An Examination of *Ex Ante* Risk and Return in the Cross-Section Using Option-Implied Information⋆

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This paper examines cross-sectional relations between *ex ante* expected returns and betas. As a proxy for ex ante expected returns, we use implied returns obtained from the risk-adjusted option pricing model suggested in this paper. We find that implied returns have a positive and significant cross-sectional relation with implied betas in all maturity groups considered. This significant relation is maintained regardless of the inclusion of the well-known CAPM-anomaly variables such as firm size, book-to-market, past returns, and earnings-to-price ratio. Ex ante market risk premium estimates have a statistical significance as well as an economic significance in that they contain significant forward-looking information on future macroeconomic conditions. We also find that implied betas have a significant negative cross-sectional relation with ex post realized returns measured over the option life. This negative relation is consistent with the volatility feedback effect. We thus argue that implied market betas are priced in ex ante basis.

JEL classification: G12, G13, G14

Keywords: Option-implied return and risk; Black-Scholes option pricing model; Risk-adjusted option pricing; Cross-section of expected returns; Forward-looking macroeconomic information

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Abstract

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1. 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, and various areas. Indeed, 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 future expected returns and betas 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 a finite sample. 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 premia. 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 variables, such as constant dividend growth. Furthermore, most models use indirect measures for expected stock returns. For example, the Brav, Lehavy, and Michaely

[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.

(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 is that for many firms bond 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, and expected returns implied from option prices should 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 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

[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

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. Further, our model reduces to the Black-Scholes model when their assumptions are imposed.

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 static CAPM relation on an ex ante basis. While more complex versions of the CAPM may include quite a number of parameters, in the standard CAPM that we study in this paper, two ex ante parameters are needed in this test: expected return and market beta. In order to obtain these two parameters, we must derive a risk-adjusted option pricing model based on the Black-Scholes model. We limit our scope to investigate the traditional static relation between ex ante mean return and risk as the standard CAPM implies. We therefore use the Black-Scholes model that contains these ex ante parameters and that is consistent with the standard static CAPM, rather than using models containing other random factors such as stochastic volatility (those similar to the Heston (1993) model).

In fact, the use of the Black-Scholes model is a compromise between sacrifice of completeness and practical implementability. It is well-known in the literature that the Heston (1993) stochastic volatility model is more complete than the Black-Scholes model in that it better captures a dynamic behavior of volatility in stock price. Nevertheless, practical difficulties arise when implementing the Heston model to estimate implied return and volatility. When using the risk-adjusted Heston model, there are four

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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).

parameters plus implied return and volatility to be estimated. For a given trade date, at least six call option prices with the same time-to-maturity but different strike prices are thus needed to estimate these six unknowns for each individual stock. For a given trade date, however, only a few number of stocks actually have a sufficient number of available option prices to estimate these six unknown.[4] This small number of stocks is not sufficient to perform full-scale cross-sectional regression tests on the relation between ex ante return and risk. Due to this difficulty, we use the Black-Scholes model rather than the Heston stochastic volatility model in estimating implied return and volatility.

Our model to obtain the expected return and market beta follows a two-step process. First, at the 3rd Friday 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 based on the risk-adjusted option model. We regard these option-implied returns (or simply, implied returns) as a proxy for ex ante expected returns. At the same time, we also observe the prices of a market index option such as Standard & Poor's 500 index option whose maturity is matched with that of the stock option. Then we compute implied market returns from the observed market index options based on the risk-adjusted option model. Thus, each implied return of a stock has its counterpart implied market return.

Second, 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.[5] 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 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. Christoffersen, Jacob, and Vainberg (2006) show that implied betas can be extracted from option prices without using this new derivative. Implied betas in their model are computed using forward-

[4] We have attempted to use the risk-adjusted Heton (1993) model to estimate the 4 parameters and implied return and volatility. For a given trade date, the average number of stocks that have valid estimates of implied return and volatility is only 110 for all maturities. Meanwhile, when the risk-adjusted Black-Scholes model is used, 1,230 stocks, on average, have valid estimates of implied return and volatility for a given trade date.

