Is the Time-Varying Risk-Return Relation Positive?

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Abstract

We use a cross-section of stock and bond portfolios to estimate the aggregate risk-return relation. We use an empirical implementation of the ICAPM and assume that the market price of risk is time-varying. When the market price of risk changes over time, one needs to check not only that the average price of risk is positive, but also whether the market price of risk is sufficiently high during times when the market variance is high. Checking both of these conditions represents a true test of whether the relation between conditional market variance and return is positive. We compute both of these quantities for the period from 1927 to 2005 and find that the market price of risk is positive on average and the relation between conditional market variance and return is significantly positive. We show that the bond market plays an important role in detecting the risk-return relation at the aggregate market level.

1. Introduction

Existing studies on the relation between market risk and return find conflicting evidence regarding the sign of the relationship.[1] Most of these studies assume that the price for bearing market risk (or relative risk aversion) is constant over time. However, Whitelaw (1994) shows that imposing a constant risk-return relation may lead to erroneous conclusions since the relation is not stable. More recently, Brandt and Wang (2007) and Lundblad (2007) present evidence that the price of market risk at the aggregate level is changing over time.[2]

In this paper, we show that (a) the price of market risk is time-varying, and (b) in the presence of time-varying price of risk and market variance, the aggregate risk-return relation is positive and significant. However, to show a positive aggregate risk-return relation when both the price of market risk and market variance change over time, we need to show that both (a) the average price for bearing market risk is positive, and (b) the market price of risk is sufficiently high during times when the market variance is high such that the relation between conditional market variance and return is positive. The following equation provides the intuition. Assuming away hedging demands for simplicity, Merton's (1973) Intertemporal Capital Asset Pricing Model (ICAPM) for the market portfolio implies:

$$E_t(R_{M,t+1}) = \gamma_{M,t} Var_t(R_{M,t+1}), \tag{1}$$

where $E_t(R_{M,t+1})$ and $Var_t(R_{M,t+1})$ are the conditional return and variance of the excess market return, and $\gamma_{M,t}$ is the price for bearing market risk. This is also the coefficient of relative risk aversion.[3] All quantities are conditional on information available at time t. Taking unconditional expectations on both sides of (1) leads to:

$$E(R_{M,t+1}) = E(\gamma_{M,t})E(Var_t(R_{M,t+1})) + Cov(\gamma_{M,t}, Var_t(R_{M,t+1})). \tag{2}$$

The above equation shows that the aggregate risk-return relation is positive if (a) the market price of risk (or the coefficient of relative risk aversion) is positive on average, and if (b) the market price of risk is sufficiently high during times when the market variance is high. This intuition is similar

[1] Campbell (1987), Breen, Glosten, and Jagannathan (1989), Glosten, Jagannathan, and Runkle (1993), Whitelaw (1994) and Brandt and Kang (2004) report that the relation between aggregate market risk and return is negative, while French, Schwert, and Stambaugh (1987), Scruggs (1998), Ghysels, Santa-Clara, and Valkanov (2005), Guo and Whitelaw (2006) and Ludvigson and Ng (2005) report a positive relationship.

[2] The habit formation model of Campbell and Cochrane (1999) provides room for a changing price of risk through time-varying risk aversion.

[3] Harvey (1989) argues that this is the case under certain assumptions, e.g., iid consumption.

to the one behind the conditional CAPM of Jagannathan and Wang (1996).

The above intuition reveals that simply establishing that the market price of risk is positive on average does not necessarily imply that the conditional market return is high when the conditional market variance is high. That is, a positive average risk aversion (or even a positive risk aversion in each time period) does not guarantee that the risk-return tradeoff will be positive. If the covariance between time-varying risk aversion and conditional market variance is sufficiently negative (the second term in equation (2)), then a negative aggregate risk-return relationship is possible. Therefore, studies that look at a time-varying relation as the one in equation (1) should not only check whether $\gamma_{M,t}$ is positive, but also whether the covariance between conditional market variance, $Var_t(R_{M,t+1})$, and the risk component of the expected market return, $\gamma_{M,t}Var_t(R_{M,t+1})$, is positive. The covariance between $\gamma_{M,t}$ and $\gamma_{M,t}Var_t(R_{M,t+1})$ could be positive even if the covariance between $\gamma_{M,t}$ and $Var_t(R_{M,t+1})$ is negative, and constitutes a direct check of the aggregate risk-return relation.

We explicitly show that high values of conditional market variance, $Var_t(R_{M,t+1})$, correspond to high values of the risk component of the expected market return, $\gamma_{M,t}Var_t(R_{M,t+1})$, only when we use state variables that pertain to both the stock and the bond markets. In portfolio decisions, the overall allocation between stocks and bonds is key because stocks and bonds have different risk-return profiles that make them natural hedges of each other. By varying the mix of stocks and bonds in a portfolio, an investor can achieve the desired risk-return profile. Therefore, for analyzing the risk-return relation of the aggregate market portfolio, we need to take into account the bond market. This is where our paper differs from Brandt and Wang (2007). Using equity portfolios only, they show that the market price of risk, $\gamma_{M,t}$, is mostly positive and varies considerably over time. However, we emphasize that in the context of a time-varying price of risk, it is important to examine the covariance between conditional market variance and the risk component of the expected market return. Reporting an average positive value for $\gamma_{M,t}$ without examining the above covariance does not conclusively show that the aggregate risk-return relation is positive.

Therefore, consistent with increasing evidence that stocks and bonds are driven by common factors and cross-market hedging demands (see, for example, Keim and Stambaugh (1986), Fama and French (1989, 1993), Fleming, Kirby, and Ostdiek (1998), Kodres and Pritsker (2002), Scruggs and Glabadanidis (2003) and Connolly, Stivers, and Sun (2005)), we estimate the stock market risk-return relation after controlling for the bond market. We show that for the period from

1927 to 2005, the market price of risk varies substantially over time. It is predominantly positive and significant, and tends to rise during recessionary periods. We also show that the correlation between conditional market variance and return is positive and significant, and positive over all decades of our long sample. Without considering the bond market, we would have obtained a different aggregate risk-return relation, as explained below.

We find that the correlation between $\gamma_{M,t}$ and conditional market variance is negative regardless of whether or not we use bonds in our analysis. However, when bonds are used (that is, bond portfolios are included among the test assets and bond factors among the state variables), the overall correlation between conditional market return and risk is positive. In other words, even if $\gamma_{M,t}$ and conditional market variance are negatively correlated, we still find that their product is positively correlated with conditional market variance. This result holds only when we link the stock and bond markets. To better understand the relation between risk, the market price of risk, and return, we further separate out the short-term cyclical and the long-term trend components of the market price of risk.

In the case in which we include bond portfolios, the simple correlation between the cyclical component of the market price of risk, $\gamma_{M,t}$, and conditional market variance is significantly positive at 9%. On the other hand, the trend component of $\gamma_{M,t}$ has a significantly negative correlation with conditional market variance at -19%. Taken together, the correlation between the overall market price of risk and conditional market variance is negative. However, the correlation between conditional market return and variance is positive. This is the case because during the short-run fluctuations in the business cycle, higher market volatility is accompanied by higher compensation for being exposed to this volatility.

Now we look at the case in which we exclude bonds from the analysis. The correlation between the cyclical component of $\gamma_{M,t}$ and conditional market variance is significantly negative at -24%, and the trend component also has a significantly negative correlation with conditional market variance at -61%. The correlation between the market price of risk and conditional market variance is even more negative than in the previous case discussed above. Consequently, the overall correlation between conditional market return and variance is negative. This is because, when we exclude bonds, even during the short-run fluctuations in the business cycle, high market volatility is accompanied by low compensation for bearing this volatility, which is counter-intuitive.

We dig deeper to find out what could be driving the difference in the results between case

1 (linking the stock and bond markets) and case 2 (using the stock market alone). Out of 942 months in our sample, 917 months correspond to positive market price of risk, $\gamma_{M,t}$, in case 1 and 859 months in case 2. Therefore, in case 2 there are more months with negative estimates for the market price of risk. If the months in which the market price of risk is positive in case 1 but negative in case 2 correspond to months of high market volatility, then this could explain the strong negative correlation between the market price of risk and market variance in case 2. We find that most of these months correspond to periods of high volatility like the Great Depression, the recession of the early 1980s, and the recession of the early 2000s.

When market variance is high, risk-averse investors want to be compensated for bearing market risk and so the market must offer a higher expected return. This is the traditional argument behind the positive relation between risk and return. Following the literature on cross-market hedging mentioned above, there is an additional channel that strengthens the positive relation between risk and return. During months with high market variance the stock market becomes more uncertain and investors would want to rebalance into safer assets such as bonds. We find that the correlation between the risk component of the market return and the hedge component related to the bond market is significantly negative at -41%. This negative correlation is another indication that bonds provide hedging opportunities in periods of high market variance. Furthermore, we compute the correlation between these two components in recessions and expansions. The numbers are -55% and -25% respectively. Therefore, bonds are important hedging tools, especially in high volatility or recessionary periods. In order to induce investors to hold stocks when bonds are more attractive, the compensation for bearing stock risk, and consequently expected stock returns, must rise. Therefore, the cross-market hedging argument predicts that linking the stock and bond markets makes the positive relation between aggregate market risk and return stronger. This is precisely what we find in this paper.

The rest of the paper is organized as follows. Section 2 discusses previous studies that are related to ours. Section 3 presents our empirical methodology. Section 4 describes the data we use and reports the main results. Section 5 examines the importance of including bond portfolios in the analysis of the aggregate risk-return relation in an ICAPM setting. Section 6 performs robustness checks and Section 7 concludes.

2. Related Literature

In this paper, we show that the bond market plays an important role in detecting the risk-return relation at the aggregate market level. Estimating the aggregate risk-return relation for the equity market by linking the stock and the bond markets is important since the literature has shown that there are strong linkages between the two markets.

