On the Ex-Ante Cross-Sectional Relation Between Risk and Return Using Option-Implied Information

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This paper examines cross-sectional relations between *ex ante* expected returns and ex ante betas. As a proxy for ex ante expected returns, we use the implied mean returns obtained from the risk-adjusted option pricing model suggested in this paper. We find that ex ante expected returns have a positive and significant cross-sectional relation with ex ante betas in all investment horizons considered. This significant relation is maintained regardless of the inclusion of firm size, book-to-market, and momentum. The cross-sectional regression estimate of ex ante market risk premium has a statistical significance as well as an economic significance in that it contains significant forward-looking information on future macroeconomic conditions. Further, we find that ex ante betas have significant explanatory power for realized ex post returns. A significant relation between ex ante forward returns and forward betas is also found. Other interesting findings are that, in an ex ante world, firm size is still negatively significant, but book-to-market is negatively significant, which is the opposite of the ex post results; also, investors' ex ante expectation on returns is not predicated on past stock performance.

JEL classification: G12, G13, G14

Keywords: CAPM, *Ex ante* expected return, Implied mean return, Implied beta, Risk-adjusted option pricing

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Abstract

This paper examines cross-sectional relations between *ex ante* expected returns and ex ante betas. As a proxy for ex ante expected returns, we use the implied mean returns obtained from the risk-adjusted option pricing model suggested in this paper. We find that ex ante expected returns have a positive and significant cross-sectional relation with ex ante betas in all investment horizons considered. This significant relation is maintained regardless of the inclusion of firm size, book-to-market, and momentum. The cross-sectional regression estimate of ex ante market risk premium has a statistical significance as well as an economic significance in that it contains significant forward-looking information on future macroeconomic conditions. Further, we find that ex ante betas have significant explanatory power for realized ex post returns. A significant relation between ex ante forward returns and forward betas is also found. Other interesting findings are that, in an ex ante world, firm size is still negatively significant, but book-to-market is negatively significant, which is the opposite of the ex post results; also, investors' ex ante expectation on returns is not predicated on past stock performance.

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I. Introduction

One of the most fundamental issues in finance is what is the appropriate amount of return expected (or required) by investors when they bear risk. The first and most prominent model among others to address this issue is the Capital Asset Pricing Model (CAPM) by Sharpe (1964), Lintner (1965), and Black (1972). This model posits a linearly positive relationship between systematic risk (or market beta) and expected return on a risky asset. Indeed, the CAPM applies to all areas: computation of the cost of capital, measurement of investment performance, determination of fair returns for regulated industry, etc. Numerous investment institutions, such as Value Line, Standard & Poor's, and Merrill Lynch, use beta as the appropriate risk index and report beta to their customers. Due to the importance of the model, many researchers have been testing its validity since it was introduced. Empirical testing of the validity of the CAPM is the most heavily investigated area in finance.

Contrary to the prediction of the CAPM, however, most empirical results have found that idiosyncratic risk factors have significant explanatory power for stock returns, while market beta has little power. For example, Fama and French (1992) reports that firm size and book-to-market explain well the cross-section of average stock returns, while market beta has no explanatory power. This challenges the validity of the CAPM, one of the most important models in finance.

In fact, the CAPM determines the equilibrium risk–return relationship on an *ex ante* basis. Thus, empirical test of the CAPM should be performed on an ex ante basis. It is difficult, however, to empirically test the CAPM on an ex ante basis, since the future expected return and beta are unavailable at the beginning of the investment period. Because of this empirical difficulty, most previous tests have been done on an ex post historical basis, implicitly assuming that historical realized average returns are good estimates of future expected returns. However, there is ample evidence that average realized return does not converge to expected return in finite samples. One of the features, which work against the convergence of average realized return to expected return, is the time-variation of expected returns and market risk premium (i.e., nonstationarity). Unless return distributions are stable and precise over time, the expected returns estimated by these methods may not perform well as a true representation of ex ante market expectations.[1] In his presidential address, Elton (1999) notes that "there are periods longer than 10 years during which stock market realized returns are on average less than the risk-free rate (1973 to 1984). There are periods longer than 50 years in which risky long-term bonds on average underperform the risk-free rate (1927 to 1981)." In these circumstances, the use of realized returns for expected returns and market betas could lead to biased estimation and to rejection of the CAPM. Despite the problems caused by the use of realized returns, most results in the empirical asset pricing literature are obtained from such returns.

Elton (1999) also notes that "developing better measures of expected return and alternative ways of testing asset pricing theories that do not require realized returns have a much higher payoff than any additional development of statistical tests that continue to rely on realized returns as a proxy for expected returns." In this vein, several studies construct alterative proxies for expected returns. Gebhardt, Lee, and Swaminathan (2001), Fama and French (2002), Botosan and Plumlee (2005), and Easton and Monahan (2005) use valuation models to estimate expected returns. Brav, Lehavy, and Michaely (2005) construct estimates of expected returns using financial analysts' target prices from Value Line, and Campello, Chen, and Zhang (2008) use corporate bond yields to estimate expected equity returns.[2] In particular, Brav, Lehavy, and Michaely (2005) and Campello, Chen, and Zhang (2008) conduct cross-sectional tests for the relation between market beta and expected return by using their own measures of expected returns, and find that market beta is significantly priced.

However, the measures of expected returns used in the previous studies have several problems. The most frequently used approach to obtain estimates of expected returns is to use valuation models and calculate internal rates of return for the estimates. Most valuation models use unrealistic assumptions for the future evolution of accounting

[1] Fama and French (1997) and Pastor and Stambaugh (1999) find that both the CAPM and the Fama and French three-factor model are imprecise owing to the uncertainty about true factor risk premiums and imprecise estimates of the factor loadings that are based on historical returns.
[2] Levy (1997) conducts a classroom experiment to estimate ex ante parameters.

variables, such as constant dividend growth. Furthermore, most models use indirect measures for expected stock returns. For example, the Brav, Lehavy, and Michaely (2005) approach of using analyst target prices from Value Line adopts similar assumptions. Another popular measure of investors' expected return is bond yields, which are used in Campello, Chen, and Zhang (2008). Bond yields are forward-looking expected returns over the life of the bonds, under the conditions that the bonds do not default, the yields do not change in the next periods, and coupon payments are reinvested at the same rate as the yield until maturity. However, although bond yields reflect the expected risk premium for default risk, which is the financial side of systematic risk, bond yields may not reflect the expected risk premium caused by an uncertain business environment, which is the business side of systematic risk. It would be difficult to say, therefore, that bond yields fully reflect the expected risk premium of all systematic risks of a firm. Another problem inherent in using bond yields as a proxy for ex ante expected return is that many firms' bond trade prices are unavailable.

To overcome the shortcomings of the above-mentioned measures, we use option prices to extract information regarding ex ante expected returns and market beta of the underlying asset. Since option prices reflect investor expectations for future stock price movements, option data are an excellent information source for ex ante parameters. Option data have many advantages over other information sources for expected returns used in the previous studies. Option data are observed market prices, are not obtained from any specified model, and expected returns implied from option prices might reflect investor expectations for all systematic risk of the underlying asset. We extract implied mean return and implied volatility of the underlying asset from forward-looking option prices. We regard this implied mean return as a proxy for ex ante expected return.

The approach we follow is a risk-adjusted option pricing model that prices an option in discrete time and that retains the expected return of the underlying asset in the pricing equation. The Black-Scholes (1973) risk-neutral model prices options by taking advantage of the interesting feature that a particular portfolio of the stock and the option can cancel out the unknowns—namely the expected mean returns of the option and its underlying stock in continuous time.[3] However, if our objective is to extract expected return given the market price of options, we should form the corresponding risk-adjusted valuation model that will retain the expected returns in the pricing model.

Option pricing models that embed mean stock returns are not new. The early option pricing models of Sprenkle (1961), Ayres (1963), and Boness (1964) have implicitly or explicitly assumed some form of risk-adjusted framework such that investors who employ a buy and hold strategy could be linked to expected stock returns. However, none of these models provides an adequate theoretical structure that relates option returns and stock returns, hence they lack the ability to extract stock returns from option prices. Our risk-adjusted model, however, provides the pricing equations necessary to jointly estimate the expected returns of both the stock and the option.

The main purpose of this study is to examine the CAPM relation on an ex ante basis. Two ex ante variables are needed in this test: expected return and market beta. In order to obtain ex ante expected returns, we compute implied mean returns from the risk-adjusted option pricing model that we derive in this paper. These option-implied returns (or simply, implied returns) are used as expected returns. At the end of each month (i.e., at the last trading day of each month), we observe the prices of a stock option with a particular maturity and compute implied returns of the underlying stock from the observed option prices. At the same time, we find a market index option such as Standard & Poor's 500 index option whose maturity is matched with that of the stock option, and we estimate implied market returns from the market index option. Thus, each implied return of the stock has its counterpart implied market return.

There is no explicit way to directly extract expected market betas. The literature is limited in the area of extraction of implied betas from option prices. To our knowledge, there are only two papers in this area. Siegel (1995) proposes a new "exchange option," the price of which is based on the number of units of a specific stock that can be

[3] Black and Scholes (1973) show that if the market is complete, the expected return of the stock should disappear from the valuation of the option as dynamic hedging (known as continuous rebalancing, price by no arbitrage, or risk neutral pricing) effectively removes the dependence of the option price on the stock return. This is true, however, only if the market is truly complete in reality. In other words, if the reality is exactly described by the Black-Scholes model, it is impossible to theoretically solve for both expected return and volatility. However, it has been empirically shown that the Black-Scholes model cannot explain all option prices (known as the volatility smile and volatility term structure).

exchanged for one unit of an index. Thus, he argues that the price of this exchange option can reveal the implied beta of the stock. However, such exchange options do not exist in current capital markets. More recently, Christoffersen, Jacob, and Vainberg (2006) show that implied beta can be extracted from option prices without using this new derivative. The beta in their model is computed using forward-looking variances and the skewnesses of the stock and the market. However, the main limitation in their approach is the internal conflict between the assumption of the CAPM where returns of the stocks follow a multivariate normal distribution, and the existence of skewness in stock returns. Furthermore, their approach does not generate the unique implied beta in that an implied beta can be obtained by using kurtosis (or any moment), which can differ from the one obtained by using skewness. Because of these problems, we simply estimate expected market betas by regressing option-implied returns of the underlying stock on option-implied returns of the market index, the Standard & Poor's 500 Index.

Option-implied monthly returns for a total of 4,078 stocks are obtained over the period January 1996 through April 2006. One feature of our implied returns is that it portrays how investor expectations differ for different investment horizons. We find that there is apparently a downward sloping term structure of implied returns. That is, the longer the investment horizon, the smaller the expected return. The term structures of implied volatility and implied market beta are also downward sloping.[4]

In month-by-month, cross-sectional regressions of ex ante implied returns on implied market betas, which is an ex ante version of the CAPM test, we find that there is a significantly positive relation between these two ex ante variables. Even though firm characteristics such as firm size, book-to-market, and momentum are included in the model, this positively significant relation is strongly maintained. We also examine whether implied market betas have explanatory power for ex post realized stock returns and find that implied market betas are significantly priced. Since there is apparently a nonconstant term structure of expected returns, we repeat the cross-sectional asset pricing

[4] The downward sloping term structure of volatilities is well documented in the literature. See Hull (2002).

tests for each maturity group. In all maturity groups, we find results similar to those obtained from using the whole sample.

Since we have implied returns with various investment horizons at a given time, it is possible to compute forward-implied returns and betas and to examine cross-sectional relations between these two forward variables. We find that forward-implied returns also have a positive and significant relation with forward market betas.