[5] Camara, Chung, and Wang (2009) estimate the cost of equity capital implied by option prices from an option pricing model in which the expected return of the underlying asset is a tractable parameter.

looking variances and the skewnesses of the stock and the market. However, 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. Several authors attempt to obtain implied betas by multiplying the ratio of stock-to-market implied volatilities by a proxy for the expected future stock-to-market correlation. As such a proxy for the correlation, French, Groth, and Kolari (1983) use the historical correlation coefficient, Chang, Christoffersen, Jacobs, and Vainberg (2012) use a function of the stock-to-market implied skewness ratio, and Buss and Vilkov (2012) suggest an explicit parametric form of the implied correlation. In fact, French, Groth, and Kolari's betas are not pure forward-looking implied betas. Chang et al. (2012) assume that idiosyncratic skewness is zero, which is not empirically supported.[6] Buss and Vilkov (2012) put some restrictions to identify the implied correlations under the risk-neutral probability measure. Without depending on any assumptions and restrictions, as in the standard approach, we estimate forward-looking implied betas simply by regressing implied returns of the underlying stock on implied market returns.

We obtain option-implied monthly returns for a total of 5,835 stocks over the period January 1996 through December 2014. 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.[7] In month-by-month cross-sectional regressions (CSR) of ex ante implied returns on implied betas, we find that there is a significantly positive relation between these two ex ante variables in any maturity group. Even though firm characteristics such as firm size, book-to-market, past returns, and earnings-to-price ratio are included in the model, this positively significant relation is strongly maintained. This supports that market beta is priced on an

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[6] Ang, Hodrick, Xing, and Zhang (2006), Boyer, Mitton, and Vorkink (2010) and Conrad, Dittmar, and Ghysels (2013) find that expected idiosyncratic skewness and returns are negatively correlated. Buss and Vilkov (2012) find that implied beta estimates by Chang et al. (2012) have a flat relationship with future stock returns. Chen, Chung, and Tsai (2016) suggest an improved version of Chang et al.'s implied betas by controlling for the effect of idiosyncratic skewness.

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

ex ante basis. However, since the intercept estimates are also significant, these results indicate that market beta may not be a unique ex ante risk measure. To our knowledge, this paper is the first one that considers the term structure of expected returns in examining the ex ante risk-return relationship.

We also examine the relation between ex ante implied betas and ex post realized returns measured over the option life and find that implied betas are significantly negatively related with realized returns in the cross-section. That is, a stock with large (small) forward-looking risk earns low (high) realized return afterwards. As investors anticipate more risk for the coming period and if risk priced, they would require more risk premium and higher ex ante expected return. This drives stock price down and so does the return for the period. This phenomenon is often referred to as the ‘volatility feedback effect’ [French, Schwert and Stambaugh (1987), Campbell and Hentschel (1992), Bekaert and Wu (2000), Wu (2001)]. Since implied betas represent forward-looking anticipated risk level, this significant negative relation is evidence that implied betas are also priced in ex post basis. The volatility feedback effect is also found intertemporally.

To further investigate whether our CSR estimate of ex ante market risk premium has economic significance in addition to statistical significance, we examine whether our ex ante market risk premium estimates contain forward-looking information on macroeconomic conditions. To do so, we regress the CSR ex ante market risk premium estimates on the future values of macroeconomic variables. The regression coefficient estimates on the macroeconomic variables are statistically significant in most cases. Specifically, the CSR ex ante risk premium estimates have a significant positive relation with Treasury yield, default premium, and term premium, while they have a significant negative relation with dividend yield, GDP, consumption growth rate, and labor income growth rate. The firmer three macroeconomic variables are related with discount rate for future cash flows, while the latter four macroeconomic variables are related with future cash flows. These results indicate that high ex ante risk premium is related with high discount rates and low future cash flows and results in low realized returns. A negative relation between ex ante risk premium and realized returns is thus induced. These results are consistent with the previously-mentioned volatility feedback effect. In sum, the CSR estimates of the ex ante market risk premium contain information about future economic conditions. When implied market returns (from Standard & Poors 500 Index options) are used instead of the CSR ex ante market risk premium estimates, we also obtain overall 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 information on future macroeconomic conditions.