Keim and Stambaugh (1986) and Fama and French (1989) find common predictable components in bond and equity returns. Fama and French (1993) show that there are five common risk factors driving the returns on stocks and bonds: the market portfolio, factors related to size and book-to-market, and two bond market factors related to term and default premia. Stock and bond returns have shared variation due to these common factors. The underlying principle is that both equity and bonds are contingent claims written on the same set of productive assets, which goes back to Merton (1974).[4]

Fleming, Kirby, and Ostdiek (1998) show that in addition to common movements in returns, stocks and bonds exhibit common movements in volatility. They arise due to the existence of cross-market hedging. If a trader who operates in both stock and bond markets receives information that alters his expectations about stock returns, then this directly affects his demand for stocks. It, however, also affects his demand for bonds even if it does not alter his expectations about interest rates. This occurs because the trader considers the correlation between stock and bond returns. In effect, he takes a position in bonds to hedge his speculative position in stocks. Because the information changes his demand for both stocks and bonds, information spillover occurs, generating trading and volatility in both markets. Kodres and Pritsker (2002) also develop a rational expectations model in which a shock in one asset market generates cross-market asset rebalancing with pricing influences in the other non-shocked asset market. Finally, Connolly, Stivers, and Sun (2005) document the time-varying correlation between daily stock and bond returns, and show that the variation is related to equity market uncertainty as measured by the VIX index. Their findings suggest that stock market volatility has important cross-market pricing influences and should be taken into consideration when setting optimal portfolio allocations. Indeed Scruggs and Glabadanidis (2003) report that the conditional stock variance responds to both stock and bond return shocks.

[4] Another paper which is based on this principle is Campello, Chen, and Zhang (2008). They use corporate bond yield spreads to construct new measures of expected equity returns. Then they replace standard ex-post, averaged measures of equity returns with their ex-ante measures in asset pricing tests.

We use a large cross-section of stock and bond portfolios to estimate the market price of risk at the aggregate level. We can do so because in the context of the ICAPM of Merton (1973), the parameter $\gamma_{M,t}$ which drives the risk-return relation in the time series, also drives the price for covariance with risk factors in the cross-section. Therefore, we estimate cross-sectionally a version of the ICAPM using stocks and bonds as test assets. Other papers have also used a cross-section of assets to estimate the risk-return relation for the aggregate stock market. This approach ensures that the time-series relation between variance and return is estimated in a way that is consistent with the cross-sectional relation between covariance risk and return. For example, Brandt and Wang (2007) estimate the ICAPM for a cross-section of size and book-to-market portfolios, assuming that the market price of risk changes over time. They show that information from the cross section is helpful in estimating the aggregate risk-return relation. Our paper differs since (a) we include bond portfolios in the cross-section of test assets and (b) we not only show that $\gamma_{M,t}$ is positive, but also examine whether $\gamma_{M,t}$ is high when conditional market variance is high. Both (a) and (b) are important in documenting a positive aggregate risk-return relation. Scruggs and Glabadanidis (2003) estimate the risk-return tradeoff for the aggregate market portfolio and a long-term government bond. They assume that the prices of covariance risk are constant over time. Overall, they do not find significant prices of risk. Our paper differs since we allow for the prices of risk to be time-varying. In addition, we use a larger cross-section of bond portfolios, including corporate bonds. Two other papers that incorporate cross-sectional information are Bali and Wu (2005) and Bali and Engle (2008). However, they also impose a constant risk-return relation.

3. Empirical Methods

3.1. General Framework

The ICAPM of Merton (1973) states that assets' risk premia are determined by their comovements with risk factors. One of the risk factors is the excess return on the market portfolio. Other risk factors are related to shifts in the investment opportunity set over time. We start out by writing the ICAPM equation for a set of assets:

$$E_t(R_{i,t+1}) = \gamma_{M,t} Cov_t(R_{i,t+1}, R_{M,t+1}) + \gamma_{S,t} Cov_t(R_{i,t+1}, S_{t+1}), \quad (3)$$

where $R_{i,t+1}$ and $R_{M,t+1}$ are the excess returns of a cross section of assets and the market portfolio, S_{t+1} stands for realizations of a state variable, and E_t and Cov_t are the expectation and covariance operators conditional on information available at time t. The equation above states that risk premia are driven by time-varying covariances with risk factors. The coefficients $\gamma_{M,t}$ and $\gamma_{S,t}$ are the corresponding prices of covariance risk and they are time-varying.

Applying (3) to the market portfolio yields:

$$E_t(R_{M,t+1}) = \gamma_{M,t} Var_t(R_{M,t+1}) + \gamma_{S,t} Cov_t(R_{M,t+1}, S_{t+1}). \tag{4}$$

The coefficients $\gamma_{M,t}$ and $\gamma_{S,t}$ are the same across equations (3) and (4). They have two equivalent interpretations: $\gamma_{M,t}$ measures the time series relation between aggregate market risk and return (it is the coefficient of relative risk aversion), while also measuring the cross sectional price of risk for covariance with the market portfolio. Similarly, $\gamma_{S,t}$ measures the time series relation between the conditional covariance of the market with the state variable and the market risk premium, while also measuring the cross sectional price of risk for covariance with the state variable.

Theoretically, the sign of $\gamma_{M,t}$ is usually considered to be positive, indicating that the premium for bearing market risk should be positive. The sign of $\gamma_{S,t}$ is not clearly identified. It depends on whether the corresponding state variable predicts improvement or deterioration in investment opportunities.

We estimate the $\gamma_{M,t}$ coefficient each month from a cross-section of stock and bond returns following equation (3). Subsequently, we draw inferences about the relation between risk and return at the aggregate level specified in equation (4). This way, we estimate the aggregate risk-return tradeoff imposing the condition that it is consistent not only within the stock and bond markets, but also across the two markets. This is important in light of the studies that show return and volatility linkages between the two markets.

Next we explain in detail the estimation of equation (3). Cochrane (2005) shows that standard asset-pricing models as the one in (3) can be expressed in a stochastic discount factor (SDF) form. In particular:

$$E_t(m_{t+1} R_{i,t+1}) = 0, \tag{5}$$

where m_{t+1} is the stochastic discount factor. To show this in our case, let

$$m_{t+1} = a_t - \gamma_{M,t} R_{M,t+1} - \gamma_{S,t} S_{t+1}, \tag{6}$$

where a_t is a normalizing condition that insures that $E_t(m_{t+1}) = 1$. Then we have

$$E_t(R_{i,t+1}) = \gamma_{M,t} Cov_t(R_{i,t+1}, R_{M,t+1}) + \gamma_{S,t} Cov_t(R_{i,t+1}, S_{t+1}) \tag{7}$$

$$E_t(R_{i,t+1}) = Cov_t(\gamma_{M,t} R_{M,t+1} + \gamma_{S,t} S_{t+1}, R_{i,t+1}) \tag{8}$$

$$E_t(m_{t+1}) E_t(R_{i,t+1}) + Cov_t(a_t - \gamma_{M,t} R_{M,t+1} - \gamma_{S,t} S_{t+1}, R_{i,t+1}) = 0 \tag{9}$$

$$E_t(m_{t+1} R_{i,t+1}) = 0. \tag{10}$$

We focus on estimating (5) using GMM, for a set of assets. However, we need to make further assumptions. In particular, we assume that the time-varying coefficients in the SDF are linear functions of variables known at time t:

$$\begin{aligned} a_t &= a' z_t, \\ \gamma_{M,t} &= \gamma'_M z_t, \\ \gamma_{B,t} &= \gamma'_B z_t, \end{aligned} \tag{11}$$

where z_t is a vector of conditioning variables, including a constant.[5] We use the same vector of conditioning variables and the law of iterated expectations to transform the conditional moments in (5) to unconditional moments:

$$E(m_{t+1} R_{i,t+1} \otimes z_t) = 0. \tag{12}$$

Adding the normalizing condition on the SDF, we get the full system of moment conditions:

$$\begin{bmatrix} E(m_{t+1} R_{i,t+1} \otimes z_t) \\ E(m_{t+1} \otimes z_t) \end{bmatrix} = \begin{bmatrix} 0 \\ z_t \end{bmatrix}. \tag{13}$$

These are the moment conditions that we use to estimate the time-varying prices of covariance risk. Note that this approach does not impose any assumptions regarding the model that drives the variance of the market or the covariance with the state variable. The only assumption we make is standard: the coefficients in the SDF are linear functions of instrumental variables. The Appendix contains further details about the GMM estimation.

3.2. Choice of Variables

Here we describe in more detail the choice of test assets in vector $R_{i,t+1}$, state variables in vector S_{t+1}, and conditioning variables in vector z_t.

We use a cross-section of stock and bond portfolios as test assets. The stock portfolios include

[5] The assumption of linearity is used in many previous papers and it has become standard: see Cochrane (1996, 2005).

25 assets sorted by size and book-to-market. The bond portfolios include Treasury bonds with different maturities and corporate bonds with different ratings. We choose these assets since they provide a large spread in terms of average returns. In addition, using stocks and bonds allows us to measure the risk-return relation from a cross-section of assets with diverse risk-return profiles.

The choice of state variables is motivated by the literature that shows that there are common factors driving stock and bond returns. These factors can be classified into two groups: stock and bond factors. The stock market factors include the market portfolio, HML, and SMB. These have been shown to be very successful at explaining the time series behavior of equity returns. The bond market factors include a term premium and a default premium, consistent with evidence that these premia are important for bond returns. Fama and French (1995) show that stock and bond returns respond to both stock and bond market factors.

The conditioning variables used to proxy for the information set of investors include the aggregate dividend yield, term spread, default spread, the short-term risk free rate, and average stock volatility. All of these variables have been shown to track time variation in both stock and bond returns. Chen, Roll, and Ross (1986), Keim and Stambaugh (1986), Campbell and Shiller (1988), Fama and French (1988, 1989), Fama (1990), Campbell (1991), and Ferson and Harvey (1991) find evidence that returns can be predicted by variables such as the dividend yield, the Treasury bill rate, the term spread, and the default spread. Goyal and Santa-Clara (2003) show that average stock variance has a significant predictive ability for the aggregate market return in the presence of these business cycle variables. Furthermore, average stock variance is important in our context since it may be related to the risk aversion of investors. Goyal and Santa-Clara (2003) argue that the total risk of individual stocks is related to the riskiness of non-traded assets. The non-traded assets held by investors add background risk to their traded portfolio decisions. When the risk of the non-traded assets goes up, investors would be less willing to hold other traded risky assets. Thus, they would require an increase in expected return to be persuaded to hold the market portfolio of traded stocks. Therefore, the market price of risk (or relative risk aversion) might be affected. Finally, average stock variance affects bond returns as well, which is relevant given that we use both stocks and bonds in our analysis (see Black and Scholes (1973), Merton (1974), and, more recently, Campbell and Taksler (2002)).