Another way to test whether our CSR estimate of ex ante market risk premium has economic significance is to examine whether the ex ante market risk premia estimate contains forward-looking information on macroeconomic conditions. We find that the ex ante market risk premium has a significant positive relation with the future default premium. And, it has a significant negative relation with future dividend yield and a generally negative relation with the future growth of real economic activity as measured by consumption, GDP, and labor income. These results indicate that as more cash flows (from more dividends and expanding real economic activity) are expected in the future, the stock price level increases and then the subsequent ex ante expected return is lowered. In sum, the ex ante market risk premium contains significant forward-looking information on future macroeconomic conditions. When the implied market returns (from S&P 500 Index options) are used instead of the ex ante market risk premium estimate, we obtain stronger but similar results. However, when the CRSP value-weighted market returns are used in the regression, we find that the realized market returns have no significant forward-looking information on future macroeconomic conditions.

This paper is organized as follows. Section II describes the risk-adjusted option pricing model for implied return and volatility, Section III describes the data, and Section IV explains the computational details for the implied variables. Section V presents empirical results, and Section VI sets forth our conclusion.

II. A Model for the Forward-Looking Implied Return and Volatility

The seminal Black-Scholes model provides not only a formula to price derivatives, but it lays the groundwork for asset pricing using the equivalent martingale (or risk neutral) methodology. According to Black and Scholes (1973) and many later researchers (e.g., Merton, 1973, 1976; Cox and Ross, 1976; Harrison and Kreps, 1979; and Harrison and Pliska, 1981), there always exists a risk neutral measure where all assets should earn the risk free rate of return. This facilitates the derivation and computation of various pricing models. This methodology is still the dominant method for asset pricing.

However, Heston (1993) shows that the "risk-free rate" result in the Black-Scholes model is an important consequence of the distribution assumption. He shows that with an alternative stochastic process, the expected return of the underlying asset will show up in the formula. Taking a different approach in this paper, we derive an option pricing model under the physical measure where each asset must be discounted by its proper (risk-adjusted) discount rate. In doing so, we are able to back out the expected return of the underlying stock and arrive at a closed-form solution for options, which allows us to use option price data to compute ex ante expected stock returns. Furthermore, the distribution assumption still remains Gaussian, which is consistent with the Black-Scholes model and the CAPM of Sharpe (1964) and Lintner (1965).

In this section, we derive several propositions required to compute the implied return and implied volatility. Our objective is not to price options as the Black-Scholes model does, but to have a closed-form solution in which the expected (risk-adjusted) return is retained. Using this framework, we jointly estimate implied return and implied volatility through the market prices of options.

It is well known that the Black-Scholes model can be used to compute the implied volatility but not the implied mean return of the underlying stock, due to the fact that the no-arbitrage argument renders a preference-free model and hence contains no such parameter. In this subsection, we demonstrate that such parameter can be re-discovered via an "equilibrium" pricing approach similar to Samuelson (1965) and Sprenkle (1961). Proposition 1, below, describes how the implied mean return and volatility can be simultaneously estimated from option prices.

Proposition 1:

Assume stock price S follows a geometric Brownian motion with an expected instantaneous return of μ_S and volatility of σ_S. Let a call option on the stock at any point in time *t* be given by $C(S,t)$ that matures at time *T*. Let μ_c be the expected instantaneous return on this option. Then for a small interval of time, Δt, the relationship between the expected returns on the underlying stock and the option, μ_s and μ_c, can be given by:

$$\mu_c = r_f + \beta_{cs}(\mu_s - r_f) \tag{1}$$

where

$$\beta_{cs} = \frac{\mathrm{Cov}(r_c, r_s)}{\mathrm{Var}(r_s)}, \tag{2}$$

and $r_s = \Delta S/S$ and $r_c = \Delta C/C$ are two random variables representing the stock return and call option return, respectively, over the period Δt. And, r_f is the instantaneous risk-free rate of return for the period Δt. Note that Proposition 1 can be proved without assuming the CAPM. Also, note that all returns and volatility are annualized, otherwise mentioned.

Proof: See Appendix A.

If the CAPM holds, then the expected returns on the underlying stock and call option are expressed, respectively, as

$$\mu_s = r_f + \beta_s(\mu_m - r_f)$$

and

$$\mu_c = r_f + \beta_c(\mu_m - r_f), \tag{3}$$

where μ_m is the instantaneous expected return on the market portfolio, and β_s and β_c are the market betas of the underlying stock and the call option, respectively, which are defined as

$$\beta_s = \frac{\mathrm{Cov}(r_s,\ r_m)}{\mathrm{Var}(r_m)} \text{ and } \beta_c = \frac{\mathrm{Cov}(r_c,\ r_m)}{\mathrm{Var}(r_m)}.$$

Thus, it can be seen that

$$\beta_{cs} = \frac{\beta_c}{\beta_s}. \tag{2a}$$

Equation (1) holds for a small interval of time Δt. We assume the distributions of stock and option returns, r_s and r_c, are both Gaussian and stationary over the life of the option. This implies that β_{cs} is constant over this period. Since our approach is to price the option in a discrete setting, we approximate β_{cs} over the discrete time from *t* to *T* as

$$\beta_{cs}^* = \frac{\mathrm{Cov}(C_T/C_t, \quad S_T/S_t)}{\mathrm{Var}(S_T/S_t)} = \left(\frac{S_t}{C_t}\right)\frac{\mathrm{Cov}(C_T, S_T)}{\mathrm{Var}(S_T)}. \qquad (2b)$$

The linear relation between μ_s and μ_c in discrete time is the same as in continuous time when r_s and r_c are stationary over the life of the option. Since we use the risk-adjusted model for pricing the option where the expectation of the pricing kernel is based on the entire life of the option, β_{cs}^* as given in equation (2b) is more appropriate for our equations.

Equation (1) in continuous time and equation (2b) in discrete time can also be proved using the CAPM. For these two equations to hold, however, it is not necessary that the CAPM should hold. The assumptions of the CAPM are much stronger, so that all return distributions are stationary. However, here we need only the stationarity and Gaussian distribution assumption of the stock and option returns to obtain these two equations. Hence, the stationarity assumption of r_s and r_c is weaker than what is needed for the CAPM. Furthermore, Galai (1978) demonstrates many similarities between the continuous time and discrete time properties of r_c that support our stationarity assumption for the return distribution.[5] We also note that the right hand side of equation (2b) is a close approximation of β_{cs} under the stationarity of r_s and r_c .

Proposition 2:

Under the physical measure, the risk-adjusted price of the call option over the discrete time period from *t* to *T* is given by:

$$C_t = e^{(\mu_s - r_f)(1-\beta_{cs})(T-t)} S_t N(h_1) - e^{-\mu_c(T-t)} K\, N(h_2), \qquad (4)$$

where *K* is the strike price of the option, *N*(·) is the standard normal probability density function, and

$$\mu_c = r_f + \beta_{cs}(\mu_s - r_f)$$

[5] Note that our assumption of stationarity of r_s and r_c is applicable only to the options with the same days-to-maturity. This means that the distributional properties of r_s and r_c are allowed to differ for different days-to-maturity.

$$h_1 = \frac{\ln S_t - \ln K + (\mu_s + \sigma_s^2/2)(T-t)}{\sigma_s\sqrt{T-t}}$$

$$h_2 = h_1 - \sigma_s\sqrt{T-t}\,.$$

Proof: See Appendix B.

Equation (4) is obtained based on the assumption that the expected return of the option, μ_c, the expected return of the stock, μ_s, and the volatility of stock price, σ_s, are constants. We approximate β_{cs} by β_{cs}^*, based on the discrete time period of the option from t to T as explained above. Furthermore, we assume that the stock price follows a geometric Brownian motion.

Proposition 3:

The ratio of the market betas of the stock to the option, β_{cs}^*, over the life of the option can be written as

$$\beta_{cs}^* = \frac{S_t\left[e^{\sigma_s^2(T-t)}\,N(h_3) - \left(\frac{K}{S_t}\right)e^{-\mu_s(T-t)}\{N(h_1) - N(h_2)\} - N(h_1)\right]}{C_t\left[e^{\sigma_s^2(T-t)} - 1\right]}, \qquad (5)$$

where

$$h_3 = \frac{\ln S_t - \ln K + \left(\mu_s + \frac{3}{2}\sigma_s^2\right)(T-t)}{\sigma_s\sqrt{T-t}}.$$

Proof: See Appendix B.

Substituting equations (1), (2b), and (5) into (4), we arrive at an option pricing model as a function of the known variables S_t (current stock price), C_t (current call option price), K (strike price), r_f (risk-free interest rate), and T-t (time to maturity), along with two unknown variables, μ_s and σ_s. If we observe two or more call option prices with the same days-to-maturity but different strike prices, we can simultaneously solve the option pricing model for μ_s and σ_s for each individual stock and days-to-maturity.[6] Through this approach, for each stock, we obtain different μ_s and σ_s pairs for different days-to-maturity. Similarly, we can estimate the market expected return (μ_m) and market volatility (σ_m) using S&P 500 Index call options.

Note that the implied return here indicates investors' forward-looking ex ante expected return of the stock over the period from the current time, *t*, to the maturity date, *T*. We therefore obtain different implied returns and volatilities for different maturities at a given trade date, *t*. This is consistent with investor expectations of return and volatility, which could differ according to their investment horizon.

III. Data

In order to extract forward-looking information on implied return and volatility from option trading prices, we obtain daily close transaction data of the options of individual stocks listed on NYSE, NASDAQ, and AMEX from OptionMetrics for the last trading day of each month for the period from January 1996 to April 2006. This data file contains CUSIP, trade date, strike price, offer price, bid price, trading volume, option open interest, Black-Scholes implied volatility, and maturity date for each option. This data set also contains the daily closing data of S&P 500 Index options.

For the corresponding stocks whose option data are available, we obtain daily stock prices and returns from the CRSP. To match the stock price with option records, we use the CUSIP and trade date of the stock. A total of 4,078 stocks are found to have both option and stock price data. We also obtain information of firm characteristics, such as firm size and book-to-market, from CRSP and Compustat.

For the risk-free interest rates, we use the St. Louis Fed's 3-month, 6-months, 1-year, 2-year, 3-year, and 5-year Treasury Constant Maturity Rates. Assuming a step-function of interest rates, we match the days-to-maturity in the option record with its corresponding constant maturity rate. For example, if the days-to-maturity of the option is

[6] With prices for options with more than two strike prices, we can find values for μ_s and σ_s that produce option prices closest to the observed prices in the least squares sense. A similar least-squares methodology is used by Melick and Thomas (1997).

less than or equal to 3 months, we use 3-month rates, and if the days-to-maturity is between 3 months and 6 months, we use the 6-month rate, and so on.

IV. Computation of the Implied Return, Volatility, and Market Beta

We jointly estimate implied mean return (or implied return) and implied volatility of the underlying stock, μ_s and σ_s, by using the risk-adjusted option pricing model through equations (4) and (5). At a given trade date (i.e., the last trading day of each month), we obtain the market prices of only near-the-money call options with same maturity date but different strike prices. We define the near-the-money option as any option whose ratio of stock price to strike price (S_t/K) falls between 0.9 and 1.3. By using all these options, we compute the implied return and implied volatility via a method of grid search to look for global optima that minimizes the error square. The error is defined as the difference between the observed option price and the right hand side of equation (4) using market observed values along with implied return and implied volatility. For the grid search, we set the implied return search range from 0 to 175.00 percent, and the implied standard deviation search range from 0 to 100 percent. The reason we take only near-the-money options is to minimize the effect of measurement error in estimating implied returns and volatilities, since measurement error could be caused by failing to adjust for jumps and the stochastic behavior of volatilities, such as the volatility smile, which are observed in deep-out-of-money options.[7] Options with zero trading volume are excluded. Put options are not used only because our models are designed for call options.

We use the closing bid/ask mid-point as the closing American option price. The option dataset also has the Black-Scholes implied volatility adjusted for any stock dividends during the life of the option. Using this information along with interest rates, we reverse to compute the corresponding European option price. If the computed European option price is higher than the American option price, we take the American

[7] According to Canina and Figlewski (1993), measurement errors may also be systematically affected by time-to-maturity, even though there are no jumps and stochastic behavior of volatilities. To mitigate these errors, options with the same maturity are used to compute implied return and implied volatility.

option price as the option price. Otherwise, we take the European price as the option price. Our results are based on the last trading day observations of option prices of each calendar month. Taking any other day of the month produces similar results. For example, we verify our results by taking the first working day, second Thursday, and third Friday of each month. The results are qualitatively similar.