This paper is organized as follows. Section 2 describes the risk-adjusted option pricing model to extract implied return and volatility, Section 3 describes the data, and Section 4 explains the computational details for the implied variables. Section 5 presents empirical results, and Section 6 sets forth our conclusion.

2. A Model to Extract Information on *Ex Ante* Expected Return and Volatility

As mentioned in the previous section, in order to test the CAPM on a true ex ante basis, we need an option pricing model that contains information of forward-looking expected return and risk and at the time when the CAPM is tested. While the seminal Black-Scholes model is consistent with the standard CAPM [see page 645 in Black and Scholes (1973)], it is well-known that the Black-Scholes model contains only the volatility of the stock. As a result, we must derive an option pricing model that contains the parameters desired and is also consistent with the Black-Scholes model and the standard CAPM.

Black and Scholes (1973) first show that if continuous rebalancing is possible then the expected return will be replaced by the risk-free rate as continuous rebalancing effectively removes any risk in option prices (known as no arbitrage trading). Furthermore, they demonstrate that their model is consistent with the CAPM over the infinitesimal time period. In this paper, under the physical measure, we derive an option pricing model containing information about ex ante expected return and risk where there is no rebalancing before maturity and the return period is not infinitesimal.[8] We shall note that our option pricing model is consistent with the standard CAPM. In testing the

[8] Note that if either assumption holds (i.e., continuous rebalancing is permitted, or the return period is infinitesimal), our option pricing model reduces to the Black-Scholes model.

standard CAPM which is a static one-period model, it is consistent to use ex ante return and risk parameters extracted from an option pricing model that accommodates constant return and volatility.

The classical microeconomic valuation theory states that any price today must be a properly discounted future payoff. For a call option,

$$C_t = E_t\left[M_{t,T}\, C_T\right], \tag{1}$$

where $E_t[\cdot]$ is the expectation taken under the physical measure taken at time t, $M_{t,T}$ is the pricing kernel, also known as the marginal rate of substitution, between time t and time T, and C_T is the payoff at maturity T from a call option. Continuous rebalancing, which constitutes a dynamically complete market, guarantees the existence of the risk neutral pricing measure where the risk premium is removed from the expectation and hence the discount rate is the risk-free rate as follows:[9]

$$\begin{aligned} C_t &= E_t\left[M_{t,T}\, C_T\right] = E_t\left[M_{t,T}\right] \hat{E}_t[C_T] \\ &= e^{-r_f(T-t)}\, \hat{E}_t[C_T], \end{aligned} \tag{2}$$

where r_f is the risk-free rate and $\hat{E}_t[\cdot]$ is the expectation under the risk neutral measure. [10,11] Or alternatively, one can find a more familiar pricing measure where the expected payoff is discounted at a properly risk-adjusted discount rate as follows:

$$\begin{aligned} C_t &= E_t\left[M_{t,T}\, C_T\right] = E_t^C\left[M_{t,T}\right] E_t[C_T] \\ &= e^{-\mu_C(T-t)} E_t[C_T]\,, \end{aligned} \tag{3}$$

where C represents the measure where the option price serves as a numeraire, and μ_C is the annualized expected instantaneous return on this option in the physical measure. We then assume that the C-measure expectation of the pricing kernel takes a form of continuous discounting.[12]

Assuming stock price S follows a geometric Brownian motion with an expected instantaneous return of μ_s and volatility of σ_s, under the physical measure, we derive the risk-adjusted price of the call option, C_t, over the discrete time period from t to T. Under

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[9] See Duffie and Hwang (1985) for this result.

[10] This result assumes constant interest rate.

[11] Note that the last line of the equation is a classical result of economic valuation.

