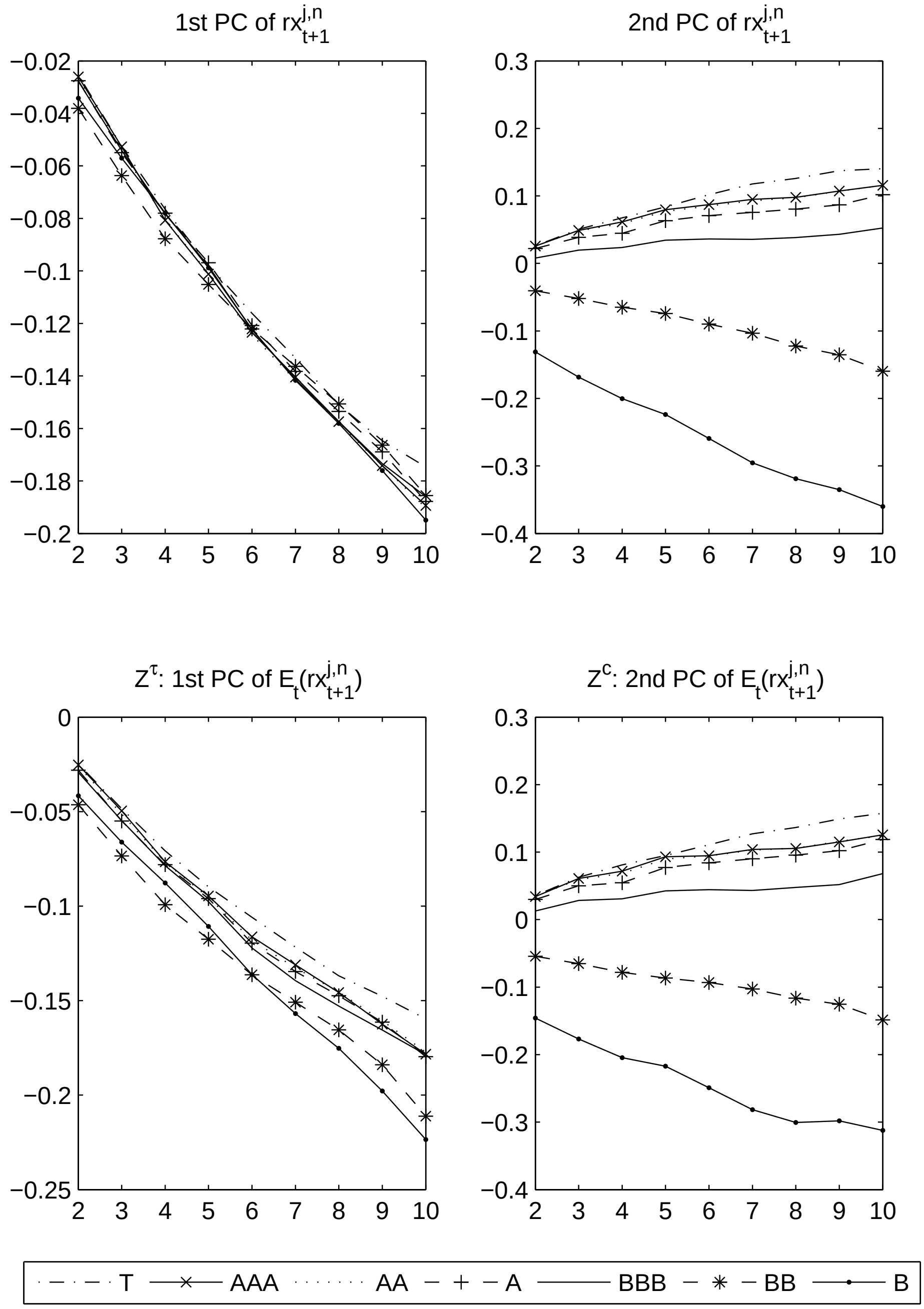

Figure 5: **Unrestricted Model: Average Forward $\bar{f}$ Coefficients**
Forward maturity in years on the x axis. Legend refers to initial bond maturity τ_n of the migration dataset.

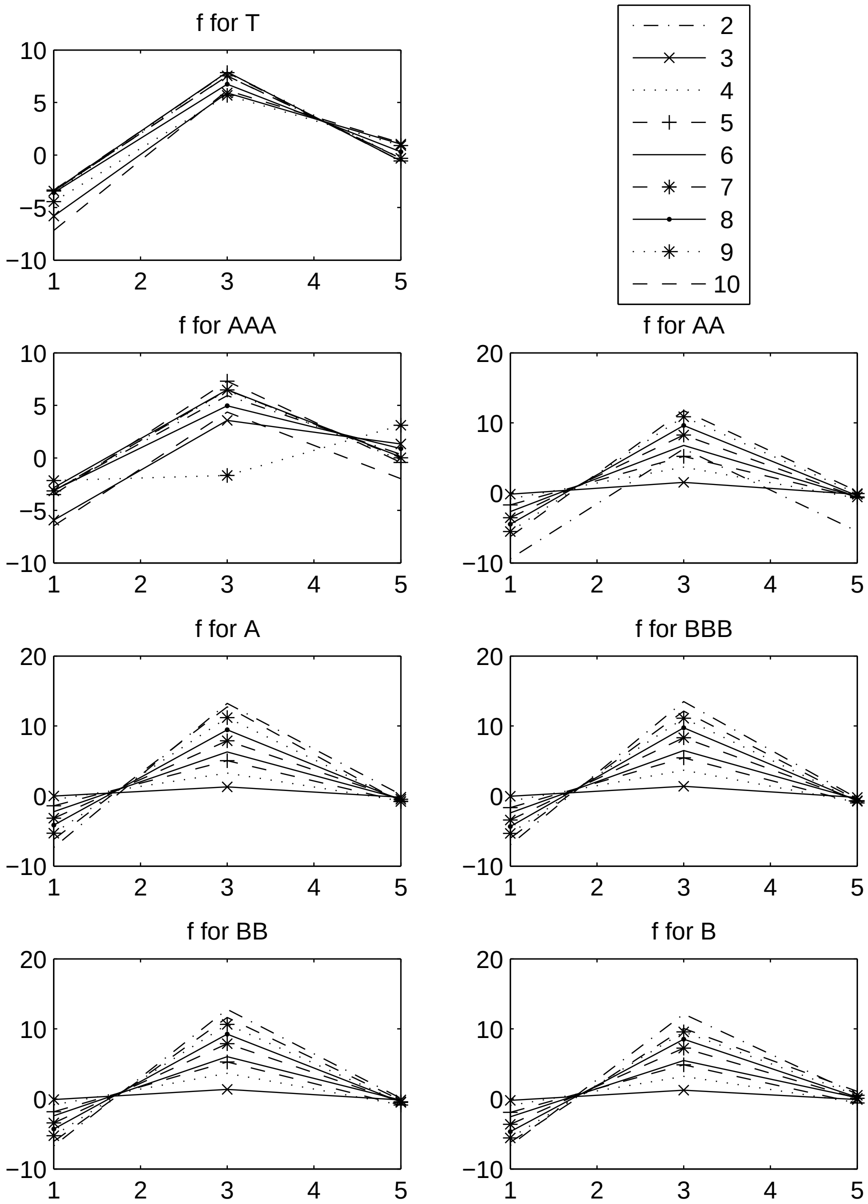

Figure 6: **Unrestricted Model: Junk-Investment Grade forward spreads fs^{JI} Coefficients**

Forward spread maturity in years on the x axis. Legend refers to initial bond maturity τ_n of the migration dataset.