4. Data and Main Results

We use monthly data for the period 1927-2005. This provides a time series of 942 monthly observations to be used in the GMM system. We use the CRSP value-weighted portfolio (with distributions) as a proxy for the market portfolio and the 30-day Treasury bill as a proxy for the risk-free rate. We define the term premium bond factor as the return spread of a long-term government bond over the T-bill rate. The default premium bond factor is the return spread of a long-term corporate bond over the long-term government bond. The returns of the long-term government and corporate bonds come from the Ibbotson database module on Stocks, Bonds, Bills, and Inflation. We also use the monthly returns of a cross-section of test assets: 25 portfolios sorted by size and book-to-market, collected from Ken French's website[6], as well as the monthly returns of a 10-year and 1-year Treasury bonds, and a BAA- and AAA-rated corporate bonds, collected from Ibbotson.

In addition, we use conditioning variables that track time-variation in stock and bond returns: the dividend yield of the value-weighted market index, computed as the sum of dividends over the last 12 months, divided by the level of the index, the difference between the yields of a 10-year and 1-year government bonds (term spread), the difference between the yields of a BAA and AAA corporate bonds (default spread), the one-month Treasury bill return, and average stock variance computed as the equally-weighted total variance for all stocks based on daily stock returns. Data on bond yields is taken from Ibbotson (pre-1953) and from the Federal Reserve Bank of St. Louis (post-1953).

To summarize, we estimate the following system of moment conditions:

$$\left[\begin{array}{c} E(m_{t+1} R_{i,t+1} \otimes z_t) \\ E(m_{t+1} \otimes z_t) \end{array} \right] = \left[\begin{array}{c} 0 \\ z_t \end{array} \right]. \tag{14}$$

where $R_{i,t+1}$ consists of the excess returns of 25 equity portfolios sorted by book-to-market and size, a 10-year government bond, 1-year government bond, BAA-rated corporate bond, and AAA-rated corporate bond. The stochastic discount factor is defined as:

$$m_{t+1} = a_t - \gamma_{M,t} R_{M,t+1} - \gamma_{GB,t} R_{GB,t+1} - \gamma_{CB,t} R_{CB,t+1} - \gamma_{HML,t} R_{HML,t+1} - \gamma_{SMB,t} R_{SMB,t+1}, \tag{15}$$

where GB stands for the term premium bond factor, CB stands for the default premium bond factor, and HML and SMB are the book-to-market and size state variables. Finally, the vector z_t consists

[6] We thank Professor French for making these returns available.

of a constant, the aggregate dividend yield (DIV), term spread (TERM), default spread (DEF), the short-term Treasury bill (RF), and average stock variance (AV). Therefore, the coefficients of the stochastic discount factor in (15) can be further expressed as linear functions of these instrumental variables:

$$m_{t+1} = a'z_t - (\gamma'_M z_t)R_{M,t+1} - (\gamma'_{GB} z_t)R_{GB,t+1} - (\gamma'_{CB} z_t)R_{CB,t+1} \\ -(\gamma'_{HML} z_t)R_{HML,t+1} - (\gamma'_{SMB} z_t)R_{SMB,t+1}. \tag{16}$$

The conditioning variables that we use in the stochastic discount factor have been chosen for their ability to track variation in stock and bond returns across the business cycle. Fama and French (1989) point out that some of these variables, namely the dividend yield and default spread, track variation in returns that goes beyond the business cycle. Other variables, namely the term spread and short-term T-Bill rate, track variation in returns in response to short-term fluctuation in business conditions.

Table 1 reports results from estimating the model in (14) for the period from 1927 to 2005. The table reports the coefficients of the stochastic discount factor in (16) and their corresponding t-statistics, adjusted for heteroskedasticity and autocorrelation. Since we use both equity and bond portfolios, the coefficients are estimated imposing consistency not only within the equity and bond markets, but also across the two markets.

Table 1 shows that the market price of risk is significantly related to the term spread, the default spread, the short-term T-bill, and average stock variance. The positive relation with average stock variance is in line with the argument that risk aversion increases with the variance of non-traded assets. A test for the joint significance of the coefficients that track time-variation in the market price of risk reveals that they are jointly significant.

Table 1 also shows that the prices of risk for covariance with the state variables are changing over time as well. The price of risk with respect to the term premium factor is significantly related to the dividend yield, T-bill rate, and average stock variance. The negative relation with average stock variance is in line with the argument that the value of debt decreases as the variance of firm's assets increases. The price of risk with respect to the default premium factor is significantly related to the dividend yield, default spread, and T-bill rate. The price of risk with respect to HML is significantly related to all instrumental variables, while the price of risk with respect to SMB is significantly related to the dividend yield. The coefficients that track time-variation in the prices of risk for all state variables are jointly significant. These results indicate that hedging demands play an important role in the sample period we examine.

The results in Table 1 suggest that there is substantial variation in the prices of market risk over time. To examine this variation, we first plot the time series of estimated $\gamma_{M,t}$ in Panel A of Figure 1. The 95 percent confidence intervals (dotted lines) are also plotted. The figure shows that there is a significant time variation in the market price of risk. We test for the overall significance of $\gamma_{M,t}$, computed following (11), at each month in the sample. Out of 942 months, 709 correspond to a significant $\gamma_{M,t}$. Furthermore, out of 942 months, 917 correspond to a positive $\gamma_{M,t}$. Among the months with a negative value for $\gamma_{M,t}$, only one corresponds to a significant estimate: September, 1931. The average value for the market price of risk over the sample period is 4.11.

Our results on $\gamma_{M,t}$ are consistent with Brandt and Wang (2007) who also find that the aggregate market price of risk varies significantly over time. As Brandt and Wang state, it is also consistent with intuition about time-variation in aggregate risk aversion.[7] As mentioned earlier, $\gamma_{M,t}$ is related to aggregate risk aversion. If aggregate risk aversion is constant, then the usual assumption is that the expected market return is an increasing function of risk. Therefore $\gamma_{M,t}$ should be positive.

However, in Brandt and Wang (2007), the aggregate market price of risk is negative for about 20% of the months over the period 1953-2003, while we find that the market price of risk is negative for less than 3% of the months over the same period. Therefore, estimating the aggregate risk-return relation for the equity market by linking the stock and bond markets is important.

An interesting period is the 1990s, during which the S&P 500 index appreciated an average of about 15% per year, more than twice its average growth rate over the previous 40 years. Real interest rate changes do not, however, appear to be large enough to fully account for the high price to earnings ratios of this period. One possible explanation that has been suggested is that risk aversion has decreased in the 1990s. Our results are consistent with this explanation: in our sample period 1927-2005, there is a drop in risk aversion through the 1990s, which could reflect the eagerness of investors to bear stock market risk in these periods.

So far our results show that the price of market risk is time-varying and predominantly positive for the period 1927 to 2005. However, as discussed in the introduction, this does not necessarily

[7]A number of papers examine time-varying risk aversion. In a habit formation model, Campbell and Cochrane (1999) show that the representative agents risk aversion changes with the difference between consumption and the habit-level of consumption. This habit-level is based on past consumption. Brandt and Wang (2003) point out an alternative explanation for time-varying aggregate risk aversion based on heterogeneous preferences and changes in the cross-sectional distribution of real wealth due to inflation shocks. They find that periods of strong economic conditions are associated with falling risk aversion while recessions are associated with rising risk aversion.

imply that the relation between conditional market risk and return is positive. In the presence of state variables that proxy for changes in the investment opportunity set, we need to check for a positive relation between conditional market variance and the variance component of the market return ($\gamma_{M,t} Var_t(R_{M,t+1})$). Therefore, we need to examine further whether high values of $Var_t(R_{M,t+1})$ correspond to high values of $\gamma_{M,t} Var_t(R_{M,t+1})$. To accomplish this we need an estimate of the conditional variance of the market return.

We estimate the conditional variance of the market return as a linear function of instrumental variables, following previous studies like Campbell (1987) and Whitelaw (1994). We first compute the realized market variance based on daily market returns, following Schwert (1989), and then regress the realized variance on the set of conditioning variables used in the estimation of $\gamma_{M,t}$. In a second approach, we first compute the conditional market return, $E_t(R_{M,t+1})$, as a linear function of the instrumental variables. The conditional market variance is then computed by regressing $[R_{M,t+1} - E_t(R_{M,t+1})]^2$ on the same variables. Both approaches lead to very similar results, therefore we report our findings based on the first one.

The two columns of the last row of Table 1 report the unconditional correlation between the market price of risk and conditional market variance. The correlation is -13% and significant. This implies that in $E(R_{M,t+1}) = E(\gamma_{M,t})E(Var_t(R_{M,t+1})) + Cov(\gamma_{M,t}, Var_t(R_{M,t+1}))$ the first term is positive, while the second one is negative (ignoring state variables for investment opportunities). The important question is which term dominates, i.e. is the overall relation between conditional market variance and return positive?[8] To answer this question we also report in Table 1 the unconditional correlation between conditional market variance and the variance component of the expected market return. The correlation is 73% and highly significant. Therefore, the market price of risk is positive on average and the relation between conditional market risk and return is positive. This result is new and it has not been documented before in the literature that examines the ICAPM with time-varying prices of risk. In other words, even if market price of risk and conditional market variance are negatively correlated, we still find that their product is positively correlated with conditional market variance when we link the stock and bond markets. To better understand the relation between risk, the price of risk, and return, we look at the separate components of $\gamma_{M,t}$.

We use a set of conditioning variables to track variation in the market price of risk. Therefore, we would expect that the market price of risk exhibits fluctuations that track the NBER cycle as

[8] This argument has benefitted directly from comments by Kerry Back.

well as variations that go beyond that. Using a Hodrick-Prescott filter allows us to decompose the estimated market price of risk into two components: a short-term cyclical component and a long-term trend component. The market price of risk is the sum of these two components. Panels B and C of Figure 1 plot the trend and cyclical components of the market price of risk computed using a Hodrick-Prescott filter. Panel B shows a significant upward trend in $\gamma_{M,t}$ from the early 60s until the mid 80s. This upward trend is largely reversed starting from the mid 80s and going until the end of the sample. The trend component of $\gamma_{M,t}$ has a negative correlation with conditional market variance, namely -19% (t-stat = -5.93).

In Panel C we find evidence consistent with a countercyclical behavior for $\gamma_{M,t}$. Panel C shows that $\gamma_{M,t}$ tends to increase during recessionary periods. A linear regression of the cyclical component of $\gamma_{M,t}$ on the NBER recession dummy has a slope coefficient of 0.68 with a t-statistic of 6.95. Thus, the price of risk is countercyclical. The correlation between the cyclical component of $\gamma_{M,t}$ and conditional market variance is 9% (t-stat = 2.77). Taken together, the correlation between the overall market price of risk and conditional market variance is negative. However, the correlation between conditional market return and variance is positive. This is the case since during the short-run fluctuations in the business cycle, high market volatility is accompanied by high compensation for being exposed to this volatility.