Since one pair of the estimated implied return and volatility is obtained for each maturity and there are several different maturity dates at a given trade date, we obtain several sets of implied return and volatility pairs at a given trade date. That is, we obtain term structures of implied returns and implied volatilities of a stock at a given date. Similarly, at a given trade date, we also obtain similar term structures for S&P 500 Index options.

If there are no such market index options available at a given trade date, we interpolate the value of market implied return and volatility using other days-to-maturity information of the market index options. For example, suppose that for a particular trade date, we have three different implied market returns corresponding to three different days-to-maturities: 90 days, 120 days, and 150 days. For the implied return of an underlying stock whose option has 140 days to maturity, the corresponding market implied return will be obtained from a linear interpolation using the market implied returns of 120 days and 150 days. If days-to-maturity of stock implied return is more than 150 days, the corresponding market implied return will be the market implied return of 150 days. Therefore, there is one-to-one correspondence between the implied return of an underlying stock and the market implied return. Hence, we obtain the matched implied market returns and implied stock returns.

Since options whose payoffs are determined by the correlation between the underlying stock and the market portfolio do not exist, it would be difficult to directly extract information regarding implied market betas like the implied mean return. Therefore, we estimate implied market betas of an underlying stock by regressing implied returns of the stock on implied market returns.

V. Empirical Results

A. Basic Statistics of the Implied Variables

Table 1 presents the basic statistics of the three key implied variables of all pooled sample obtained from all 4,078 firms' individual stock call options over the period from January 1996 to April 2006: implied return, μ_i, implied volatility, σ_i, and implied beta estimate, $\hat{\beta}_i^{\text{imp}}$. Note that for the implied variables of individual stock options, now we use subscript i instead of s. These implied variables are computed from the option prices observed at the last trading day of each month. The total number of firm-month observations is 179,048. Days to maturity of the sample ranges from 3 days to 1,027 days. μ_i and σ_i are implied instantaneous return (or continuously compounded return; CCR) and volatility, respectively. As seen in Table 1, the number of firm-year observations is much greater for short-term options than for long-term options.[8] This is because the near-the-money options of most of the stocks are actively traded on short maturities.

Table 1 shows that implied return decreases with maturity; that is, the term structure of implied returns is apparently downward sloped. Specifically, when days to maturity are less than or equal to 30 days ($0 < T \leq 30$), between 30 and 60 days ($30 < T \leq 60$), between 60 and 120 days ($60 < T \leq 120$), between 120 and 210 days ($120 < T \leq 210$), and longer than 210 days ($T > 210$), the averages of implied returns are 0.538, 0.336 0.243, 0.178, and 0.122, respectively. The average of the whole implied returns is 0.315. This indicates that investors have high expectation in a short-term horizon, while they are more subdued and hold more reasonable expectation in a long-term horizon. Chen, Kim, and Panda (2009) show that this downward term structure is robust to market friction proxies such as option volume, open interest, and bid-ask spread. Furthermore, this term structure is found for both European and American option prices.[9] Our findings

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[8] Among these, the numbers of firm-month observations whose days to maturity are between 0 and 30 days, between 30 and 60 days, between 60 and 120 days, between 120 and 210 days, and longer than 210 days are 47863, 41838, 31188, 34171, and 23988, respectively.

[9] This downward sloping term structure of the implied returns is also found in deep-in-the-money call options. We separately estimate implied returns and volatilities by using deep-in-the-money call options where stock price divided by strike price is greater than 1.20 and deep-out-of-the-money call options where stock price divided by strike price is less than 0.90. In both cases, we obtain a similar downward term structure of implied returns (not reported).

on this term structure indicate that expected returns are affected by investment time horizon. These findings are consistent with McNulty et al. (2002). They argue that shorter-horizon investments should be discounted at a higher rate and that the marginal risk of an investment declines as a function of the square root of time. This falling marginal risk should be reflected in the annual discount rate for longer-horizon investments. A recent paper by Camara et al. (2007) also shows the similar result that short-term expected returns are higher than long-term expected returns when using market-observed option prices.[10]

Implied volatility also shows a downward sloping term structure. That is, implied volatility is higher for a shorter maturity than for a longer maturity. However, the decreasing rate of the slope over days-to-maturity is smaller than the case of implied returns. The averages of the implied standard deviations are 0.515, 0.497, 0.474, 0.456, and 0.423 over the above-mentioned five intervals of maturity, respectively.

Since we observe a downward sloping term structure of implied returns and volatilities, the risk-return structure differs across maturities (or investment horizon). It is appropriate, therefore, that implied returns be matched with implied market betas in the tests, which are both in the same maturity group. As mentioned above, we classify the whole sample into five maturity groups: $0 < T \leq 30$, $30 < T \leq 60$, $60 < T \leq 120$, $120 < T \leq 210$, and $T > 210$. In each maturity group, implied betas are estimated by regressing implied returns of an underlying stock on implied market returns over the whole period contained in the maturity group. For any stock, therefore, there can be up to five implied betas according to the availability of implied returns. Since the CAPM is a one-period model, holding period return (HPR) should be used in the tests. Thus, implied HPRs are used in estimating implied market betas, $\hat{\beta}_i^{\mathrm{imp}}$, instead of CCRs. Implied HPR is

[10] However, there are at least two differences between our approach and theirs. First, they assume a specific utility structure for the representative agent that has a decreasing proportional risk aversion (DPRA). Based on this utility structure, they show that their option pricing equation contains implied stock return as one of the parameters to be estimated. Our approach instead uses a risk-adjusted version of option pricing with no explicit assumption about the utility structure. Second, their approach requires an intermediate parameter that needs to be computed using options of all companies, before computing the implied return of any individual firm. On the other hand, our model does not need information about other companies to compute the expected return and volatility. Our model jointly computes implied volatility using all stock options and S&P 500 Index options.

computed as $e^{\mu} - 1$, where μ is implied CCR. The implied beta also shows a similar downward pattern across maturities. The averages of the implied beta over the five maturity groups are 1.146, 0.959, 0.542, 0.530, and 0.467, respectively. The longer is the investment horizon, the smaller is the beta. These results are somewhat consistent with Levhari and Levy (1977), who show theoretically that market beta is a function of investment horizon.

Table 1 also reports the correlation coefficients between the implied variables and their historical counterparts. Using the whole pooled sample, the correlation coefficient ($\rho_{\mu,\bar{r}}$) between the implied return (μ) and its historical counterpart (annualized CCR of the underlying stock over the option life, ($\bar{r}$)) is 0.100. There is no particular pattern in this correlation coefficient across the five maturity groups. The correlation coefficient ($\rho_{\sigma,s}$) between the implied volatility (σ) and its historical counterpart (annualized sample standard deviation over the option life is 0.695, and the correlation coefficient ($\rho_{\beta,\hat{\beta}}$) between the implied beta (β) and its historical market beta (Scholes-William's (1977) beta estimate using daily returns over the option life) is 0.114. The correlation coefficients, $\rho_{\sigma,s}$ and $\rho_{\beta,\hat{\beta}}$, tend to increase with length to maturity, which indicates that implied volatility and beta could be more informative in predicting their historical counterparts.

Table 2 presents the basic statistics of the implied variables of the market index option, S&P 500 Index call option. The number of firm-month observations of the market-implied variables is exactly matched with the number of observations of individual stock options. The term structure of the implied market returns is also apparently downward across investment horizons, although its slope is less steep than the case of implied returns for individual stocks. The averages of the implied market return and standard deviation are 0.169 and 0.202, respectively, using the whole pooled sample. These are much smaller in magnitude than those of individual stock options. The term structure of the volatility of S&P 500 Index option is almost flat.

B. Cross-Sectional Regression Tests Using *Ex Ante* Implied Returns and Implied Betas

As mentioned above, the forward-looking implied variables obtained from option prices can be used as investors' ex ante expectation on the risk and return. In this sense, implied return and implied beta are the most plausible proxies for ex ante return and risk. By using the computed implied returns and betas, we examine the ex ante risk–return relationship by using the classical Fama and MacBeth methodology. In order to do this, we estimate the following cross-section regression (CSR) model at month t,

$$\mu_{i,[t,T]} - r_{f,[t,T]} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_{it}^{\text{imp}} + \Gamma_t \text{ (Control variables)} + \varepsilon_{it}, \tag{6}$$

where $\mu_{i,[t,T]}$ is the implied annualized HPR on underlying stock i over the option life ([t, T]) from the last trading day of month t to maturity T, and $r_{f,[t,T]}$ is the Treasury bill annualized holding period yield over the period $[t, T]$. In fact, $\mu_{i,[t,T]}$ is the expected return over the period from the first trading day of month t+1 to the maturity, T. $\hat{\beta}_{it}^{\text{imp}}$ is the OLS implied beta estimate of stock i obtained from regressing implied HPRs of stock i on implied market HPRs over the whole period in each maturity group. The control variables used in the CSR tests are firm characteristics such as firm size, book-to-market, and momentum (past six-month returns), which are the variables for the widely known market anomalies that the CAPM fails to explain.

Table 3 shows the CSR estimation results of equation (6) over the period from January 1996 to April 2006. The upper panel presents time series averages of the gammas (or the risk premium estimates) with implied market beta alone in the model, and the bottom panel presents those of the full model including the control variables. The estimates of the risk premium ($\bar{\hat{\gamma}}_1$) are positively significant regardless of the inclusion of the control variables. When the implied market beta is alone in the model, the risk premium estimate is 11.30 percent per year (with t-statistic of 13.67), using the whole sample. Its significance is also maintained in each maturity group, although it is weakened. That is, the risk premium estimates are 6.12 percent (t=7.43), 2.45 percent (t=5.09), 0.75 percent (t=1.89), 0.57 percent (t=1.73), and 1.06 percent (t=4.18), respectively, in the five maturity groups. However, the intercept estimates are strongly positive in all cases, which means that the implied ex ante returns may not be fully explained by the implied market beta. The large positive intercept estimates may be from a large value of the implied mean returns.

Even when the control variables (firm size, book-to-market, and momentum) are added to the model, the estimates of the risk premium are even more positively significant; using the whole sample, it is 12.31 percent (t=14.80). The risk premium estimates in the five maturity groups are 5.10 percent (t=5.95), 3.53 percent (t=7.32), 1.93 percent (t=4.83), 1.98 percent (t=5.68), and 2.03 percent (t=6.72), respectively. The above results indicate that the implied market beta has a significant explanatory power for ex ante expected returns in all maturity groups.

Table 3 also presents the estimation results on the control variables. The CSR coefficient estimates on the firm size variable (log(ME)) are all negative and statistically strongly significant. That is, investors have high (low) ex ante expected returns on small (large) firms. The CSR coefficient estimates on the book-to-market variable (log(BM)) are all negative and statistically significant, which implies that investors have high ex ante expected returns on low book-to-market stocks, while they have low ex ante expected returns on high book-to-market stocks. These results are consistent with the Lakonishok, Shleifer, and Vishny (1994) explanation that low book-to-market stocks are in fact growth stocks whose ex ante expected return tends to be high. The opposite holds for high book-to-market value stocks. The CSR coefficient estimate on the momentum variable (annualized past six-month return) is overall insignificant, which implies that investors may not have an a priori, ex ante expectation based on past intermediate-term stock performance. These ex ante results on momentum are interesting because they contrast with the ex post results in which the presence of momentum is significant.[11]

C. Cross-Sectional Regression Tests Using *Ex-Ante* Implied Betas and *Realized* Returns

[11] The above results on the control variables are also similar when each of the control variables is alone in the CSR model.