[12] Similarly, if the stock price is used as the numeraire, then $S_t = e^{-\mu_s(T-t)} E_t[S_T]$.

the physical measure, it is given by

$$
\begin{aligned}
C_t &= e^{-\mu_c(T-t)}\, E_t[\max\{S_T - K, 0\}] \\
&= e^{-\mu_c(T-t)} \left[\int_K^{\infty} S_T\, \phi(S_T)\, dS_T \;-\; K \int_K^{\infty} \phi(S_T)\, dS_T \right] \\
&= e^{(\mu_s-\mu_c)(T-t)}\, S_t N(h_1) - e^{-\mu_c(T-t)}\, K\, N(h_2), \qquad (4)
\end{aligned}
$$

where

$$\mu_c \;=\; r_f + \beta_{cs}(\mu_s - r_f) \qquad (5)$$

$$
\begin{aligned}
\beta_{cs} &= \frac{\mathrm{Cov}(C_T/C_t,\;\; S_T/S_t,)}{\mathrm{Var}(S_T/S_t)} \;=\; \left(\frac{S_t}{C_t}\right) \frac{\mathrm{Cov}(C_T, S_T)}{\mathrm{Var}(S_T)} \\
&= \left(\frac{S_t}{C_t}\right) \left\{ \frac{e^{\sigma_s^2(T-t)}\, N(h_3) - (K/S_t) e^{-\mu_s(T-t)} [N(h_1) - N(h_2)] - N(h_1)}{e^{\sigma_s^2(T-t)} - 1} \right\} \qquad (6)
\end{aligned}
$$

$$h_1 = \frac{\ln S_t - \ln K + (\mu_s + \sigma_s^2/2)(T-t)}{\sigma_s \sqrt{T-t}} \qquad (7)$$

$$h_2 = \frac{\ln S_t - \ln K + (\mu_s - \sigma_s^2/2)(T-t)}{\sigma_s \sqrt{T-t}} \qquad (8)$$

$$h_3 \;=\; \frac{\ln S_t - \ln K + (\mu_s + 3\sigma_s^2/2)(T-t)}{\sigma_s \sqrt{T-t}}. \qquad (9)$$

Equation (5) holds for a small interval of time Δt, which is proved by Black and Scholes (1973).[13] When the time interval is not infinitesimally small, equation (5) can only hold under quadratic utility, which is what we assume in this paper. The derivation of equation (6) is given in the Appendix.

Equations (4) through (9) provide a risk-adjusted option pricing model as a function of the known variables S_t, K, r_f, 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 time-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 time-to-maturity.[14] Through this approach, for each stock, we obtain different μ_s and σ_s pairs for different time-to-

[13] See their equations (15) through (17).

[14] 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).

maturity. Similarly, we can estimate the market expected return (μ_m) and market volatility (σ_m) using Standard & Poor's 500 Index call options.

As a result, μ_s and σ_s are option-based implied return and volatility. Since the implied return here indicates investors' forward-looking expected return of the underlying stock over the period from the current time, t, to the maturity date, T, it must represent the ex ante expected return of the stock. Hereafter, we change the notations μ_s to $\mu_{[t,T]}$ and σ_s to $\sigma_{[t,T]}$. We obtain different implied returns and volatilities for different maturities at any given trade date, t. This is consistent with investor expectations of return and volatility, which could differ according to their investment horizon.

3. 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 3rd Friday of each month for the period from January 1996 to December 2014. 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 Standard & Poors 500 Index options.

For the corresponding stocks whose option data are available, we obtain daily and monthly stock prices and returns from the CRSP. A total of 5,835 stocks are found to have both option and stock price data. We also obtain information of firm characteristics, such as firm size, book-to-market ratio, and earnings-to-price ratio, 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 according to the maturity of the option. Assuming a step-function of interest rates, we match the time-to-maturity in the option record with its corresponding constant maturity rate. For example, if the time-to-maturity of the option is less than or equal to 3 months, we use 3-month rates, and if the time-to-maturity is between 3 months and 6 months, we use the 6-month rate, and so on.