To examine possible time-variation in the risk-return relation, we compute the simple correlation between conditional market variance and expected market return in each decade. Figure 2 plots these correlations. It is clear that the risk-return tradeoff is positive in all decades in the sample. The correlations tends to be close to or higher than 70% in all decades except the 50s and 60s. Further calculations reveal that the risk-return correlation is 77% in recessions and 60% in expansions. The difference is significant, with a t-statistic of 2.02.

In Panel A of Figure 3 we plot the estimated time-series for the variance component of the market return, i.e. we plot the term $\gamma_{M,t} Var_t(R_{M,t+1})$. The NBER recession periods are also indicated. The graph reveals that the variance component is countercyclical: it tends to spike during the recessions in the sample. This is consistent with the cyclical behavior of the market price of risk we documented before. The correlation between the variance component of the market return and the NBER recession dummy is 27% (the corresponding t-statistic is 8.60). The risk component of the market return is predominantly positive. One notable exception is September 1931 when the risk component drops to -3%. A possible estimation error cannot be ruled out as a potential explanation for this negative value.

In Panel B of Figure 3 we plot the estimated time-series for the hedge component of the market return related to bond factors. This component is based on the term $\gamma_{GB,t}Cov_t(R_{M,t+1}, R_{GB,t+1}) + \gamma_{CB,t}Cov_t(R_{M,t+1}, R_{CB,t+1})$. The conditional covariance between the excess market return and each state variable is computed using the same approach as the one used for computing conditional market variance. The simple correlation between the variance component of the market return and the hedge component related to bond market factors is significantly negative at -41%. The correlation between these two components is significantly negative at -55% in recessions and -25% in expansions.

In Panel C of Figure 3 we plot the estimated time-series for the hedge component of the market return related to HML and SMB. This component is based on the term $\gamma_{HML,t}Cov_t(R_{M,t+1}, R_{HML,t+1}) + \gamma_{SMB,t}Cov_t(R_{M,t+1}, R_{SMB,t+1})$. The correlation between the variance component and this hedge component is significantly positive at 60% over the entire sample period. Further, this correlation is significantly positive at 73% in recessions and 28% in expansions.

Overall, the negative correlation between the variance component and the hedge component related to bonds shows that bonds provide hedging opportunities. The correlation is more negative during recessionary periods including the Great Depression, the recession of the early 1980s, and the recession of the early 2000s. This suggests that bonds are important state variables in general, and particularly so during recessionary or high market volatility periods, because they provide safer investment opportunities. The implication is that during high market volatility periods, investors rebalance to bonds and so the expected market return should rise to induce investors to hold stocks now that bonds are more attractive. This cross-market hedging argument is the main reason for the significantly positive aggregate market risk-return relation we uncover. In other words, omitting the bond factors might result in a downward bias in the estimate of the market price of risk. In the next section we show that omitting the bond market does have a significant effect on the sign and significance of the relation between aggregate risk and return.

5. How Important is the Bond Market for Extracting the True Aggregate Risk-Return Relation?

We document a significantly positive risk-return tradeoff by linking the stock and bond markets. In this section we show that the presence of bond portfolios among the test assets and bond factors among the state variables is important for detecting a positive risk-return relation. To show this, we exclude the bond market from the investment opportunity set and repeat our previous analysis.

Table 2 reports results from estimating the model in (14) for the case in which the test assets are 25 size and book-to-market portfolios, the state variables are HML and SMB, and the conditioning variables are dividend yield, term spread, default spread, and short-term T-bill.[9] Therefore, we look at equity returns only. The sample period is from 1927 to 2005. This specification makes our results comparable to other papers that use stock returns in estimating the risk-return tradeoff (e.g., Brandt and Wang, 2007). The table reports the coefficients of the stochastic discount factor and their corresponding t-statistics, adjusted for heteroskedasticity and autocorrelation.

Table 2 shows that the market price of risk is significantly related to all instrumental variables. A test for the joint significance of the coefficients that track time-variation in the market price of risk reveals that they are jointly significant. Table 2 also shows that the price of risk for covariance with HML is significantly related to the short-term T-Bill, while the price of risk for covariance with SMB is significantly related to all conditioning variables. A test for the joint significance of the coefficients that track time variation in these prices of risk shows that they are jointly significant. As before, hedging demands play an important role in the sample period we examine.

To examine the variation of the market price of risk in more detail, we plot the time series of estimated $\gamma_{M,t}$ in Panel A of Figure 4. The 95 percent confidence intervals (dotted lines) are also plotted. The figure shows that there is a significant time variation in the market price of risk. We test for the overall significance of $\gamma_{M,t}$, at each month in the sample. Out of 942 months, 764 correspond to a significant $\gamma_{M,t}$. Furthermore, out of 942 months, 859 correspond to a positive $\gamma_{M,t}$, as compared to 917 months with positive $\gamma_{M,t}$ when we allow for the presence of bond portfolios among the test assets and bond factors among the state variables. Among the months with a negative value for $\gamma_{M,t}$, 33 correspond to a significant estimate. A notable period in which the market price of risk is significantly negative is the early 80s. The average value for the market price

[9] We drop the average stock variance from the set of conditioning variables to make the results in this section comparable to Brandt and Wang (2007) who use the same four instrumental variables. However, even if average stock variance is included in the set, the conclusions are not affected. These results are available upon request.

of risk over the entire sample period is 4.59.

Panels B and C of Figure 4 plot the trend and cyclical components of the market price of risk computed using a Hodrick-Prescott filter. Panel B shows an upward trend in $\gamma_{M,t}$ until the 50s. This upward trend is largely reversed by the 70s. Panel C plots the cyclical component of the market price of risk together with the NBER recessions. The Panel shows that $\gamma_{M,t}$ tends to decrease during recessionary periods. A simple linear regression of the cyclical component of $\gamma_{M,t}$ on the NBER recession dummy has a slope coefficient of -1.13 with a t-statistic of 6.00. Thus, there is no evidence that the price of risk estimated with equity portfolios is countercyclical.

The two columns of the last row of Table 2 report the unconditional correlation between the market price of risk estimated with equity portfolios alone and conditional market variance. The correlation is -57% and highly significant. Note that the correlation in this case is even more negative than in the case when we use bond portfolios. To better understand the reason for this we look at the separate components of the market price of risk. The trend component of $\gamma_{M,t}$ has a significantly negative correlation with conditional market variance, namely -24%. The correlation between the cyclical component of $\gamma_{M,t}$ and conditional market variance is also significantly negative at -61%. As a result, the overall correlation between conditional market variance and the variance component of the expected market return ends up being significantly negative as well, namely -18% as reported in Table 2.[10]

In summary, when the bond market is omitted from the analysis, we fail to detect a positive risk-return tradeoff. Even though the market price of risk is positive on average, the overall relation between conditional market risk and return is negative. This is the case since even during the short-run fluctuations in the business cycle, high market volatility is accompanied by low compensation for bearing this volatility, and this seems to be counter-intuitive.

6. Robustness

In this section we perform robustness tests for the main results reported so far. The robustness checks include looking at a more recent sample, incorporating equity portfolios sorted by industry classification, and including more bond portfolios. We look at the period from 1953 to 2005 to make our results comparable to Brandt and Wang (2007) and other papers that examine the ICAPM

[10]Further investigation reveals that only the correlation between the trend component of the market price of risk and the trend component of market variance is negative when we include bonds, while all four correlations between the two components of the price of risk and the two components of market variance are negative when we exclude bonds.

in the more recent sample. We incorporate industry portfolios following Lewellen, Nagel, and Shanken (2006). They argue that the 25 size and book-to-market portfolios have a strong covariance structure which can cause misleading results in asset pricing tests. As a result, Lewellen, Nagel, and Shanken (2006) suggest including industry portfolios to the set of 25 assets. Finally, we include additional bond portfolios which test the robustness of our results to different maturity and default levels.

6.1. Recent Sample Period: 1953-2005

Table 3 reports the coefficients of the stochastic discount factor for two cases. In Panel A we use both equity and bond portfolios (case 1), while in Panel B we use only equity portfolios (case 2). Both Panels show that the market price of risk and the prices of risk for all state variables vary significantly over time. In all cases, the coefficients of the stochastic discount factor are jointly significant. A notable observation in Panel A is that the market price of risk is positively related to average stock variance, while the price of risk associated with the default premium bond factor is negatively related to the same variable. This result is in line with our previous discussion on the opposite effects average stock variance has on stock and bond returns.

In Figure 5 we plot the two time series of estimated $\gamma_{M,t}$ together with the NBER recession dummy. The solid plot corresponds to the case in which we use both equity and bond portfolios, while the dotted plot is based on using equity portfolios alone. The figure shows that there is significant time variation in both estimates of the market price of risk. In addition, both of them seem to exhibit a countercyclical pattern. The simple correlation between the two series is 85%. We test further for the overall significance of the two $\gamma_{M,t}$ series at each month in the sample. Out of 627 months, 544 correspond to a significant $\gamma_{M,t}$ in case 1 and 483 in case 2. Furthermore, out of 627 months, 609 correspond to a positive $\gamma_{M,t}$ in case 1 and 544 in case 2. Among the months with a negative value for $\gamma_{M,t}$, 2 correspond to a significant estimate in case 1 and 24 in case 2. The average value for the market price of risk over this sample period is 7.97 in case 1 and 5.57 in case 2. In summary, even though the two series of $\gamma_{M,t}$s are highly correlated, the one based on equity and bond portfolios is significantly positive with a higher frequency.

The two columns of the last row of each panel in Table 3 report the simple correlation between the market price of risk and conditional market variance. The correlation is -21% in case 1 and -72% in case 2 (both are significant). We further report the correlation between conditional market variance and the variance component of the expected market return. This correlation is 54% in case

1 and -23% in case 2 (both are significant). As previously reported, the relation between market risk and return is significantly positive only when we account for the link between the stock and bond markets.

This section shows that the results for the shorter sample of 1953-2005 are very similar to the main results for the longer sample. The market price of risk exhibits a significant variation over time, it tends to rise in recessions, and it is significantly positive on average. The overall relation between risk and return at the aggregate level is significantly positive.

6.2. Using Industry Portfolios

The next robustness check we perform is to include industry portfolios in the set of test assets. Industry portfolios have different risk-return profiles relative to the assets sorted by size and book-to-market. We test whether our earlier results are affected by the presence of these new portfolios in the investment opportunity set.