In order to examine whether implied betas explain the cross-section of realized ex post returns, we also cross-sectionally regress realized ex post returns on the implied betas and the control variables. The CSR model to be estimated at month *t* is

$$R_{i,[t,t+H]} - r_{f,[t,t+H]} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_{it}^{\text{imp}} + \Gamma_t \text{ (Control variables)} + \varepsilon_{it}, \tag{7}$$

where $R_{i,[t,t+H]}$ is the ex post HPR of an underlying stock *i* over the period *H* (i.e., from one day after the last trading day of month *t* to *H* days after the last trading day of month *t*), and $r_{f,[t,T]}$ is the Treasury bill annualized holding period yield over the corresponding measurement period $R_{i,[t,T]}$. We consider two different holding periods, *H*. The first holding period is up to maturity (*H*=*T*), which means that investors invest in each stock at the last trading day of every month according to the value of the implied betas and hold the stock until the option maturity date. The second holding period is one month (*H*=one month), which means that investors invest in each stock at the last trading day of each month according to the value of the implied betas and hold each stock for one month. Thus, the investment period overlaps in the first scheme, while it does not overlap in the second scheme.

Table 4 presents the time series averages of the CSR coefficients ($\bar{\bar{\gamma}}$) of equation (7) when the holding period is up to the maturity (in Panel A; $R_{i,\cdot}$ is annualized retutn) and up to one month (in Panel B; $R_{i,\cdot}$ is monthly return), respectively. Panel A shows that implied market betas have cross-sectionally significant explanatory power for average realized returns over the option life. That is, the coefficient estimate ($\bar{\bar{\gamma}}_1$) on the implied betas is 9.49 percent per year, with t-statistic of 8.44, using the whole sample. It is also positive and statistically significant in all maturity groups except for the shortest maturity group. That is, it is 1.61 percent (*t*=1.27), 5.75 percent (*t*=3.68), 6.35 percent (*t*=3.71), 6.50 percent (*t*=3.89), and 10.67 percent (*t*=4.36), respectively, for the five maturity groups. Even when the three control variables are added to the model, the risk premium estimates are more strongly significant. They are 12.11 percent (*t*=9.72) for the whole sample, 3.06 percent (*t*=2.22), 7.43 percent (*t*=4.89), 6.95 percent (*t*=3.60), 13.21 percent (*t*=6.74), and 15.04 percent (*t*=6.46), respectively, for the five maturity groups.

Panel B of Table 4 also presents the time series average of the gammas when the holding period is one month. The results indicate that implied market betas also have a significant explanatory power for the cross-section of average realized returns over the next 1-month period. That is, the coefficient estimate ($\bar{\gamma}_1$) on the implied betas is 0.21 percent per month, with t-statistic of 2.74, using the whole sample. It is also positive and statistically significant in all maturity groups except for the shortest maturity group; -0.02 percent (t=-0.43), 0.25 percent (t=2.01), 0.32 percent (t=2.15), 0.65 percent (t=2.17), and 0.99 percent (t=1.91), respectively, for the five maturity groups. Even when the control variables are added to the model, the risk premium estimates are more strongly significant. The intercept estimates are insignificant in all cases.

Table 4 also presents the CSR estimation results of ex post realized returns on the control variables. The CSR coefficient estimates on the firm size variable are also negative and statistically significant, as ex ante expected returns are used. It could be argued, therefore, that investors' ex ante expected return based on firm size tends to be realized as expected. However, investors' ex ante expectation based on book-to-market and momentum tends to be realized differently from their expectation. That is, the CSR coefficient estimates on the book-to-market variable are overall positive and marginally significant, which is opposite when ex ante expected returns are used. The CSR coefficient estimates on the momentum variable are positive and significant, which means that momentum does not exist a priori but appears significant a posteriori. Note that even when each of the control variables is alone in the model, the estimated coefficients on the control variable are similar.

D. Forward Relationships Between *Ex Ante* Implied Betas and Implied Ex Ante Returns

Since implied returns and volatilities observed at any given time have a variety of maturities (from short to long), it is possible to compute forward-implied returns and volatilities for an underlying stock. That is, the forward-implied return, observed at time t, on an underlying stock over the forward period $[T_1, T_2]$ is computed as

$$\mu^f_{t,[T_1,T_2]} = \frac{\mu_{[t,T_2]}(T_2 - t) - \mu_{[t,T_1]}(T_1 - t)}{(T_2 - T_1)}, \tag{8}$$

where $\mu_{[t,T_1]}$ and $\mu_{[t,T_2]}$ are the implied (annualized) returns on the underlying stock over the option lives $[t, T_1]$ and $[t, T_2]$, respectively. These implied returns are observed at time *t* (i.e., at the last trading day of each month), and T_1 and T_2 are the shorter and longer maturities of the option, respectively. Note that implied returns in equation (8) are CCRs, but their HPRs are used in estimating forward-implied betas and in the CAPM tests. Similarly, the forward-implied standard deviation over the forward period $[T_1, T_2]$ is computed as

$$\sigma^f_{t,[T_1,T_2]} = \sqrt{\frac{\sigma_{[t,T_2]}(T_2 - t) - \sigma_{[t,T_1]}(T_1 - t)}{(T_2 - T_1)}}, \tag{9}$$

where $\sigma_{[t,T_1]}$ and $\sigma_{[t,T_2]}$ are the implied standard deviations of the underlying stock over the option lives $[t, T_1]$ and $[t, T_2]$, respectively. When there are more than two options with different maturities at a given time, say, T_1, T_2, and T_3, we compute the forward-implied variables over nonoverlapped forward periods, such as over the periods $[T_1, T_2]$ and $[T_2, T_3]$, not $[T_1, T_3]$.

Table 5 presents the basic statistics of the forward-implied returns, standard deviation, and betas. Note that forward-implied betas are estimated by regressing the forward-implied HPRs of an underlying stock on the forward-implied market HPRs in each forward period length group over the whole sample period. Forward period length groups are classified as four groups: $0 < [T_1, T_2] \leq 30$, $30 < [T_1, T_2] \leq 90$, $90 < [T_1, T_2] \leq 120$, and $[T_1, T_2] > 120$ days. As shown in Table 5, the forward-implied return also decreases with the length of the forward period; that is, the term structure of forward-implied returns is downward shaped, although its slope is slower than that of the implied returns. The forward-implied volatility and forward-implied beta estimates also show a modestly downward term structure across the length of the forward period.

It would be interesting to examine whether there is a positive forward relation between ex ante expected returns and betas. To do this, we estimate the following CSR model at month *t*,

$$\mu^f_{it,[T_1,T_2]} - r_{ft,[T_1,T_2]} = \gamma^f_{0t} + \gamma^f_{1t}\hat{\beta}^{f,imp}_{it} + \varepsilon_{it}, \tag{10}$$

where $\mu^{f}_{it,[T_1,T_2]}$ is the implied *forward* annualized HPR on underlying stock i over the forward period $[T_1, T_2]$, $r_{ft,[T_1,T_2]}$ is the Treasury bill annualized holding period yield over the same forward period, and $\hat{\beta}^{f,imp}_{it}$ is the forward-implied estimate of stock i obtained from regressing forward-implied HPRs of stock i on forward-implied market HPR returns over the whole sample period; both forward returns are contained in each forward period length group.

Table 6 reports the time series averages of the gamma estimates of equation (10), which are the forward risk premium estimates ($\hat{\gamma}^{f}_{0t}$ and $\hat{\gamma}^{f}_{1t}$); these are positively significant in all cases. Using the whole forward sample, the forward market risk premium estimate is 1.88 percent per year (with *t*-statistic of 5.42). This positive significance holds regardless of the length of the forward period. That is, the forward market risk premium estimates are 1.12 percent (*t*=2.41), 0.75 percent (*t*=1.87), 1.05 percent (*t*=2.70), and 1.58 percent (*t*=4.16), respectively, for the four forward period length groups.

E. Do the Ex Ante Market Risk Premia Estimates Contain the Forward-Looking Information of Macroeconomic Conditions?

Investors' ex ante returns reflect their forward-looking expectation for individual stocks and the market as a whole. Therefore, another way to test whether our CSR estimate of ex ante market risk premium (presented in Table 3) has an economic significance is to examine whether the ex ante market risk premium estimates contain forward-looking information on macroeconomic conditions. To do so, we regress the ex ante market risk premia estimate on the future macroeconomic variables. That is, we estimate the following time-series regression model:

$$\hat{\gamma}_{1t} = b_0 + b_1 \mathrm{TB}_{t+1,t+L} + b_2 \mathrm{TERM}_{t+1,t+L} + b_3 \mathrm{DEF}_{t+1,t+L} + b_4 \mathrm{DIV}_{t+1,t+L} + b_5 \mathrm{CONSUME}_{t+1,t+L} + b_6 \mathrm{GDP}_{t+1,t+L} + b_7 \mathrm{LABOR}_{t+1,t+L} + \varepsilon_t, \quad (11)$$

where $\hat{\gamma}_{1t}$ is the estimate of ex ante market risk premium (i.e., the CSR coefficient estimates) at month t, $\mathrm{TB}_{t+1,t+L}$ is the three-month Treasury bill yield from month *t*+1 through month *t*+*L* (*L* is the number of months of the forward-looking period), TERM is the term spread defined as the difference between the yield on 10-year government bonds and the yield on the three-month Treasury bill, DEF is the default spread defined as the difference between the yield on Moody's BAA rated bonds and the yield on Moody's AAA rated bonds, DIV is the dividend yield on the value-weighted market index, CONSUME is the growth rate of personal consumption expenditures, GDP is the growth rate of GDP, and LABOR is the growth rate of personal labor income.[12] The value of each macroeconomic variable is its geometric average (i.e., compounded value) over L forward-looking months from t+1 to t+L.[13] The sample period is from January 1996 to April 2006.

Table 7 presents the regression estimation results of the ex ante market risk premium estimated using each maturity group on the future macroeconomic variables with L = 1 month (Panel A), L = 2 months (Panel B), L = 4 months (Panel C), and L = 6 months (Panel D), respectively. The results apparently show that the ex ante market risk premium reflects the forward-looking information on future macroeconomic conditions. The association between the ex ante market risk premium and the future macroeconomic variables becomes stronger with the length of the forward-looking period (L) and with the maturity of implied mean returns used in estimating the ex ante market risk premium. Specifically, the adjusted R-squares of equation (11) using all maturities are 0.329, 0.357, 0.432, and 0.454 for L = 1 month, 2 months, 4 months, and 6 months, respectively. For a particular length of the forward-looking period, say L = 4 months, (in Panel C), the adjusted R-squares are 0.201, 0.295, 0.247, 0.401, and 0.427 for the maturities of $0 < T \leq 30$, $30 < T \leq 60$, $60 < T \leq 120$, $120 < T \leq 210$, and $T > 210$ days, respectively. These R-squares are quite high.

The ex ante market risk premium also has a significant forward-looking relation with individual macroeconomic variables. In all regressions (all 24 regressions), it has a strongly significant positive relation with future default premium (DEF). This indicates that investors' ex ante risk premium is *proactively* increased as the default premium will

[12] The dividend yield (DIV) is obtained by using the CRSP value-weighted market returns with and without dividends through the method in Fama and French (1988).

[13] The minimum number of forward-looking months is one month. Over the last L months from the last sample period, therefore, we calculate the geometric average value of the macroeconomic variables by using the remaining observations up to the last month of the sample period.

be increased in the future (at least one month through six months later). In turn, option-implied returns contain important information about future defaults. The ex ante market risk premium also has a clear relation with future dividend yield (DIV). It has a strongly significant negative relation with DIV in most regressions. This indicates that as dividend yield increases in the future, the stock price level increases and the subsequent expected return (i.e., ex ante market risk premium) is lowered. The negative magnitude of the regression coefficients tends to decrease with the length of maturity.

The ex ante market risk premium has generally negative relations with the future growth of real economic activity as measured by consumption, GDP, and labor income (CONSUME, GDP, and LABOR), although the estimated coefficients are not as statistically significant as those on DEF and DIV. This indicates that as real economic activity is expected to be in expansion, the stock price level increases and then the ex ante market risk premium declines. The ex ante market risk premium is insignificantly related to future short-term interest rates (TB). This may be because the riskless rate of return is already adjusted in the market risk premium; however, it generally has a significant positive relation with future term structure (TERM). Since the coefficient on TERM can also be the coefficient on long-term interest rates (10-year Treasury bond yield), these results indicate that the ex ante market risk premium is positively associated with future long-term interest rates.