4. Computation of Implied Returns, Volatilities, and Betas

We jointly estimate the implied mean return and implied volatility of an underlying stock, μ_s and σ_s (or $\mu_{[t,T]}$ and $\sigma_{[t,T]}$), by using the risk-adjusted option pricing model through equations (4) and (6). At a given trade date t (i.e., the third Friday of each month), we obtain the market prices of only near-the-money call options with same maturity date (T) but different strike prices. We thus need at least two call option prices with the same time-to-maturity but different strike prices to compute the two unknowns μ_s and σ_s for each individual stock. We use all options whose moneyness (S_t/K) falls between 0.9 and 1.3. By using these options, we can compute the implied return and implied volatility via a method of grid search to look for a global optimum that minimizes the sum of squared errors. The error is defined as the difference between the observed option price and the right hand side of equation (1) 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 150.00 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 in- and out-of-money options.[15] Options with zero trading volume are excluded. Put options are not used only because our models are designed for call options.

Options traded on the CBOE are American-style options that need to be priced with a numerical method. Luckily the option dataset contains the implied volatility computed properly adjusted for American option premium and any stock dividends during the life of the option.[16] Using this information along with interest rates, we compute the Black-Scholes European option prices. These European option prices can be regarded as the theoretical counterpart of the American option prices traded in the market.

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[15] 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.

[16] It is our understanding that OptionMetrics adopts the binomial model for the calculation of the implied volatility.

In other words, these European prices are the "what-if" prices if they would be European. We use our model to compute the implied mean return and implied volatility of an underlying stock.[17] Our results are based on the 3rd Friday 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, third Thursday, and last working day of each month. The results are qualitatively similar.

Since one pair of the estimated implied return and volatility are 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 a term structure of implied returns and a term structure of implied volatilities of a stock at a given date. Similarly, at a given trade date, we also obtain two similar term structures for Standard & Poors 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 time-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 time-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 time-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 betas like the implied mean return. Instead, we estimate implied betas of an underlying stock by regressing implied returns of the stock

[17] We use the closing bid/ask mid-point as the closing American option price. If the computed European option price is higher than the American option price, we take the American option price as the option price. Otherwise, we take the European price as the option price.

on implied market returns with the same maturity. We use three different implied beta estimates. The first one is the whole-period implied beta using all implied returns in each maturity group, and the second one is the rolling-over implied beta using past 36 monthly implied returns with all maturities available up to month t-1. The third one is the monthly implied beta for month t using (weekly-measured) implied returns with all maturities measured at every Friday in month t.[18] Unlike the whole-period beta and the rolling-over beta, this monthly implied beta uses non-overlapped implied returns. Note that the rolling-over beta is predictive which relies on prior implied information, while the monthly beta is contemporaneous which relies on current implied information.[19]

5. Empirical Results

5.1. Basic Statistics of the Implied Variables

Table 1 presents the basic statistics of the implied returns ($\mu_{[t,T]}$), implied volatilities ($\sigma_{[t,T]}$), and implied whole-period betas ($\beta_{[t,T]}^{\text{imp}}$), which are obtained from all 5,835 firms' individual stock call options over the period from January 1996 to December 2014. The total number of firm-maturity observations is 353,327. Days to maturity of the sample ranges from 5 days to 1,065 days. We divide the whole sample into seven subgroups according to the maturity; less than or equal to 1 month, between 1 month and 2 months, between 2 months and 3 months, between 3 months and 4 months, between 4 month and 6 months, between 6 month and 9 months, and longer than 9 months. For convenience, we call these maturities as 1 month, 2 months, 3 months, 4 months, 6 months, 9 months,

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[18] The third implied beta can also be estimated in each month using daily-measured implied returns for the month. However, this beta estimation accompanies a big computational burden. As a robustness check, we have examined how two monthly implied betas obtained from using daily- and weekly-measured implied returns are close. For a short period from January 2014 to March 2014, we compute daily-measured and weekly-measured implied returns for all individual stocks and estimate their two monthly implied betas. We find a high cross-sectional correlation coefficient between these two implied betas; it is 0.83. Because of computational burden and effectiveness of the monthly implied betas using weekly-measured implied returns, we decide to use weekly-measured implied returns to estimate monthly implied betas in this study.