We examine the coefficients of the stochastic discount factor for two cases: in case 1 we use both equity and bond portfolios, while in case 2 we use only equity portfolios. In both cases, the equity portfolios include assets sorted by size and book-to-market and industry. Panel A of Table 4 reports the results for case 1 and Panel B reports the results for case 2. The sample period examined is 1927-2005. We find that the market price of risk and the prices of risk for all state variables vary significantly over time. In all cases, the coefficients are jointly significant. The simple correlation between conditional market variance and the variance component of the expected market return is 70% in case 1, and -23% in case 2 (both are significant). [11]

Figure 6 plots two time series of estimated $\gamma_{M,t}$ together with the NBER recession dummy. The sample period is 1927-2005. As before, the solid plot corresponds to the case in which we use both equity and bond portfolios (case 1), while the dotted plot is based on using equity portfolios alone (case 2). There is significant variation over time in both series. The market price of risk in case 1 seems to exhibit a countercyclical pattern. The simple correlation between the two series is 13%. The average value for the market price of risk is 4.81 in case 1 and 4.78 in case 2. The series based on equity and bond portfolios is predominantly positive, while the one based on equity portfolios assumes large negative values (notably, in the early 80s). Once again, by linking the stock and bond markets, we document a significantly positive relation between risk and return.

[11] The results for the period 1953-2005 are similar. These results are untabulated but are available from the authors upon request.

6.3. Using Additional Bond Portfolios

So far our test assets include bond portfolios representing the long and short end of the maturity range, as well as corporate bonds representing high and low rating categories. In this section, we introduce several other government and corporate bonds to the set of test assets. Given that bonds are important in detecting the risk-return relation, we check the robustness of out main results to the presence of additional bond categories along the maturity and default spectrum. Namely, we add an intermediate government bond, A-rated and AA-rated corporate bonds, and a low-grade corporate bond.

The results are easily summarized. Out of 942 months, 769 correspond to a significant $\gamma_{M,t}$ and 912 correspond to a positive $\gamma_{M,t}$. Among the months with a negative value for $\gamma_{M,t}$ only four correspond to a significant estimate: August, 1929, September, 1931, January, 1934, and February, 1934. The average value for the market price of risk over the sample period is 4.22. The time-series of $\gamma_{M,t}$ exhibits a countercyclical patter; the correlation between the cyclical component of $\gamma_{M,t}$ and the NBER recession dummy is significant at 22%. Finally, the correlation between conditional market variance and the risk component of the market return is significant at 66%. The risk-return relation continues to be positive in the presence of a wider range of bond maturities and ratings.

7. Conclusion

We use a large cross-section of equity and bond portfolios to estimate the aggregate risk-return tradeoff. Our framework follows the ICAPM of Merton (1973). We assume that the market price of risk varies over time and we control for hedging demands using factors that affect both the stock and the bond market. We show that when the market price of risk changes over time, one needs to check not only that the average price of risk is positive, but also whether the market price of risk is sufficiently high during times when the market variance is high. Checking both of these conditions represents a true test of wether the relation between conditional market variance and return is positive. Our findings can be summarized easily: the market price of risk is positive on average over the period 1927-2005 and the relation between conditional market variance and return is significantly positive. Furthermore, the market price of risk is countercyclical.

We present three pieces of evidence to show that including bond portfolios as test assets and bond factors as state variables matter in uncovering the true aggregate risk-return relation. First, when we include bond portfolios, the simple correlation between the cyclical component of the market price of risk and conditional market variance is significantly positive. When we exclude bonds from the analysis, the correlation between the cyclical component of the market price of risk and conditional market variance is significantly negative. Consequently, the overall correlation between conditional market return and variance is negative. Second, out of 942 months in our sample, 917 (859) months correspond to a positive market price of risk when we include (exclude) bond portfolios. The months in which the market price of risk is positive in the first case but negative in the second case correspond to periods of high volatility, namely the Great Depression, the recession of the early 1980s, and the recession of the early 2000s. When we exclude bonds from the analysis, we obtain a counter-intuitive result of negative price of risk in these recessionary periods. Third, we find that the correlation between the risk component of the market return and the hedge component related to the bond market is significantly negative, and more so in recessions. Therefore, bonds are important hedging tools, especially in high volatility periods. In periods of high market variance, investors would want to rebalance into safer assets such as bonds. In order to induce investors to hold stocks now that bonds are more attractive, the compensation for bearing stock risk, and consequently expected stock returns, must rise. Therefore, this cross-market hedging argument predicts that linking the stock and bond markets makes the positive relation between aggregate market risk and return stronger. This is precisely what we find in this paper. The importance of including bonds in an ICAPM framework is corroborated by recent literature that documents strong return and volatility linkages between the stock and bond markets. Understanding and modeling the link between the bond and stock markets, and understanding the implications for asset pricing remains an interesting topic for future research.

Appendix: GMM Estimation

The system of moment conditions is:

$$\begin{bmatrix} E(m_{t+1}R_{t+1} \otimes z_t) \\ E(m_{t+1} \otimes z_t) \end{bmatrix} = \begin{bmatrix} 0 \\ z_t \end{bmatrix}, \tag{17}$$

where R_{t+1} is a column vector of excess returns on a number of assets. Following the notation in Cochrane (2005), if we let

$$x_{t+1} = \begin{pmatrix} R_{t+1} \\ 1 \end{pmatrix} \otimes z_t, \tag{18}$$

and

$$p_t = \begin{pmatrix} 0 \\ 1 \end{pmatrix} \otimes z_t, \tag{19}$$

then equation (12) becomes

$$E(m_{t+1}x_{t+1}) = p_t. \tag{20}$$

Following Cohrane (2005) further, if we let

$$f_{t+1} = \begin{pmatrix} 1 \\ R_{M,t+1} \\ R_{GB,t+1} \\ R_{CB,t+1} \\ R_{HML,t+1} \\ R_{SMB,t+1} \end{pmatrix}, \tag{21}$$

then the stochastic discount factor can be expressed as $m_{t+1} = b'f_{t+1}$, where b is the parameter vector of interest. Using the moment conditions in (17), we use GMM to estimate the coefficient vector b. The second-stage estimate of b and its corresponding standard error are:

$$\hat{b} = (d'S^{-1}d)^{-1}d'S^{-1}E_T(p), \tag{22}$$

$$Cov(\hat{b}) = \frac{(d'S^{-1}d)^{-1}}{T}, \tag{23}$$

where E_T denotes a time-series average, $d' = E_T(fx')$, and S is the optimal weighting matrix. S is replaced by its sample equivalent, the covariance matrix of the moment conditions.

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Table 1 . Estimating the Market Price of Risk and the Risk-Return Tradeoff: 1927:01-2005:12

This table reports results from estimating the model

$$\begin{bmatrix} E(m_{t+1}R_{i,t+1} \otimes z_t) \\ E(m_{t+1} \otimes z_t) \end{bmatrix} = \begin{bmatrix} 0 \\ z_t \end{bmatrix},$$

where $R_{i,t+1}$ consists of the excess returns of 25 portfolios sorted by book-to-market and size, a 10-year government bond, 1-year government bond, BAA-rated corporate bond, and AAA-rated corporate bond. The table reports the coefficients of the stochastic discount factor m_{t+1} and their corresponding t-statistics, adjusted for heteroskedasticity and autocorrelation. The coefficients of the stochastic discount factor are linear functions of instrumental variables: $m_{t+1} = a'z_t - (\gamma'_M z_t)R_{M,t+1} - (\gamma'_{GB} z_t)R_{GB,t+1} - (\gamma'_{CB} z_t)R_{CB,t+1} - (\gamma'_{HML} z_t)R_{HML,t+1} - (\gamma'_{SMB} z_t)R_{SMB,t+1}$, where M stands for the excess market return, GB stands for term premium, CB stands for default premium, and HML and SMB are the Fama-French (1993) portfolios. The vector of conditioning variables, z_t, consists of a constant, the aggregate dividend yield (DIV), term spread (TERM), default spread (DEF), the short-term Treasury bill rate (RF), and average stock variance (AV). The two columns of the last row report the unconditional correlation between the market price of risk, $\gamma_{M,t}$, and conditional market variance, $\sigma^2_{M,t}$, and between the variance component of the market return, $\gamma_{M,t}\sigma^2_{M,t}$, and conditional market variance. The sample period is January 1927-December 2005.

	γ_M	$\gamma_M DIV_t$	$\gamma_M TERM_t$	$\gamma_M DEF_t$	$\gamma_M RF_t$	$\gamma_M AV_t$
Estimate	4.11	1.05	2.68	-1.54	3.52	0.96
t-stat	5.45	1.76	4.66	-2.31	4.52	2.42
	γ_{GB}	$\gamma_{GB} DIV_t$	$\gamma_{GB} TERM_t$	$\gamma_{GB} DEF_t$	$\gamma_{GB} RF_t$	$\gamma_{GB} AV_t$
Estimate	0.12	0.16	-0.01	0.01	-0.14	-0.19
t-stat	3.50	4.14	-0.43	0.29	-5.63	-6.84
	γ_{CB}	$\gamma_{CB} DIV_t$	$\gamma_{CB} TERM_t$	$\gamma_{CB} DEF_t$	$\gamma_{CB} RF_t$	$\gamma_{CB} AV_t$
Estimate	0.04	0.32	-0.01	-0.24	-0.16	0.01
t-stat	0.59	5.14	-0.18	-4.15	-2.66	0.67
	γ_{HML}	$\gamma_{HML} DIV_t$	$\gamma_{HML} TERM_t$	$\gamma_{HML} DEF_t$	$\gamma_{HML} RF_t$	$\gamma_{HML} AV_t$
Estimate	5.84	2.60	7.93	-4.98	9.91	2.31
t-stat	5.68	3.49	7.14	-5.17	9.36	3.76
	γ_{SMB}	$\gamma_{SMB} DIV_t$	$\gamma_{SMB} TERM_t$	$\gamma_{SMB} DEF_t$	$\gamma_{SMB} RF_t$	$\gamma_{SMB} AV_t$
Estimate	0.98	-1.98	1.52	1.38	-0.88	0.50
t-stat	0.93	-1.96	1.03	0.94	-0.58	0.54

	Corr($\gamma_{M,t}, \sigma^2_{M,t}$)	Corr($\gamma_{M,t}\sigma^2_{M,t}, \sigma^2_{M,t}$)
Estimate	-0.13	0.73
t-stat	-4.02	32.77

Table 2 . Estimating the Market Price of Risk and the Risk-Return Tradeoff with Equity Portfolios Only: 1927:01-2005:12

This table reports results from estimating the model

$$\left[\begin{array}{c} E(m_{t+1}R_{i,t+1} \otimes z_t) \\ E(m_{t+1} \otimes z_t) \end{array}\right] = \left[\begin{array}{c} 0 \\ z_t \end{array}\right],$$

where $R_{i,t+1}$ consists of the excess returns of 25 portfolios sorted by book-to-market and size. The table reports the coefficients of the stochastic discount factor m_{t+1} and their corresponding t-statistics, adjusted for heteroskedasticity and autocorrelation. The coefficients of the stochastic discount factor are linear functions of instrumental variables: $m_{t+1} = a'z_t - (\gamma'_M z_t)R_{M,t+1} - (\gamma'_{HML} z_t)R_{HML,t+1} - (\gamma'_{SMB} z_t)R_{SMB,t+1}$, where M stands for the excess market return, and HML and SMB are the Fama-French (1993) portfolios. The vector of conditioning variables, z_t, consists of a constant, the aggregate dividend yield (DIV), term spread (TERM), default spread (DEF), and the short-term Treasury bill rate (RF). The two columns of the last row report the unconditional correlation between the market price of risk, $\gamma_{M,t}$, and conditional market variance, $\sigma^2_{M,t}$, and between the variance component of the market return, $\gamma_{M,t}\sigma^2_{M,t}$, and conditional market variance. The sample period is January 1927-December 2005.