In sum, the CSR estimates of the ex ante market risk premium are significantly associated with forward-looking economic conditions and are rationally consistent with our perception. These results support that the CSR estimates have economic significance as well as statistical significance.

Table 8 presents the estimation results of the time-series regression model of equation (11) by using the implied market returns (extracted from S&P 500 Index options) as the dependent variable, rather than the CSR estimates of the ex ante market risk premium. The results are stronger than but overall similar to those using the ex ante market risk premium estimates (Table 7), except for the results for future short-term interest rates (TB). The coefficient estimates on TB are mostly positively significant, which means that the ex ante market return increases with future short interest rates. In sum, implied market returns contain significant information on future macroeconomic conditions. In order to compare these ex ante results with ex post results, we regress the CRSP value-weighted market returns on the forward-looking economic variables. The results are reported in Table 9. Most of the estimated coefficients are insignificant. The R-squares are quite low, compared with the R-squares from the regressions using the ex ante values. It is difficult to say that the realized market returns contain information on future macroeconomic conditions.

VI. Conclusions

This paper examines the CAPM relation on an ex ante basis. That is, we investigate the cross-sectional relation between ex ante expected returns and ex ante betas. As a proxy for ex ante expected returns, we use implied mean returns obtained from the risk-adjusted option pricing model that we suggest in this paper. Ex ante betas are estimated by regressing implied returns of an underlying stock on implied market returns.

We find that the ex ante cross-sectional relation between ex ante expected returns and betas is positive and statistically strongly significant. This significant relation is maintained regardless of the inclusion of the well known firm characteristics such as firm size, book-to-market, and momentum. Since there is an apparent downward term structure of implied mean returns and betas across investment horizons, we examine the ex ante relation in each maturity group and find there is still a strongly significant ex ante cross-sectional relation. We also find a significant positive forward relation between these two ex ante variables.

In order to examine whether ex ante betas have explanatory power for realized ex post returns, we estimate cross-sectional regressions of realized returns on ex ante betas and find that ex ante betas have a positive and statistically significant relation with ex post realized returns, regardless of the inclusion of the firm characteristics mentioned above. That is, ex ante betas are significantly priced in realized returns.

We also find an interesting difference between ex ante and ex post market anomalies such as firm size, book-to-market and momentum. Investors' ex ante expected return based on firm size tends to be realized as expected. However, investors' ex ante expectation based on book-to-market and momentum tends to be realized differently from their expectation. That is, investors' ex ante expected returns are negatively associated with book-to-market, but their realized returns are positively related with book-to-market. Investors' ex ante expected returns are not associated with past stock returns, but their realized returns are positively related with past stock returns.

In order to test whether our CSR estimate of ex ante market risk premium contains forward-looking information on future macroeconomic conditions, we regress the ex ante market risk premia estimate on the future macroeconomic variables. We find that the ex ante market risk premium has a significant positive relation with future default premium. Further, it has a significant negative relation with future dividend yield and also has generally negative relations with the future growth of real economic activity as measured by consumption, GDP, and labor income. These results indicate that as more cash flows (from increasing dividends and expanding real economic activity) are expected in the future, the stock price level increases and then the subsequent ex ante expected return is lowered. In sum, the ex ante market risk premium contains significant forward-looking information on future macroeconomic conditions. When the implied market returns (from S&P 500 Index options) are used instead of the ex ante market risk premium estimate, we obtain stronger but similar results. However, when the CRSP value-weighted market returns are used in the regression, we find that realized market returns contain no significant forward-looking information on future macroeconomic conditions.

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Appendix

A. Proof of Proposition 1:

We prove the proposition without assuming the CAPM. Let the price change for the stock and call option during this interval be ΔS and ΔC, respectively. Without loss of generality let *t* be the current time, and let current stock and option prices be S_t and C_t, respectively. This implies:

$$E(r_s) = \mu\,\Delta t \quad \text{and} \quad E(r_c) = \mu_c \Delta t, \tag{A1}$$

where $r_s = \Delta S/S$ and $r_c = \Delta C/\mathrm{C}$.

Since stock price S follows a geometric Brownian, the change in the price of the stock ΔS during the small interval of time Δt is

$$dS = \mu S\,dt + \sigma S\,dW, \tag{A2}$$

where dW is the Wiener differential. Then, following Ito's Lemma, option price change is given by

$$\begin{aligned} dC &= \frac{\partial C}{\partial S}\,dS + \left(\frac{1}{2}\frac{\partial^2 C}{\partial S^2}\,\sigma^2 S^2 + \frac{\partial C}{\partial t}\right) dt \\ &= \frac{\partial C}{\partial S}\,dS + \left(r_f C - \frac{\partial C}{\partial S}\right) dt, \end{aligned} \tag{A3}$$

where the second line of equation (A3) is derived from the Black-Scholes partial differential equation. From equation (A3), we can then compute the covariance between the option return and the stock return as follows

$$\begin{aligned} \mathrm{Cov}\left(\frac{dC}{C}, \frac{dS}{S}\right) &= \frac{1}{CS}\,\mathrm{Cov}(dC, dS) \\ &= \frac{1}{CS}\left(\frac{\partial C}{\partial S}\right)\mathrm{Var}(dS) \\ &= \frac{S}{C}\left(\frac{\partial C}{\partial S}\right)\mathrm{Var}\left(\frac{dS}{S}\right). \end{aligned} \tag{A4}$$

Then it follows that from equation (A4),

$$\begin{aligned} \frac{S}{C}\left(\frac{\partial C}{\partial S}\right) &= \mathrm{Cov}\left(\frac{dC}{C}, \frac{dS}{S}\right) \Big/ \mathrm{Var}\left(\frac{dS}{S}\right) \\ &= \beta_{cs}. \end{aligned} \tag{A5}$$

Finally, taking the expectation of equation (A3), we obtain

$$\mu_c\, dt = \beta_{cs}\mu\, dt + r_f(1-\beta_{cs}). \tag{A6}$$

And, the proposition is proved.

B. Proof of Proposition 2:

Under the physical measure, the risk-adjusted call option price is described as

$$\begin{aligned} C_t &= e^{-\mu_c(T-t)}\, E_t[\max\{S_T - K, 0\}] \\ &= e^{-\mu_c(T-t)} \left[\int_K^{\infty} S_T\, \phi(S_T)\, dS_T - K\int_K^{\infty} \phi(S_T)\, dS_T\right] \\ &= e^{(\mu_s-\mu_c)(T-t)}\, S_t N(h_1) - e^{-\mu_c(T-t)}\, K\, N(h_2) \\ &= e^{(\mu_s-r_f)(1-\beta_{cs})(T-t)}\, S_t N(h_1) - e^{-\mu_c(T-t)}\, K\, N(h_2) \end{aligned} \tag{B1}$$

C. Proof of Proposition 3:

From equation (3), we can compute the expected value of the call payoff:

$$\begin{aligned} E(C_T) &= e^{\mu_c(T-t)}\, C_t \\ &= S_t e^{\mu(T-t)}\, N(h_1) - K\, N(h_2). \end{aligned} \tag{C1}$$

From the known result of the moment generating function of a Gaussian variable, we have

$$\begin{aligned} \mathrm{Var}(S_T) &= \mathrm{E}(S_T^2) - [\mathrm{E}(S_T)]^2 \\ &= S_t^2\, e^{(2\mu+\sigma^2)(T-t)} - S_t^2\, e^{2\mu(T-t)} \\ &= S_t^2\, e^{2\mu(T-t)}\left[e^{\sigma^2(T-t)} - 1\right], \end{aligned} \tag{C2}$$

and

$$\begin{aligned} E(S_T C_T) &= \int_0^{\infty} S_T \max(S_T - K, 0)\, \phi(S_T)\, d\,S_T \\ &= \int_K^{\infty} \mathrm{S}_\mathrm{T}^2\, \phi(S_T)\, d\,S_T - K\int_K^{\infty} \mathrm{S}_\mathrm{T}\, \phi(S_T)\, d\,S_T \\ &= S_t^2\, e^{(2\mu+\sigma^2)(T-t)} N(h_3) - K S_t\, e^{\mu(T-t)} N(h_1), \end{aligned} \tag{C3}$$

where

$$h_3 = \frac{\ln S_t - \ln K + \left(\mu + \frac{3}{2}\sigma^2\right)(T-t)}{\sigma\sqrt{T-t}}.$$

Hence, the covariance term in equation (2) can be computed as

$$\begin{aligned}
\mathrm{Cov}(S_T, C_T) &= E(S_T C_T) - E(S_T)\,E(C_T) \\
&= S_t^2\, e^{(2\mu+\sigma^2)(T-t)} N(h_3) - KS_t\, e^{\mu(T-t)} N(h_1) \\
&\qquad - S_t\, e^{\mu(T-t)}\left[S_t\, e^{\mu(T-t)} N(h_1) - KN(h_2)\right] \qquad \text{(C4)} \\
&= S_t^2\, e^{2\mu(T-t)}\left[\, e^{\sigma^2(T-t)} N(h_3) - \frac{K}{S_t}\, e^{\mu(T-t)}\{N(h_1) - N(h_2)\} - N(h_1)\right].
\end{aligned}$$

Finally, combining equations (2b), (B2), and (B4), we have

$$\beta_{cs}^* = \frac{S_t\left[e^{\sigma^2(T-t)}\, N(h_3) - \left(\frac{K}{S_t}\right) e^{-\mu(T-t)}\{N(h_1) - N(h_2)\} - N(h_1)\right]}{C_t\left[e^{\sigma^2(T-t)} - 1\right]}. \qquad \text{(C5)}$$

Table 1
Basic Statistics of the Implied Variables for Individual Stock Options

This table presents the basic statistics of the pooled implied data of individual stock options. By using the risk-adjusted option pricing model, the implied mean returns (μ_i) and standard deviations (σ_i) of individual stocks (all 4,078 stocks) are computed with call option prices of various maturities observed at the last trading day of each month from January 1996 to April 2006. The implied beta OLS estimate of stock i ($\hat{\beta}_i^{\text{imp}}$) is obtained from regressing the implied holding period mean returns on stock i on the implied holding period market mean returns in each maturity group (with at least 10 implied observations). Implied mean returns are measured at the end of every month. "Correlation" is the correlation coefficient between the implied variable and its historical counterpart. The historical counterpart of the implied return is the annualized continuously compounded return of the stock over the option life, that of the implied standard deviation is the annualized sample standard deviation, and that of the implied beta is the Scholes-William (1977) beta estimate using daily returns over the option life. "NSAM" is the number of all available firm-month observations.