[19] We have also estimated monthly implied betas for month t using weekly-measured implied returns measured at prior month t-1. The overall results of using these predictive monthly betas are qualitatively similar to those of using the contemporaneous monthly betas.

and longer than 9 months, respectively. As seen in Table 1, the number of firm-maturity sample tends to be greater for short-term options than for long-term options. This is because the near-the-money options of most of the stocks are actively traded on short maturities.

Table 1 shows that the implied return decreases with maturity; that is, the term structure of implied returns is apparently downward sloped. Specifically, when the maturities are up to 1 month, 2 months, 3 months, 4 months, 6 months, 9 months, and longer than 9 months, the average implied (annual) returns are 0.440, 0.288 0.233, 0.208, 0.177, 0.149, and 0.111, respectively. The overall average of the implied returns is 0.290. 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. Our findings 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.[20]

Implied volatility also shows a very mild downward sloping term structure. This is different from the result in the literature that shows a steep downward sloping term structure of volatilities under the Black-Scholes model. In other words, our model helps explain the volatility term structure puzzle to a certain extent. The average implied standard deviations are 0.524, 0.488, 0.479, 0.485, 0.469, 0.442, and 0.419 over the seven

[20] Camara, Chung, and Wang (2007) also show similar results that short-term expected returns are hig her than long-term expected returns when using market-observed option prices. However, there are at least two differences between our approach and theirs. First, they assume a specific utility structure such that the marginal utility of wealth of the representative investor is: $U'(W_T) = W_T^{\alpha} + \beta$, where α and β are risk preference parameters. 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 han d, our model does not need information about other companies to compute the expected return and vol atility. Our model jointly computes implied volatility using all stock options and S&P 500 Index optio ns.

maturity groups, respectively. The overall average of the implied standard deviations is 0.489. Implied betas also show a downward sloping term structure like implied returns.

Table 1 also reports the correlation coefficients between the implied variables and their historical counterparts. The correlation coefficient between implied returns ($\mu_{[t,T]}$) and realized historical returns ($\bar{R}_{[t,T]}$) (annualized continuously compounded returns) over the option life is negative. It is -0.045 using all maturities. These correlation coefficients over the seven maturity groups are -0.044, -0.072, -0.104, -0.114, -0.113, -0.132, and -0.127, respectively. As the maturity becomes longer, the correlation coefficient tends to be more negative. The reason of the negative correlation is as follows. As investors anticipate more risk for the coming period, say the period from today t to the maturity T, they would require more risk premium and higher expected return. This drives stock price down and return of the stock is smaller for the period. As the period is longer, the discount is more severe and then stock price is driven more down. Implied returns observed at time t represent forward-looking expected return for the period from today t to the maturity T. Therefore, the observed negative correlation coefficients between implied returns and realized returns in Table 1 are intuitively sound. Meanwhile, the correlation coefficient between implied volatilities and historical realized volatilities is positive. It tends to decrease with the maturity.

Table 2 presents the basic statistics of the implied returns and volatilities of the market index option, Standard & Poors 500 Index call option. The number of firm-maturity 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 0.166 and 0.206, 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 Standard &Poors 500 Index option is almost flat.

5.2. Cross-Sectional Regression Tests of *Ex Ante* Implied Returns on 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 Fama and MacBeth (1973) methodology. In order to do this, we estimate the following cross-section regression (CSR) model at month t,

$$\mu_{i,[t,T]} - r_{f,[t,T]} = \gamma_{0t} + \gamma_{1t}\hat{\beta}^{\text{imp}}_{i,[t,T]} + \gamma_{2t}(\text{Control variables})_{t-1} + \varepsilon_{it}, \tag{3}$$