	γ_M	$\gamma_M DIV_t$	$\gamma_M TERM_t$	$\gamma_M DEF_t$	$\gamma_M RF_t$
Estimate	4.59	1.95	1.93	-2.89	2.48
t-stat	7.00	3.39	3.40	-6.00	4.75
	γ_{HML}	$\gamma_{HML} DIV_t$	$\gamma_{HML} TERM_t$	$\gamma_{HML} DEF_t$	$\gamma_{HML} RF_t$
Estimate	2.74	0.22	2.00	0.75	6.77
t-stat	2.47	0.31	1.79	0.98	6.90
	γ_{SMB}	$\gamma_{SMB} DIV_t$	$\gamma_{SMB} TERM_t$	$\gamma_{SMB} DEF_t$	$\gamma_{SMB} RF_t$
Estimate	-1.95	-2.18	-5.63	2.78	-7.89
t-stat	-1.93	-2.76	-4.45	4.27	-7.72
	Corr$(\gamma_{M,t}, \sigma^2_{M,t})$	Corr$(\gamma_{M,t}\sigma^2_{M,t}, \sigma^2_{M,t})$			
Estimate	-0.57	-0.18			
t-stat	-21.28	-5.61			

Table 3 . Estimating the Market Price of Risk and the Risk-Return Tradeoff: 1953:04-2005:12

This table reports results from estimating the model

$$\begin{bmatrix} E(m_{t+1}R_{i,t+1} \otimes z_t) \\ E(m_{t+1} \otimes z_t) \end{bmatrix} = \begin{bmatrix} 0 \\ z_t \end{bmatrix}.$$

In Panel A the vector $R_{i,t+1}$ consists of the excess returns of 25 portfolios sorted by book-to-market and size, a 10-year government bond, 1-year government bond, BAA-rated corporate bond, and AAA-rated corporate bond. The table reports the coefficients of the stochastic discount factor m_{t+1} and their corresponding t-statistics, adjusted for heteroskedasticity and autocorrelation. The coefficients of the stochastic discount factor are linear functions of instrumental variables: $m_{t+1} = a'z_t - (\gamma'_M z_t)R_{M,t+1} - (\gamma'_{GB} z_t)R_{GB,t+1} - (\gamma'_{CB} z_t)R_{CB,t+1} - (\gamma'_{HML} z_t)R_{HML,t+1} - (\gamma'_{SMB} z_t)R_{SMB,t+1}$, where M stands for the excess market return, GB stands for term premium, CB stands for default premium, and HML and SMB are the Fama-French (1993) portfolios. The vector of conditioning variables, z_t, consists of a constant, the aggregate dividend yield (DIV), term spread (TERM), default spread (DEF), the short-term Treasury bill rate (RF), and average stock variance (AV). In Panel B, the test assets are the 25 portfolios sorted by size and book-to-market, the risk factors are the market, HML, and SMB, and the conditioning variables are DIV, TERM, DEF, and RF. The two columns of the last row of each panel report the unconditional correlation between the market price of risk, $\gamma_{M,t}$, and conditional market variance, $\sigma^2_{M,t}$, and between the variance component of the market return, $\gamma_{M,t}\sigma^2_{M,t}$, and conditional market variance. The sample period is April 1953-December 2005.

Panel A: Size and Book-to-Market Portfolios + Bond Portfolios

	γ_M	$\gamma_M DIV_t$	$\gamma_M TERM_t$	$\gamma_M DEF_t$	$\gamma_M RF_t$	$\gamma_M AV_t$
Estimate	7.97	3.35	3.77	-2.49	-0.30	2.18
t-stat	8.57	2.84	2.45	-1.85	-0.17	2.11
	γ_{GB}	$\gamma_{GB} DIV_t$	$\gamma_{GB} TERM_t$	$\gamma_{GB} DEF_t$	$\gamma_{GB} RF_t$	$\gamma_{GB} AV_t$
Estimate	-0.08	0.02	0.02	0.01	0.02	0.01
t-stat	-3.17	1.06	0.87	0.44	0.97	0.46
	γ_{CB}	$\gamma_{CB} DIV_t$	$\gamma_{CB} TERM_t$	$\gamma_{CB} DEF_t$	$\gamma_{CB} RF_t$	$\gamma_{CB} AV_t$
Estimate	-0.28	-0.02	0.08	-0.08	0.19	-0.19
t-stat	-3.64	-0.26	0.70	-0.94	1.85	-3.67
	γ_{HML}	$\gamma_{HML} DIV_t$	$\gamma_{HML} TERM_t$	$\gamma_{HML} DEF_t$	$\gamma_{HML} RF_t$	$\gamma_{HML} AV_t$
Estimate	12.10	-6.77	8.89	-5.67	9.92	-6.46
t-stat	8.17	-5.04	5.20	-3.75	5.34	-5.95
	γ_{SMB}	$\gamma_{SMB} DIV_t$	$\gamma_{SMB} TERM_t$	$\gamma_{SMB} DEF_t$	$\gamma_{SMB} RF_t$	$\gamma_{SMB} AV_t$
Estimate	5.14	4.47	-4.69	7.57	-9.19	9.19
t-stat	3.76	3.12	-2.41	4.67	-3.79	5.78
	Corr$(\gamma_{M,t}, \sigma^2_{M,t})$	Corr$(\gamma_{M,t}\sigma^2_{M,t}, \sigma^2_{M,t})$				
Estimate	-0.21	0.54				
t-stat	-5.37	16.04				

Panel B: Size and Book-to-Market Portfolios

	γ_M	$\gamma_M DIV_t$	$\gamma_M TERM_t$	$\gamma_M DEF_t$	$\gamma_M RF_t$
Estimate	5.57	3.96	5.09	-2.60	1.03
t-stat	6.58	4.94	3.95	-2.65	0.84
	γ_{HML}	$\gamma_{HML} DIV_t$	$\gamma_{HML} TERM_t$	$\gamma_{HML} DEF_t$	$\gamma_{HML} RF_t$
Estimate	8.62	1.77	8.22	-5.53	6.65
t-stat	6.22	1.60	5.04	-3.56	3.65
	γ_{SMB}	$\gamma_{SMB} DIV_t$	$\gamma_{SMB} TERM_t$	$\gamma_{SMB} DEF_t$	$\gamma_{SMB} RF_t$
Estimate	2.20	-2.24	-1.36	5.76	-3.60
t-stat	1.67	-1.93	-0.93	4.16	-2.00
	Corr$(\gamma_{M,t}, \sigma^2_{M,t})$	Corr$(\gamma_{M,t}\sigma^2_{M,t}, \sigma^2_{M,t})$			
Estimate	-0.72	-0.23			
t-stat	-25.94	-5.91			

Table 4 . Estimating the Market Price of Risk and the Risk-Return Tradeoff-Including Industry Portfolios: 1927:01-2005:12

This table reports results from estimating the model

$$\begin{bmatrix} E(m_{t+1}R_{i,t+1} \otimes z_t) \\ E(m_{t+1} \otimes z_t) \end{bmatrix} = \begin{bmatrix} 0 \\ z_t \end{bmatrix}.$$

In Panel A the vector $R_{i,t+1}$ consists of the excess returns of 25 portfolios sorted by size and book-to-market, 10 portfolios sorted by industry classification, a 10-year government bond, 1-year government bond, BAA-rated corporate bond, and AAA-rated corporate bond. The table reports the coefficients of the stochastic discount factor m_{t+1} and their corresponding t-statistics, adjusted for heteroskedasticity and autocorrelation. The coefficients of the stochastic discount factor are linear functions of instrumental variables: $m_{t+1} = a'z_t - (\gamma_M' z_t)R_{M,t+1} - (\gamma_{GB}' z_t)R_{GB,t+1} - (\gamma_{CB}' z_t)R_{CB,t+1} - (\gamma_{HML}' z_t)R_{HML,t+1} - (\gamma_{SMB}' z_t)R_{SMB,t+1}$, where M stands for the excess market return, GB stands for term premium, CB stands for default premium, and HML and SMB are the Fama-French (1993) portfolios. The vector of conditioning variables, z_t, consists of a constant, the aggregate dividend yield (DIV), term spread (TERM), default spread (DEF), the short-term Treasury bill rate (RF), and average stock variance (AV). In Panel B, the test assets are 25 portfolios sorted by size and book-to-market and 10 industry-sorted portfolios, the risk factors are the market, HML, and SMB, and the conditioning variables are DIV, TERM, DEF, and RF. The two columns of the last row of each panel report the unconditional correlation between the market price of risk, $\gamma_{M,t}$, and conditional market variance, $\sigma^2_{M,t}$, and between the variance component of the market return, $\gamma_{M,t}\sigma^2_{M,t}$, and conditional market variance. The sample period is April 1953-December 2005.