Implied variable	Maturities (in days)	Mean	Standard deviation	Correla tion	Min	1%	10%	Median	90%	99%	Max	NSAM
Implied return (μ_i)	All maturities	0.315	0.234	0.100	0.001	0.039	0.101	0.245	0.633	1.133	1.750	179,048
	$0 < T \leq 30$	0.538	0.293	0.006	0.003	0.071	0.197	0.486	0.959	1.329	1.750	47,863
	$30 < T \leq 60$	0.336	0.156	0.047	0.001	0.064	0.149	0.313	0.558	0.729	1.056	41,838
	$60 < T \leq 120$	0.243	0.107	0.068	0.001	0.048	0.116	0.231	0.391	0.522	0.704	31,188
	$120 < T \leq 210$	0.178	0.074	0.030	0.001	0.029	0.089	0.171	0.280	0.370	0.483	34,171
	$T > 210$	0.122	0.051	0.013	0.001	0.011	0.062	0.118	0.188	0.266	0.366	23,988
Implied volatility (σ_i)	All maturities	0.480	0.206	0.695	0.030	0.143	0.237	0.446	0.790	0.964	0.990	17,9048
	$0 < T \leq 30$	0.515	0.212	0.615	0.046	0.161	0.259	0.481	0.836	0.971	0.990	47,863
	$30 < T \leq 60$	0.497	0.206	0.713	0.030	0.151	0.250	0.464	0.806	0.968	0.990	41,838
	$60 < T \leq 120$	0.474	0.200	0.741	0.032	0.142	0.236	0.444	0.772	0.959	0.990	31,188
	$120 < T \leq 210$	0.456	0.200	0.765	0.038	0.134	0.222	0.421	0.754	0.956	0.990	34,171
	$T > 210$	0.423	0.189	0.727	0.039	0.133	0.204	0.389	0.700	0.935	0.990	23,988
Implied OLS beta ($\hat{\beta}_i^{\text{imp}}$)	All maturities	0.792	1.043	0.114	-9.521	-1.969	-0.087	0.684	1.847	4.385	9.866	148,973
	$0 < T \leq 30$	1.146	1.378	0.049	-9.521	-2.543	-0.119	0.997	2.673	5.787	9.805	40,910
	$30 < T \leq 60$	0.959	1.111	0.200	-7.441	-2.578	-0.055	0.974	2.033	3.900	9.866	34,581
	$60 < T \leq 120$	0.542	0.825	0.248	-5.348	-2.103	-0.308	0.606	1.288	2.872	5.209	24,630

	$120 < T \leq 210$	0.530	0.614	0.299	-3.438	-1.346	-0.069	0.540	1.064	2.188	8.161	27,793
	$T > 210$	0.467	0.369	0.398	-3.794	-0.609	0.069	0.489	0.856	1.409	1.794	21,059
# days to maturity	All maturities	125	155	-	3	16	18	53	261	785	1027	179,048

Table 2
Basic Statistics of the Implied Variables for Standard and Poors 500 Index Options

This table presents the basic statistics of the pooled implied data of Standard & Poor's 500 Index options as the market index options. By using the risk-adjusted option pricing model, the implied market mean returns (μ_m) and standard deviations (σ_m) of the market index options are computed with call option prices of various maturities observed at the last trading day of each month from January 1996 to April 2006. For each observed individual stock option, we find the corresponding Standard & Poor's 500 Index option whose maturity is the same as the stock option. Implied market mean returns are measured at the end of every month. "Correlation" is the correlation coefficient between the implied variable and its historical counterpart. The historical counterpart of the implied market return is the annualized continuously compounded return of the market index over the option life, and that of the implied standard deviation is the annualized sample standard deviation. "NSAM" is the number of all available firm-month observations.

Implied variable	Maturities (in days)	Mean	Standard deviation	Correlation	Min	1%	10%	Median	90%	99%	Max	NSAM
Implied market return (μ_m)	All maturities	0.169	0.085	0.139	0.008	0.054	0.087	0.150	0.283	0.508	0.590	179,048
	$0 < T \leq 30$	0.246	0.099	0.184	0.109	0.127	0.139	0.229	0.375	0.577	0.590	47,863
	$30 < T \leq 60$	0.169	0.059	0.096	0.091	0.091	0.109	0.153	0.243	0.334	0.371	41,838
	$60 < T \leq 120$	0.145	0.053	0.129	0.074	0.079	0.092	0.133	0.214	0.328	0.353	31,188
	$120 < T \leq 210$	0.130	0.047	0.044	0.062	0.063	0.083	0.115	0.194	0.275	0.323	34,171
	$T > 210$	0.101	0.039	0.026	0.008	0.017	0.059	0.093	0.157	0.211	0.272	23,988
Implied market volatility (σ_m)	All maturities	0.202	0.075	0.643	0.079	0.107	0.118	0.190	0.304	0.437	0.517	17,9048
	$0 < T \leq 30$	0.200	0.078	0.604	0.079	0.103	0.111	0.191	0.310	0.430	0.463	47,863
	$30 < T \leq 60$	0.202	0.075	0.644	0.107	0.107	0.118	0.197	0.314	0.448	0.456	41,838
	$60 < T \leq 120$	0.202	0.073	0.617	0.108	0.109	0.120	0.190	0.295	0.417	0.517	31,188
	$120 < T \leq 210$	0.202	0.073	0.682	0.110	0.111	0.124	0.189	0.300	0.440	0.482	34,171
	$T > 210$	0.206	0.076	0.748	0.101	0.106	0.130	0.182	0.308	0.431	0.499	23,988

Table 3

Time-Series Averages of Cross-Sectional Regressions of *Ex Ante* Implied Returns on Implied Beta Estimates

This table presents the time-series averages (in percent, ×100) of the Fama-MacBeth month-by-month cross-sectional regression coefficients:

$$\mu_{i,[t,T]} - r_{f,[t,T]} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_{it}^{\text{imp}} + \Gamma_t\ (\text{Control variables}) + \varepsilon_{it},$$

where $\mu_{i,[t,T]}$ is the *implied* annualized holding period mean return on underlying stock i over the option life, measured at the end of each month (t). $r_{f,[t,T]}$ is the Treasury bill annualized holding period yield measured at the end of each month (t). $\hat{\beta}_{it}^{\text{imp}}$ is the OLS implied beta estimate of stock i obtained from regressing the implied mean returns of stock i on the implied market mean returns in each maturity group over the whole sample period. Maturity groups are classified as 5 groups: $0 < T \leq 30$, $30 < T \leq 60$, $60 < T \leq 120$, $120 < T \leq 210$, and $T > 210$ days. Control variables are as follows: ME is the market value of common equity measured one month before the option trading day, BM is the book-to-market ratio and the earnings–price ratio, which is most recently available six months before the option trading day, and "Momentum" is the stock return over the past six months before the option trading day. Numbers in parentheses indicate *t*-statistics. The sample period is from January 1996 to April 2006.

Maturity (in days)	Intercept	$\hat{\beta}_{it}^{\text{imp}}$	Control Variables log (ME)	log(BM)	Momentum
All maturities	29.95 (62.25)	11.30 (13.67)			
$0 < T \leq 30$	68.78 (55.78)	6.12 (7.43)			
$30 < T \leq 60$	35.83 (84.65)	2.45 (5.09)			
$60 < T \leq 120$	24.23 (79.30)	0.75 (1.89)			
$120 < T \leq 210$	16.21 (74.61)	0.57 (1.73)			
$T > 210$	8.84 (59.41)	1.06 (4.18)			
All maturities	44.70 (60.19)	12.31 (14.80)	-8.84 (-44.65)	-3.44 (-13.84)	-0.87 (-1.44)
$0 < T \leq 30$	85.96 (53.51)	5.10 (5.95)	-12.92 (-33.03)	-5.95 (-12.02)	-3.25 (-2.53)
$30 < T \leq 60$	41.68 (71.56)	3.53 (7.32)	-5.68 (-34.41)	-3.46 (-14.73)	-3.46 (-1.19)
$60 < T \leq 120$	26.71 (67.73)	1.93 (4.83)	-3.21 (-29.26)	-2.61 (-13.87)	0.52 (1.17)
$120 < T \leq 210$	17.24 (58.94)	1.98 (5.68)	-1.84 (-25.87)	-1.66 (-15.59)	0.08 (0.30)
$T > 210$	10.31 (38.08)	2.03 (6.72)	-1.08 (-16.56)	-0.96 (-12.35)	0.37 (2.43)

Table 4

Time-Series Averages of Cross-Sectional Regressions of *Ex-Post* Returns on the Implied Beta Estimates

This table shows the time-series averages (in percent, ×100) of the Fama-MacBeth month-by-month cross-sectional regression coefficients:

$$R_{i,[t,t+H]} - r_{f,[t,t+H]} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_{it}^{\text{imp}} + \Gamma_t \text{ (Control variables)} + \varepsilon_{it},$$

where $R_{i,[t,t+H]}$ is the ex post annualized holding period return of underlying stock i over the period H. The period H is the option life from the following day of the end of each month (t) to its maturity date (T) (in Panel A) or is one month from the day following the end of each month (t) to the end of the next month (in Panel B). The option trading day is the last day of each month. Thus, the realized ex post return is measured from the first day of the month following the option trade month to the option maturity. $r_{f,[t,T]}$ is the Treasury bill annualized holding period yield over the same measurement period of $R_{i,[t,T]}$, and $\hat{\beta}_{it}^{\text{imp}}$ is the OLS implied beta estimate of stock i obtained from regressing implied mean returns of stock i on implied market mean returns in each maturity group. Maturity groups are classified as follows: $0 < T \leq 30$, $30 < T \leq 60$, $60 < T \leq 120$, $120 < T \leq 210$, and $T > 210$ days. Control variables are as follows: ME is the market value of common equity measured one month before the option trading day, BM is the book-to-market ratio and the earnings-price ratio, which is most recently available six months before the option trading day, and "Momentum" is the stock return over the past six months prior to the option trading day, Numbers in parentheses indicate t-statistics. The sample period is from January 1996 to April 2006.

Maturity (in days)	Intercept	$\hat{\beta}_{it}^{\text{Imp}}$	Control Variables		
			log (ME)	log(BM)	Momentum
Panel A: Y-variable = Realized returns over the option life (H = *T*)					
All maturities	31.64 (10.52)	9.49 (8.44)			
$0 < T \leq 30$	61.98 (10.53)	1.61 (1.27)			
$30 < T \leq 60$	44.11 (8.94)	5.75 (3.68)			
$60 < T \leq 120$	25.03 (8.66)	6.35 (3.71)			
$120 < T \leq 210$	18.37 (6.00)	6.50 (3.89)			
$T > 210$	6.98 (3.11)	10.67 (4.36)			
All maturities	46.74 (10.60)	12.11 (9.72)	-5.80 (-6.92)	2.47 (1.93)	7.29 (2.81)
$0 < T \leq 30$	63.49 (9.77)	3.06 (2.22)	1.41 (1.09)	4.38 (1.92)	6.15 (1.41)
$30 < T \leq 60$	54.94 (8.06)	7.43 (4.89)	-6.07 (-4.95)	-0.50 (-0.23)	3.13 (0.68)
$60 < T \leq 120$	44.64 (8.22)	6.95 (3.60)	-7.09 (-7.60)	0.08 (0.00)	11.54 (3.21)
$120 < T \leq 210$	28.76 (6.42)	13.21 (6.74)	-5.41 (-6.61)	1.35 (1.00)	10.90 (5.03)
$T > 210$	22.86 (6.74)	15.04 (6.46)	-4.58 (-5.46)	1.27 (1.26)	7.60 (4.87)

Panel B: Y-variable = Realized returns over the next one month (H = 1 month)

All maturities	0.66 (1.26)	0.21 (2.74)			
$0 < T \leq 30$	0.56 (1.03)	-0.02 (-0.43)			
$30 < T \leq 60$	0.61 (1.12)	0.25 (2.01)			
$60 < T \leq 120$	0.52 (1.06)	0.32 (2.15)			
$120 < T \leq 210$	0.40 (0.68)	0.65 (2.17)			
$T > 210$	0.39 (0.62)	0.99 (1.91)			
All maturities	0.79 (1.17)	0.26 (3.07)	-0.04 (-0.32)	0.24 (1.25)	0.90 (2.19)
$0 < T \leq 30$	0.75 (1.15)	0.07 (1.47)	0.07 (0.53)	0.36 (1.99)	0.77 (1.87)
$30 < T \leq 60$	0.61 (0.92)	0.35 (2.87)	-0.04 (-0.27)	0.21 (1.10)	0.66 (1.61)
$60 < T \leq 120$	0.68 (1.13)	0.46 (2.28)	-0.13 (-0.91)	0.04 (0.17)	0.92 (2.14)
$120 < T \leq 210$	0.63 (0.87)	0.97 (3.27)	-0.17 (-1.09)	0.22 (1.04)	1.10 (2.48)
$T > 210$	1.52 (1.70)	1.41 (2.30)	-0.32 (-1.74)	0.18 (0.75)	0.98 (2.01)

Table 5
Basic Statistics of the *Forward* Implied Variables for Individual Stock Options

This table presents the basic statistics of the pooled implied forward variables for individual stock options. $\mu^{f}_{i,[T_1,T_2]}$ is the forward-implied annualized holding period return (HPR) on underlying stock i over the forward period $[T_1, T_2]$, which is from the next of the first option maturity (T_1) to the maturity of the second option (T_2). This forward-implied return is measured at the end of every month(t) from January 1996 to April 2006. $\sigma^{f}_{i,[T_1,T_2]}$ is the forward-implied annualized standard deviation of the underlying stock i over the forward period $[T_1, T_2]$. $\hat{\beta}^{f,imp}_{it}$ is the forward-implied beta estimate of stock i obtained from regressing the forward-implied HPRs of stock i on the forward-implied market HPRs in each forward period length group over the whole sample period. Forward period length groups are classified as follows: $0 < T \leq 30$, 30 < T ≤ 90, 90 < T ≤ 120, and T > 120 days. "NSAM" is the number of all available firm-month observations.