where $\mu_{i,[t,T]}$ is the implied (annualized) return on underlying stock i over the option life ($[t,T]$) from the 3rd Friday of month t to maturity T, $r_{f,[t,T]}$ is the Treasury bill continuously compounded (annualized) yield over the period $[t,T]$, $\hat{\beta}^{\text{imp}}_{i,[t,T]}$ is the implied beta of stock i estimated using implied returns, and 'Control variables' are idiosyncratic firm characteristic variables such as firm size, book-to-market, earnings-to-price (EP) ratio, and past returns which are observed prior to month t. The control variables used in the CSR tests of equation (3) are the natural logarithm of the market value (in $million) of common equity measured one month before month t, the natural logarithm of book-to-market (BM) ratio and the EP ratio, which are most recently available six months before the CSR estimation month t, and the past six-month return from month t-7 to month t-2. Note that the two financial ratios, BM and EP, are winsorized at the upper 99% in the pooled sample. These firm characteristics are chosen as control variables since they are widely known market anomalies that the CAPM fails to explain. Since the implied return and implied beta represent forward-looking expected return and risk over the same period ($[t,T]$), equation (3) examines a contemporaneous relation between these two variables in the cross-section.

Table 3 shows time-series averages of the Fama and MacBeth (1973) month-by-month CSR coefficient estimates when the whole-period beta (Panel A), the rolling-over beta (Panel B), and the monthly beta (Panel C) are used as the beta variable in equation (3), respectively. The estimate period is from January 1996 to December 2014. When the beta variable is alone in the model, the ex ante risk premium estimates ($\bar{\bar{\gamma}}_1$) are strongly positively significant in any maturity group. Using the whole sample with all maturities, the ex ante risk premium estimates are 5.75 percent (t-statistic of 14.52), 3.36 percent (t-statistic of 22.32), and 4.02 percent (t-statistic of 15.27), respectively, for the use of the whole-period implied beta, the rolling-over implied beta, and the monthly implied beta. The average sample size (i.e., number of options) in the CSR is 1,517. Note that all t-statistics of the CSR coefficient estimates are adjusted by Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors with lag of 4.[21]

When the whole-period implied beta variable is used, the ex ante risk premium estimates in the seven maturity groups are 10.00 percent (t-statistic of 16.46), 5.20 percent (t-statistic of 10.73), 3.63 percent (t-statistic of 10.75), 3.81 percent (t-statistic of 12.00), 2.84 percent (t-statistic of 13.83), 2.67 percent (t-statistic of 9.68), and 2.35 percent (t-statistic of 8.30), respectively. The ex ante risk premium estimate decreases with maturity. That is, the term structure of the risk premium estimates is downward sloping as in the implied returns. We obtain similar results when using the predictive rolling-over implied beta. The intercept estimates are strongly positive in all cases, which means that implied returns may not be fully explained by implied betas. The large positive intercept estimates may be from an excessively large value of the implied returns.

Even when all the control variables (firm size, book-to-market, past returns, and EP ratio) are included in the model, the significance of the ex ante risk premium estimates is still maintained. For example, when the whole-period implied beta variable and all the control variables are included in the model, the ex ante risk premium estimates in the seven maturity groups are 7.54 percent (t-statistic of 10.40), 3.74 percent (t-statistic of 7.51), 2.60 percent (t-statistic of 7.59), 2.54 percent (t-statistic of 7.98), 2.28 percent (t-statistic of 8.14), 2.17 percent (t-statistic of 9.68), and 2.08 percent (t-statistic of 7.09), respectively. When the other implied betas are used, the estimation results are similar. Although the intercept estimates are also strongly positive in all cases regardless of the inclusion of the idiosyncratic variables, it is apparent that market betas have a

[21] Stock and Watson (2015, page 605) suggest a guideline for choosing the number of lags in adjustment for HAC standard errors. Their suggestion is $m = 0.75\, T^{1/3}$, where T is the time-series sample size. There are 228 monthly CSR estimates in our study.

strong positive relation with expected returns on an ex ante basis. In other words, market betas are significantly priced on an ex ante basis.