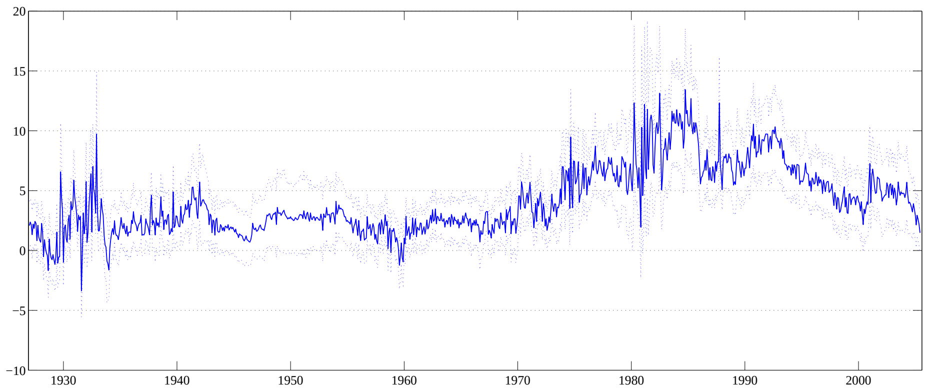
Panel A: Equity Portfolios + Bond Portfolios						
	γ_M	$\gamma_M DIV_t$	$\gamma_M TERM_t$	$\gamma_M DEF_t$	$\gamma_M RF_t$	$\gamma_M AV_t$
Estimate	4.81	1.75	3.44	-2.57	3.38	1.33
t-stat	7.40	3.42	7.43	-4.69	5.40	3.98
	γ_{GB}	$\gamma_{GB} DIV_t$	$\gamma_{GB} TERM_t$	$\gamma_{GB} DEF_t$	$\gamma_{GB} RF_t$	$\gamma_{GB} AV_t$
Estimate	0.10	0.18	-0.01	-0.02	-0.11	-0.19
t-stat	3.79	6.30	-0.72	-0.57	-6.13	-9.16
	γ_{CB}	$\gamma_{CB} DIV_t$	$\gamma_{CB} TERM_t$	$\gamma_{CB} DEF_t$	$\gamma_{CB} RF_t$	$\gamma_{CB} AV_t$
Estimate	-0.03	0.39	0.12	-0.31	-0.11	0.03
t-stat	-0.51	8.45	2.61	-7.00	-2.43	2.48
	γ_{HML}	$\gamma_{HML} DIV_t$	$\gamma_{HML} TERM_t$	$\gamma_{HML} DEF_t$	$\gamma_{HML} RF_t$	$\gamma_{HML} AV_t$
Estimate	4.11	2.52	9.15	-4.27	11.37	2.20
t-stat	4.51	3.99	10.22	-5.21	12.88	4.26
	γ_{SMB}	$\gamma_{SMB} DIV_t$	$\gamma_{SMB} TERM_t$	$\gamma_{SMB} DEF_t$	$\gamma_{SMB} RF_t$	$\gamma_{SMB} AV_t$
Estimate	0.06	-2.73	0.98	2.32	-1.57	0.38
t-stat	0.07	-3.26	0.78	1.97	-1.20	0.49
	Corr$(\gamma_{M,t}, \sigma^2_{M,t})$	Corr$(\gamma_{M,t}\sigma^2_{M,t}, \sigma^2_{M,t})$				
Estimate	-0.16	0.70				
t-stat	-4.97	30.05				

Panel B: Equity Portfolios					
	γ_M	$\gamma_M DIV_t$	$\gamma_M TERM_t$	$\gamma_M DEF_t$	$\gamma_M RF_t$
Estimate	4.78	2.08	1.69	-2.86	2.17
t-stat	8.13	4.28	3.77	-7.55	5.55
	γ_{HML}	$\gamma_{HML} DIV_t$	$\gamma_{HML} TERM_t$	$\gamma_{HML} DEF_t$	$\gamma_{HML} RF_t$
Estimate	0.52	-0.21	2.72	1.43	7.70
t-stat	0.52	-0.35	3.04	2.36	9.91
	γ_{SMB}	$\gamma_{SMB} DIV_t$	$\gamma_{SMB} TERM_t$	$\gamma_{SMB} DEF_t$	$\gamma_{SMB} RF_t$
Estimate	-2.10	-1.14	-3.66	1.84	-6.43
t-stat	-2.42	-1.75	-3.75	3.65	-8.51
	Corr$(\gamma_{M,t}, \sigma^2_{M,t})$	Corr$(\gamma_{M,t}\sigma^2_{M,t}, \sigma^2_{M,t})$			
Estimate	-0.58	-0.09			
t-stat	-21.83	-2.77			

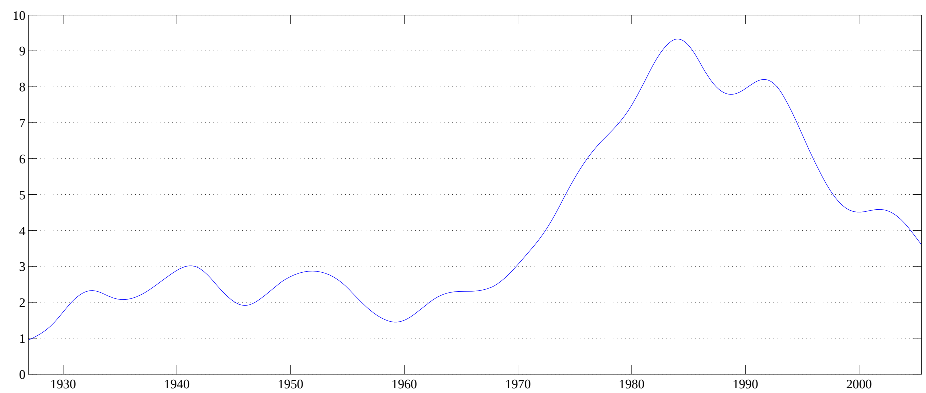
Figure 1 . Time Series of Market Price of Risk: 1927:01-2005:12

This Figure plots the market price of risk estimated from a cross-section of 25 portfolios sorted by size and book-to-market, a 10-year government bond, a 1-year government bond, a BAA- and AAA-rated corporate bonds. Panel A shows the time series of estimated price of market risk, $\gamma_{M,t}$, over 942 months spanning the period January 1927 through December 2005. The 95 percent confidence intervals (dotted lines) are also plotted. Using a Hodrick-Prescott filter, we decompose the estimated market price of risk into two components: a short-term cyclical component and a long-term trend component. The market price of risk is the sum of these two components. Panels B and C plot the trend and cyclical components of the price of market risk. The NBER recession periods are shown in Panel C.

Panel A: $\gamma_{M,t}$



Panel B: $\gamma_{M,t}$ Trend



Panel C: $\gamma_{M,t}$ Cyclical Component

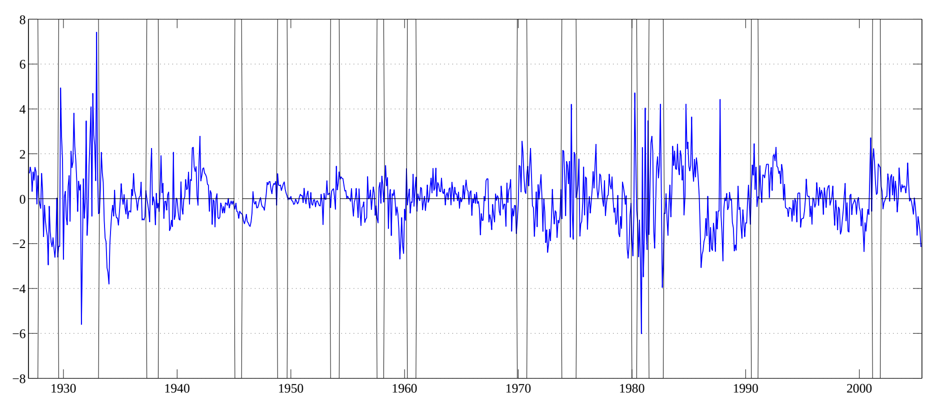


Figure 2 . Time Varying Relation between Conditional Market Risk and Return: 1927:01-2005:12

The figure plots the simple correlation between conditional market variance and expected market return for each decade of our sample period: 1927 through 2005.

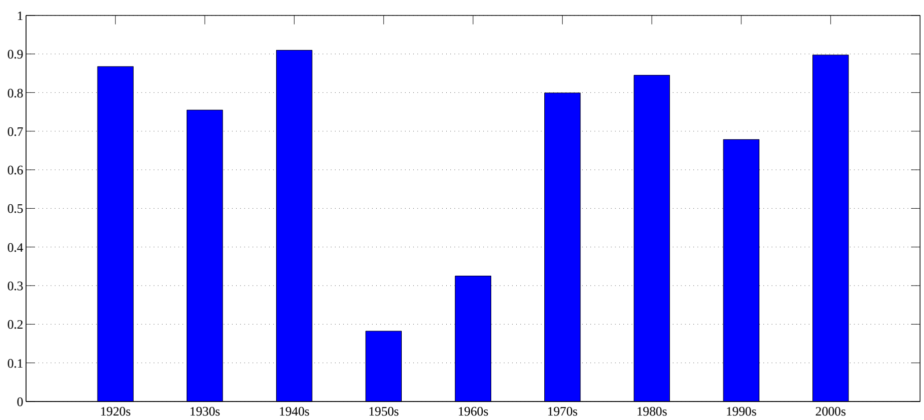
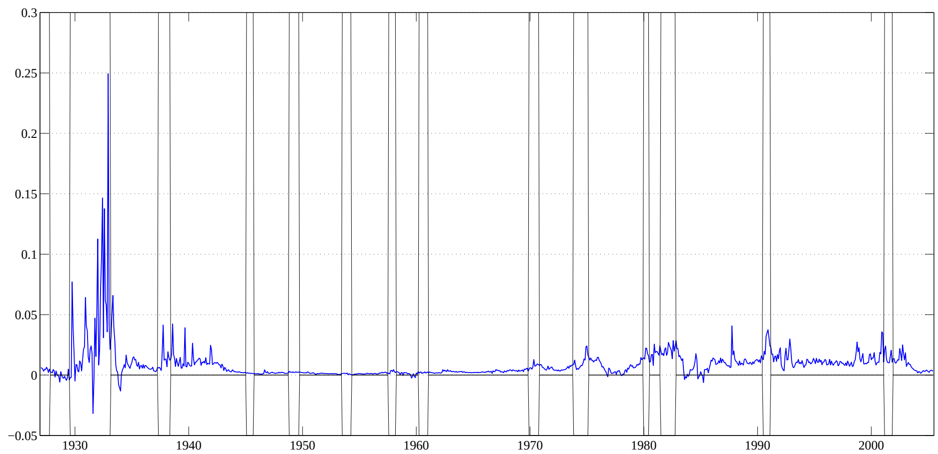