Implied forward variable	Forward period (in days)	Mean	Standard deviation	Min	1%	10%	Median	90%	99%	Max	NSAM
Forward implied return $\left(\mu^{f}_{i,[T_1,T_2]}\right)$	All forward periods	0.145	0.160	-2.053	-0.286	-0.003	0.126	0.332	0.631	2.018	106,082
	$0 < [T_1, T_2] \leq 30$	0.208	0.214	-2.053	-0.394	-0.024	0.203	0.451	0.791	2.018	25,643
	$30 < [T_1, T_2] \leq 90$	0.171	0.161	-1.280	-0.271	-0.001	0.163	0.360	0.616	1.454	28,843
	$90 < [T_1, T_2] \leq 120$	0.106	0.102	-0.626	-0.211	-0.001	0.107	0.217	0.374	0.717	30,777
	$[T_1, T_2] > 120$	0.084	0.063	-0.531	-0.102	0.018	0.083	0.153	0.259	0.419	17,877
Forward implied volatility $\left(\sigma^{f}_{i,[T_1,T_2]}\right)$	All forward periods	0.464	0.211	0.002	0.109	0.215	0.431	0.773	0.985	1.551	106,082
	$0 < [T_1, T_2] \leq 30$	0.493	0.216	0.002	0.111	0.237	0.460	0.804	1.029	1.551	25,643
	$30 < [T_1, T_2] \leq 90$	0.468	0.205	0.003	0.108	0.226	0.440	0.764	0.985	1.271	28,843
	$90 < [T_1, T_2] \leq 120$	0.437	0.197	0.002	0.105	0.205	0.408	0.721	0.955	1.330	30,777
	$[T_1, T_2] > 120$	0.413	0.187	0.014	0.115	0.196	0.383	0.674	0.933	1.335	17,877
Forward implied beta $(\hat{\beta}^{f,imp}_{i})$	All forward periods	0.283	0.879	-12.407	-2.183	-0.403	0.276	0.996	2.785	13.380	89,547
	$0 < [T_1, T_2] \leq 30$	0.316	1.337	-12.407	-3.990	-0.708	0.307	1.378	3.823	12.488	21,636
	$30 < [T_1, T_2] \leq 90$	0.273	0.858	- 4.124	-2.114	-0.508	0.293	0.983	2.682	13.380	24,699
	$90 < [T_1, T_2] \leq 120$	0.290	0.557	- 3.310	-1.277	-0.257	0.277	0.859	2.184	4.769	26,080
	$[T_1, T_2] > 120$	0.175	0.330	- 2.185	-0.678	-0.149	0.148	0.529	1.037	2.263	15,037
# days of forward period	All forward periods	98	104	28	28	28	63	245	462	945	106,082

Table 6
Forward Relationship: Time-Series Averages of Cross-Sectional Regressions of Implied Forward Returns on Implied Forward Beta Estimates

This table shows the time-series averages (in percent, ×100) of the Fama-MacBeth month-by-month cross-sectional regression coefficients:

$$\mu^f_{it,[T_1,T_2]} - r_{ft,[T_1,T_2]} = \gamma^f_{0t} + \gamma^f_{1t}\hat{\beta}^{f,imp}_{it} + \varepsilon_{it},$$

where $\mu^f_{it,[T_1,T_2]}$ is the forward-implied annualized holding period return (HPR) on an underlying stock i over the forward period $[T_1, T_2]$ which is from the day following the first option maturity (T_1) to the maturity of the second option (T_2), and $r_{ft,[T_1,T_2]}$ is the Treasury bill annualized holding period yield over the forward period. Both $\mu^f_{it,[T_1,T_2]}$ and $r_{ft,[T_1,T_2]}$ are measured at time t (i.e., the last trading day of each month). $\hat{\beta}^{f,imp}_{it}$ is the forward-implied beta estimate of stock i obtained from regressing the forward-implied HPRs of stock i on the forward-implied market HPRs in each forward period length group over the whole sample period. Forward period length groups are classified as follows: $0 < T \leq 30$, $30 < T \leq 90$, $90 < T \leq 120$, and $T > 120$ days.

Forward periods (in days)	Intercept $(\bar{\hat{\gamma}}^f_{0t})$	$\hat{\beta}^{f,imp}_{it}$ $(\bar{\hat{\gamma}}^f_{1t})$
All forward periods	16.66 (91.83)	1.88 (5.42)
$0 < [T_1, T_2] \leq 30$	24.61 (52.78)	1.23 (2.41)
$30 < [T_1, T_2] \leq 90$	18.99 (45.99)	0.75 (1.87)
$90 < [T_1, T_2] \leq 120$	11.58 (81.62)	1.05 (2.70)
$[T_1, T_2] > 120$	8.44 (49.63)	1.58 (4.16)

Table 7 Relationship Between Estimated Ex Ante Market Risk Premium and Forward-Looking Macroeconomic Variables

This table presents the results of the following time-series regression model:

$$\hat{\gamma}_{1t} = b_0 + b_1 \mathrm{TB}_{t+1,t+L} + b_2 \mathrm{TERM}_{t+1,t+L} + b_3 \mathrm{DEF}_{t+1,t+L} + b_4 \mathrm{DIV}_{t+1,t+L} + b_5 \mathrm{CONSUME}_{t+1,t+L} + b_6 \mathrm{GDP}_{t+1,t+L} + b_7 \mathrm{LABOR}_{t+1,t+L} + \varepsilon_t,$$

where $\hat{\gamma}_{1t}$ is the CSR coefficient estimates (or estimated ex ante market risk premia) at month t of ex ante implied returns (with various maturities) of individual stocks on their implied beta estimates. The macroeconomic variables used as explanatory variables are as follows: $\mathrm{TB}_{t+1,t+L}$ is the 3-month Treasury bill (geometric average) yield from month t+1 through month t+L (L is the number of months of the forward-looking period), TERM is the term spread defined as the difference between the yield on 10-year government bonds and the yield on the three-month Treasury bill, DEF is the default spread defined as the difference between the yield on Moody's BAA rated bonds and the yield on Moody's AAA rated bonds, DIV is the dividend yield on the value-weighted market, CONSUME is the growth rate of personal consumption expenditures, GDP is the growth rate of GDP, and LABOR is the growth rate of personal labor income.

	All maturities		Maturities (in days) of ex ante implied returns used in estimating ex ante market risk premia									
			0<T≤30		30<T≤60		60<T≤120		120<T≤210		210<T	
					Panel A: Forward-looking period (L) = 1 month							
Intercept	0.05	(0.55)	0.18	(1.74)	0.13	(2.10)	0.17	(3.76)	0.03	(0.85)	0.04	(1.19)
TB	0.97	(1.03)	-0.97	(-0.87)	-0.88	(-1.36)	-1.40	(-2.67)	0.04	(0.08)	-0.47	(-1.31)
TERM	-0.60	(-0.48)	-0.76	(-0.54)	-0.03	(-0.04)	-1.13	(-1.80)	0.45	(0.84)	0.04	(0.09)
DEF	19.62	(4.32)	5.52	(1.04)	1.48	(0.48)	-0.22	(-0.10)	3.46	(1.79)	4.55	(2.94)
DIV	-38.72	(-2.30)	-48.50	(-2.53)	-34.41	(-3.26)	-40.71	(-4.90)	-18.43	(-2.58)	-11.29	(-2.19)
CONSUME	-3.80	(-0.93)	-4.26	(-0.92)	-2.61	(-0.95)	0.37	(0.16)	-2.12	(-1.11)	-2.88	(-2.17)
GDP	-3.22	(-2.03)	-1.47	(-0.83)	-1.34	(-1.49)	-1.98	(-2.75)	-2.34	(-3.92)	-1.66	(-3.72)
LABOR	-2.00	(-1.58)	-1.69	(-1.10)	-1.31	(-1.46)	-0.78	(-1.19)	0.01	(0.01)	-0.01	(-0.03)
Adj R^2	0.329		0.119		0.227		0.310		0.276		0.408	
					Panel B: Forward-looking period (L) = 2 months							
Intercept	0.04	(0.46)	0.09	(1.13)	0.04	(1.14)	0.05	(1.76)	0.00	(0.18)	0.00	(0.06)
TB	1.13	(1.33)	-0.18	(-0.21)	0.11	(0.26)	-0.04	(-0.10)	0.61	(2.04)	-0.09	(-0.42)
TERM	-0.06	(-0.05)	0.18	(0.14)	1.33	(2.00)	0.41	(0.75)	0.96	(2.40)	0.46	(1.64)
DEF	20.97	(4.65)	10.56	(2.14)	6.19	(2.60)	4.58	(2.38)	5.59	(3.85)	6.31	(5.85)
DIV	-45.59	(-2.05)	-55.02	(-2.16)	-46.78	(-3.43)	-43.08	(-3.61)	-27.78	(-2.91)	-12.55	(-1.75)
CONSUME	-6.33	(-1.21)	-9.56	(-1.56)	-5.65	(-1.67)	-0.38	(-0.13)	-2.02	(-0.89)	-2.16	(-1.24)
GDP	-3.74	(-2.14)	-0.60	(-0.30)	-0.67	(-0.67)	-1.10	(-1.22)	-2.27	(-3.35)	-1.56	(-2.86)
LABOR	-1.49	(-1.08)	-1.22	(-0.71)	-0.77	(-0.82)	-0.91	(-1.21)	-0.47	(-0.88)	0.00	(-0.01)
Adj R^2	0.357		0.132		0.279		0.226		0.342		0.406	

	All maturities	Maturities (in days) of ex ante implied returns used in estimating ex ante market risk premium				
		0<T≤30	30<T≤60	60<T≤120	120<T≤210	210<T
			Panel C: Forward-looking period (*L*) = 4 month			
Intercept	0.02 (0.28)	0.01 (0.17)	-0.01 (-0.49)	0.00 (-0.17)	-0.01 (-0.65)	0.00 (0.31)
TB	1.23 (1.78)	0.03 (0.04)	0.26 (0.69)	0.47 (1.45)	0.90 (3.58)	-0.13 (-0.66)
TERM	0.63 (0.57)	0.38 (0.31)	2.07 (2.84)	1.08 (1.84)	1.13 (2.70)	0.43 (1.34)
DEF	24.86 (5.74)	19.01 (3.85)	9.27 (3.98)	7.45 (3.84)	7.05 (4.98)	7.18 (6.53)
DIV	-58.56 (-2.29)	-68.49 (-2.15)	-55.52 (-2.96)	-61.17 (-3.68)	-33.12 (-2.62)	-19.44 (-1.95)
CONSUME	-16.66 (-2.15)	-26.81 (-2.84)	-10.05 (-1.95)	2.77 (0.62)	-1.21 (-0.36)	-4.27 (-1.45)
GDP	-4.63 (-2.19)	1.26 (0.51)	0.42 (0.30)	0.14 (0.11)	-2.60 (-2.76)	-1.14 (-1.43)
LABOR	0.22 (0.14)	0.80 (0.39)	0.91 (0.80)	-0.43 (-0.48)	-0.61 (-1.00)	-0.10 (-0.21)
Adj R^2	0.432	0.201	0.295	0.247	0.401	0.427
			Panel D: Forward-looking period (*L*) = 6 months			
Intercept	0.00 (0.04)	-0.05 (-0.93)	-0.04 (-1.58)	-0.02 (-1.07)	-0.01 (-0.44)	0.01 (1.16)
TB	1.25 (1.99)	-0.33 (-0.51)	0.27 (0.69)	0.37 (1.07)	1.02 (3.65)	-0.18 (-0.81)
TERM	0.93 (0.82)	0.35 (0.28)	2.92 (3.46)	1.23 (1.82)	1.04 (2.16)	0.16 (0.42)
DEF	26.77 (6.17)	26.62 (5.11)	9.48 (3.84)	8.30 (4.09)	7.14 (4.80)	7.90 (6.91)
DIV	-55.34 (-1.92)	-85.71 (-2.47)	-79.49 (-3.55)	-74.01 (-3.92)	-35.17 (-2.46)	-12.86 (-1.14)
CONSUME	-27.01 (-2.75)	-55.00 (-4.62)	-6.91 (-1.03)	5.45 (0.96)	2.43 (0.57)	-10.08 (-2.52)
GDP	-4.67 (-1.75)	5.12 (1.79)	2.16 (1.24)	1.58 (1.02)	-3.01 (-2.64)	-1.36 (-1.39)
LABOR	1.01 (0.52)	3.81 (1.58)	2.34 (1.64)	0.24 (0.21)	-1.08 (-1.43)	-0.84 (-1.35)
Adj R^2	0.454	0.298	0.308	0.268	0.411	0.453