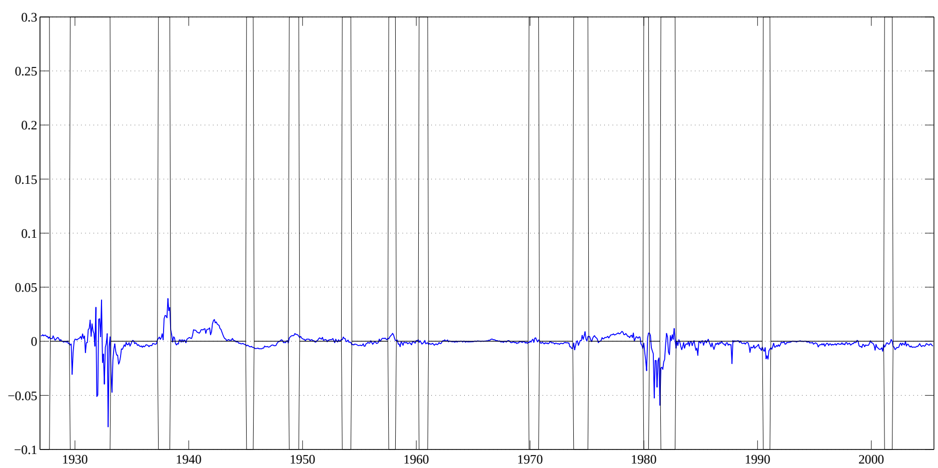
Figure 3 . Components of the Market Risk Premium: 1927:01-2005:12

Panel A plots the estimated time-series for the variance component of the expected market return, $\gamma_{M,t} Var_t(R_{M,t+1})$. The NBER recession periods are also indicated. Panel B plots the estimated time-series for the hedge component of the market return related to the bond factors. This component is based on the term $\gamma_{GB,t} Cov_t(R_{M,t+1}, R_{GB,t+1}) + \gamma_{CB,t} Cov_t(R_{M,t+1}, R_{CB,t+1})$. Panel C plots the estimated time-series for the hedge component of the market return related to the stock market factors HML and SMB. This component is based on the term $\gamma_{HML,t} Cov_t(R_{M,t+1}, R_{HML,t+1}) + \gamma_{SMB,t} Cov_t(R_{M,t+1}, R_{SMB,t+1})$

Panel A: Variance Component



Panel B: Hedge Component Related to Bond Factors



Panel C: Hedge Component Related to Stock Factors

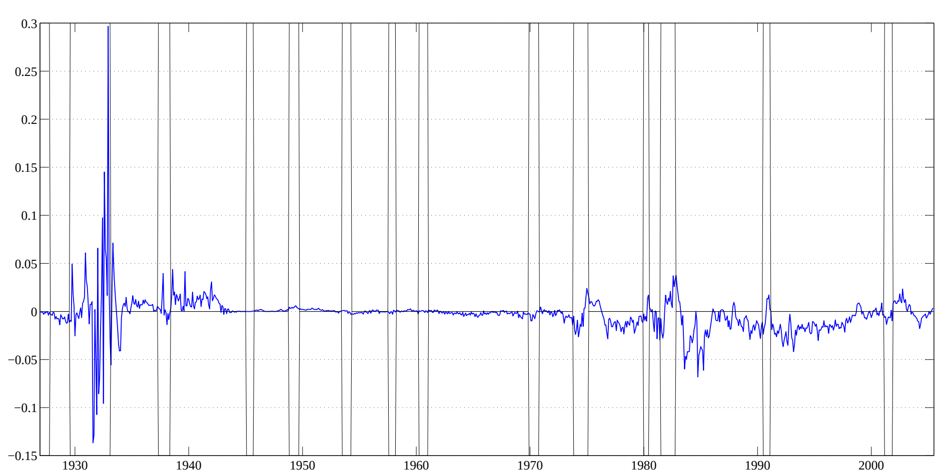
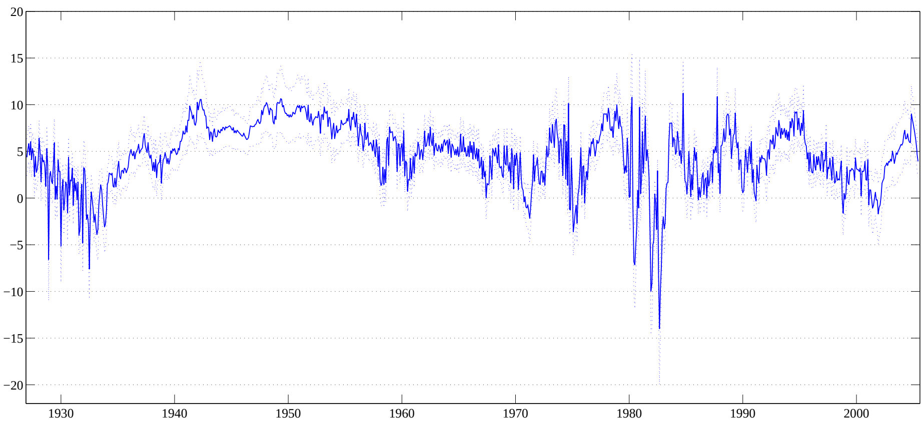
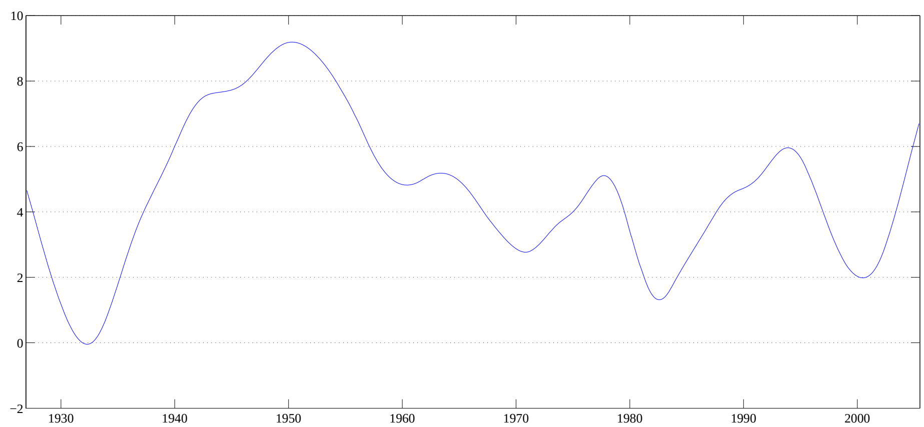


Figure 4 . Time Series of Market Price of Risk Using Only Equity Portfolios: 1927:01-2005:12 This Figure plots the market price of risk estimated from a cross-section of 25 portfolios sorted by size and book-to-market. Panel A shows the time series of estimated price of market risk, $\gamma_{M,t}$, over 942 months spanning the period January 1927 through December 2005. The 95 percent confidence intervals (dotted lines) are also plotted. Using a Hodrick-Prescott filter, we decompose the estimated market price of risk into two components: a short-term cyclical component and a long-term trend component. The market price of risk is the sum of these two components. Panels B and C plot the trend and cyclical components of the price of market risk. The NBER recession periods are shown in Panel C.

Panel A: $\gamma_{M,t}$



Panel B: $\gamma_{M,t}$ Trend



Panel C: $\gamma_{M,t}$ Cyclical Component

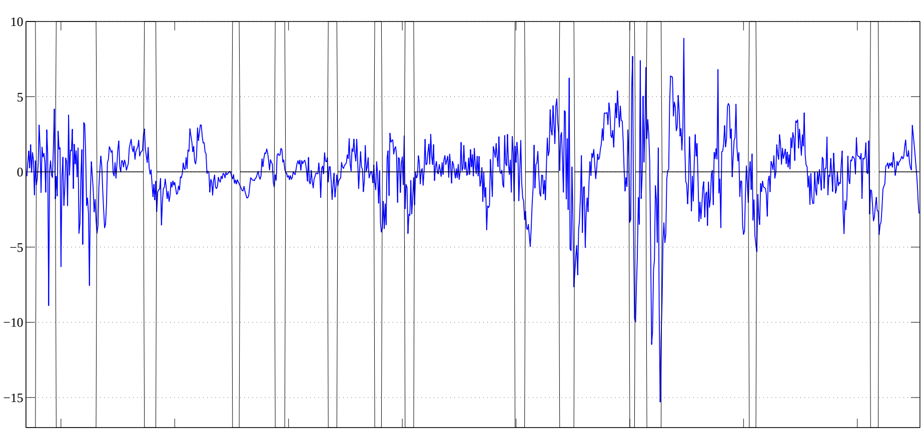


Figure 5 . Time Series of Market Price of Risk: 1953:04-2005:12

The Figure shows the time series of estimated market price of risk, $\gamma_{M,t}$, over the period April 1953 through December 2005, together with the NBER recession dummy. The solid plot corresponds to the case in which we use both equity and bond portfolios, while the dotted plot is based on using equity portfolios alone.

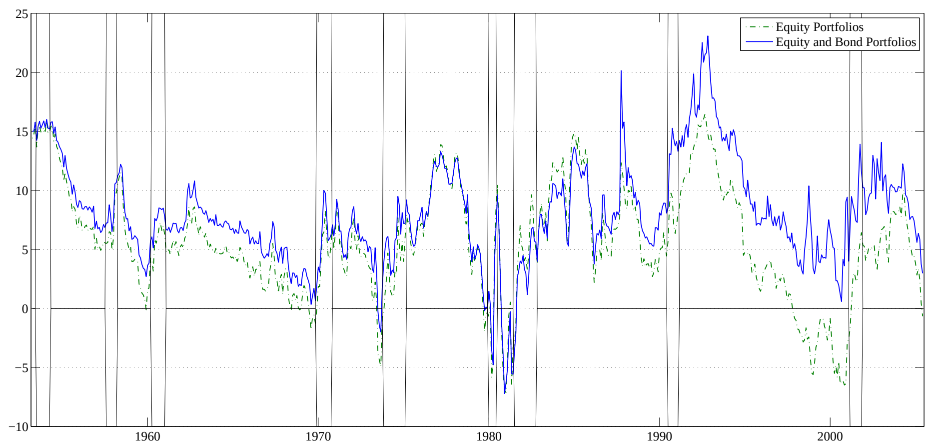


Figure 6 . Time Series of Market Price of Risk with Industry Portfolios: 1927:01-2005:12
The Figure shows the time series of estimated market price of risk, $\gamma_{M,t}$, over the period January 1927 through December 2005, together with the NBER recession dummy. The solid plot corresponds to the case in which we use both equity portfolios (sorted by book-to-market and size and industry) and bond portfolios, while the dotted plot is based on using equity portfolios alone.