Table 8 Relationships Between Implied Market Returns on S&P500 Index and Forward-Looking Macroeconomic Variables

This table presents the results of the following time-series regression model:

$$\mu_{mt} = b_0 + b_1\text{TB}_{t+1,t+L} + b_2\text{TERM}_{t+1,t+L} + b_3\text{DEF}_{t+1,t+L} + b_4\text{DIV}_{t+1,t+L} + b_5\text{CONSUME}_{t+1,t+L} + b_6\text{GDP}_{t+1,t+L} + b_7\text{LABOR}_{t+1,t+L} + \varepsilon_t,$$

where μ_{mt} is the implied market return on S&P500 Index option (with various maturities) obtained at the end of month t. The macroeconomic variables used as explanatory variables are as follows: $\text{TB}_{t+1,t+L}$ is the 3-month Treasury bill (geometric average) yield from month t+1 through month t+L (L is the number of months of the forward-looking period), TERM is the term spread defined as the difference between the yield on 10-year government bonds and the yield on the three-month Treasury bill, DEF is the default spread defined as the difference between the yield on Moody's BAA rated bonds and the yield on Moody's AAA rated bonds, DIV is the dividend yield on the value-weighted market, CONSUME is the growth rate of personal consumption expenditures, GDP is the growth rate of GDP, and LABOR is the growth rate of personal labor income. The sample period is from January 1996 to April 2006.

	All maturities		Maturities (in days) of S&P500 Index options									
			0<T≤30		30<T≤60		60<T≤120		120<T≤210		210<T	
Panel A: Forward-looking period (L) = 1 month												
Intercept	0.13	(2.60)	0.34	(2.73)	0.31	(4.64)	0.27	(5.05)	0.18	(3.89)	0.13	(3.06)
TB	1.59	(2.84)	1.27	(0.99)	0.34	(0.45)	0.34	(0.56)	0.70	(1.23)	0.50	(1.01)
TERM	-0.21	(-0.28)	1.16	(0.68)	1.06	(1.15)	0.89	(1.22)	0.90	(1.41)	1.30	(2.34)
DEF	3.96	(1.48)	1.73	(0.28)	-1.94	(-0.59)	-3.52	(-1.35)	-0.26	(-0.11)	1.69	(0.86)
DIV	-24.65	(-2.51)	-63.16	(-3.00)	-53.27	(-4.50)	-46.75	(-4.90)	-30.53	(-3.78)	-32.83	(-5.15)
CONSUME	-5.53	(-2.33)	-12.44	(-2.49)	-7.32	(-2.28)	-2.31	(-0.89)	-2.00	(-0.92)	-4.62	(-2.98)
GDP	-0.45	(-0.50)	-1.97	(-1.08)	-2.68	(-2.66)	-2.26	(-2.78)	-3.16	(-4.51)	-1.73	(-3.35)
LABOR	-1.36	(-1.80)	-1.84	(-1.02)	-0.91	(-0.94)	-0.76	(-1.04)	0.17	(0.30)	0.84	(2.13)
Adj R^2	0.295		0.239		0.262		0.282		0.357		0.505	
Panel B: Forward-looking period (L) = 2 months												
Intercept	0.14	(3.29)	0.18	(2.25)	0.15	(3.86)	0.14	(4.35)	0.09	(3.64)	0.06	(3.89)
TB	1.65	(3.65)	2.73	(2.90)	1.99	(3.82)	1.89	(4.50)	1.91	(5.39)	1.44	(6.02)
TERM	0.16	(0.25)	2.61	(1.88)	2.77	(3.71)	2.48	(4.25)	2.12	(4.56)	2.30	(6.97)
DEF	5.06	(2.04)	10.86	(2.19)	5.51	(2.10)	2.07	(1.00)	4.67	(2.71)	6.29	(5.12)
DIV	-47.43	(-3.79)	-67.73	(-2.41)	-55.11	(-3.51)	-49.60	(-3.71)	-34.77	(-3.11)	-48.88	(-5.46)
CONSUME	-8.01	(-2.68)	-15.71	(-2.42)	-7.46	(-1.88)	-1.22	(-0.37)	-2.47	(-0.92)	-3.91	(-2.04)
GDP	0.14	(0.14)	-0.78	(-0.38)	-2.21	(-1.92)	-1.67	(-1.70)	-3.04	(-3.60)	-1.10	(-1.77)
LABOR	-1.03	(-1.28)	-1.19	(-0.62)	-0.70	(-0.67)	-1.00	(-1.26)	-0.30	(-0.53)	0.32	(0.85)
Adj R^2	0.354		0.168		0.291		0.262		0.381		0.582	

	All maturities		Maturities (in days) of S&P500 Index options									
			0<T≤30		30<T≤60		60<T≤120		120<T≤210		210<T	
	Panel C: Forward-looking period (*L*) = 4 months											
Intercept	0.13	(4.05)	0.17	(3.44)	0.12	(4.15)	0.10	(4.66)	0.06	(3.83)	0.05	(6.87)
TB	1.74	(5.03)	2.32	(3.19)	2.27	(5.18)	2.21	(6.53)	2.15	(7.85)	1.53	(8.29)
TERM	0.55	(0.91)	2.00	(1.48)	2.71	(3.36)	2.56	(4.29)	1.69	(3.79)	2.10	(6.63)
DEF	8.22	(3.53)	18.26	(4.16)	8.85	(3.45)	5.77	(2.92)	8.79	(5.78)	8.33	(7.45)
DIV	-72.91	(-4.88)	-123.46	(-3.50)	-66.68	(-3.12)	-62.65	(-3.62)	-43.29	(-3.17)	-54.45	(-5.30)
CONSUME	-15.98	(-3.69)	-39.10	(-4.13)	-7.35	(-1.26)	-3.13	(-0.68)	-2.44	(-0.64)	-1.53	(-0.60)
GDP	0.93	(0.77)	5.10	(1.97)	-0.82	(-0.50)	-0.54	(-0.42)	-2.31	(-2.10)	-1.38	(-1.80)
LABOR	-0.12	(-0.13)	-0.55	(-0.25)	-0.64	(-0.51)	-0.66	(-0.76)	-0.36	(-0.55)	0.00	(0.00)
Adj R^2	0.441		0.303		0.333		0.370		0.540		0.699	
	Panel D: Forward-looking period (*L*) = 6 months											
Intercept	0.11	(3.99)	0.15	(3.23)	0.09	(3.41)	0.10	(4.89)	0.05	(3.54)	0.06	(9.83)
TB	1.78	(5.82)	1.98	(2.87)	2.02	(4.45)	2.13	(5.80)	1.83	(6.15)	1.32	(7.21)
TERM	0.73	(1.24)	2.55	(1.78)	3.06	(3.40)	2.23	(3.36)	1.06	(2.17)	1.87	(5.31)
DEF	11.37	(4.83)	22.92	(5.10)	10.40	(3.88)	6.55	(3.22)	10.11	(6.76)	9.76	(8.61)
DIV	-85.12	(-5.38)	-171.17	(-4.44)	-99.95	(-4.05)	-64.75	(-3.38)	-51.92	(-3.53)	-66.99	(-6.09)
CONSUME	-27.39	(-5.27)	-58.99	(-4.95)	-5.61	(-0.76)	-1.00	(-0.17)	1.55	(0.31)	-3.98	(-1.21)
GDP	2.09	(1.50)	9.70	(3.20)	2.23	(1.11)	-0.24	(-0.15)	-1.00	(-0.77)	-0.36	(-0.43)
LABOR	0.71	(0.66)	1.88	(0.76)	1.02	(0.67)	-0.64	(-0.60)	0.23	(0.27)	-0.21	(-0.54)
Adj R^2	0.532		0.373		0.368		0.404		0.601		0.734	

Table 9 Relationships Between Realized Market Returns and Forward-Looking Macroeconomic Variables

This table presents the results of the following time-series regression model:

$$R_{mt} = b_0 + b_1 \mathrm{TB}_{t+1,t+L} + b_2 \mathrm{TERM}_{t+1,t+L} + b_3 \mathrm{DEF}_{t+1,t+L} + b_4 \mathrm{DIV}_{t+1,t+L} + b_5 \mathrm{CONSUME}_{t+1,t+L} + b_6 \mathrm{GDP}_{t+1,t+L} + b_7 \mathrm{LABOR}_{t+1,t+L} + \varepsilon_t,$$

where R_{mt} is the CRSP value-weighted market return at month t. The macroeconomic variables used as explanatory variables are as follows: $\mathrm{TB}_{t+1,t+L}$ is the 3-month Treasury bill (geometric average) yield from month *t*+1 through month *t*+*L* (*L* is the number of months of the forward-looking period), TERM is the term spread defined as the difference between the yield on 10-year government bonds and the yield on the three-month Treasury bill, DEF is the default spread defined as the difference between the yield on Moody's BAA rated bonds and the yield on Moody's AAA rated bonds, DIV is the dividend yield on the value-weighted market, CONSUME is the growth rate of personal consumption expenditures, GDP is the growth rate of GDP, and LABOR is the growth rate of personal labor income. The sample period is from January 1996 to April 2006.

Explanatory Variables	Forward-looking period (*L*)											
	L = 1 month		*L* = 2 months		*L* = 3 months		*L* = 4 months		*L* = 5 months		*L* = 6 months	
Intercept	-0.01	(-0.25)	-0.01	(-0.10)	0.00	(-0.10)	0.01	(0.28)	0.01	(0.40)	0.02	(0.47)
TB	0.01	(0.02)	-0.04	(-0.07)	0.06	(0.12)	0.11	(0.24)	0.16	(0.36)	0.08	(0.18)
TERM	0.40	(0.51)	0.36	(0.49)	0.47	(0.65)	0.61	(0.83)	0.72	(0.97)	0.61	(0.80)
DEF	-1.02	(-0.38)	-0.58	(-0.22)	-1.04	(-0.41)	-2.70	(-1.08)	-3.56	(-1.41)	-3.52	(-1.38)
DIV	-2.73	(-0.26)	-12.17	(-0.88)	-14.10	(-0.86)	-21.59	(-1.29)	-21.92	(-1.24)	-20.07	(-1.07)
CONSUME	-0.25	(-0.10)	-3.59	(-1.10)	-0.80	(-0.19)	3.17	(0.62)	3.15	(0.52)	-0.82	(-0.12)
GDP	1.00	(1.03)	1.49	(1.37)	1.37	(1.10)	1.85	(1.27)	2.14	(1.27)	2.56	(1.36)
LABOR	1.29	(1.77)	1.55	(1.92)	1.33	(1.48)	0.59	(0.59)	0.30	(0.26)	0.42	(0.33)
Adj R^2	0.088		0.023		0.009		0.019		0.022		0.024	