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 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 also 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 estimates on the EP ratio are all negative and statistically significant as on the BM variable. This implies that investors have high (low) ex ante expected returns on low (high) EP ratio stocks. These results on book-to-market and EP ratio are contrasted with the results using ex post realized returns in which the CSR coefficients on the both variables are positive. The CSR coefficient estimate on the momentum variable (past six-month return) is all positive but almost insignificant. This implies that investors may not form *a priori* their expectation based on past stock performance. These ex ante results on momentum are also contrasted with the results using realized returns in which the presence of momentum is strongly positively significant.[22]

As a robustness check, we use implied betas from Buss and Vilkov (2012) to examine the ex ante risk–return relationship. To identify the implied betas, the Buss and Vilkov (2012) method requires one restriction that equates the observed implied variance of the market index with the calculated implied variance of a portfolio of all market index constituents. Thus, the Buss and Vilkov method uses only the constituent stocks of the Standard & Poors 500 Index in the CSR estimation. Note that our approach uses all individual stocks as far as their options are traded. The results using the Buss and Vilkov

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

implied beta, reported in Panel D of Table 3, are similar to those obtained from using our implied betas. That is, there is a strong positive relation between implied returns and implied betas, and the risk premium estimate decreases with maturity.

5.3. Cross-Sectional Regression Tests of *Realized* Returns on Implied Betas

In order to examine whether implied betas are priced in ex post basis, we also cross-sectionally regress ex post realized returns on implied betas. The CSR model to be estimated at month *t* is

$$R_{i,[t,T]} - r_{f,[t,T]} = \gamma_{0t} + \gamma_{1t}\hat{\beta}^{\text{imp}}_{i,[t,T]} + \gamma_{2t}(\text{Control variables})_{\text{t}-1} + \varepsilon_{it}, \qquad (4)$$

where $R_{i,[t,T]}$ is the realized (annualized) continuously compounded return of an underlying stock i over the option life ($[t, T]$) from the 3rd Friday of month t to maturity T, and $r_{f,[t,T]}$ is Treasury bill (annualized) continuously compounded yield over the same period $[t, T]$. The same idiosyncratic firm characteristic variables used in equation (3) are used as control variables. Since the implied beta represents forward-looking risk over the same period that realized returns are measured, equation (4) also examines a contemporaneous relation between ex ante implied risk and realized return in the cross-section.

Table 4 presents time series averages of the month-by-month CSR coefficients ($\bar{\bar{\gamma}}$) of equation (4) over the period from January 1996 to December 2014 when the whole-period beta (Panel A), the rolling-over beta (Panel B), and the monthly beta (Panel C) are used as the beta variable in equation (4), respectively. The estimated coefficient on the implied beta variable, $\bar{\bar{\gamma}}_1$, is significantly negative in all cases. Specifically, when the whole-period implied beta is alone in the model, $\bar{\bar{\gamma}}_1$ is -5.29 percent (t-statistic of -3.27) using all maturities. For the seven maturity groups, they are -5.27 percent (t-statistic of $-$2.84), -6.46 percent (t-statistic of -2.95), -5.43 percent (t-statistic of -2.43), -5.56 percent (t-statistic of -2.88), -6.40 percent (t-statistic of -2.85), -7.72 percent (t-statistic of -2.83), and -6.09 percent (t-statistic of -2.45), respectively. Unlike the previous case where implied returns are used instead of realized returns, there seems no pattern in the estimated CSR coefficient across maturity. When the firm characteristic variables are included in the model, the CSR coefficients on the implied beta variable are still negative and statistically significant using all maturities but insignificant in some maturity group. When the other predictive implied beta variable are used, we obtain similar results.[23]

The above results indicate that implied betas, which are forward-looking risk measures over the period $[t, T]$, have a negative relation with realized returns measured over the period. That is, a stock with high (low) implied beta earns low (high) subsequent realized return. As investors anticipate more risk for the coming period and if risk priced, they would require more risk premium and higher ex ante expected return. This drives stock price down and so does the return for the period. This phenomenon is often referred to as the 'volatility feedback effect' (e.g., French, Schwert and Stambaugh, 1987; Campbell and Hentschel, 1992; Bekaert and Wu, 2000; and Wu, 2001). Since implied betas represent forward-looking anticipated risk level, this significant negative relation is evidence that implied betas are also priced in ex post basis.

To further examine this volatility feedback effect in the cross-section, we also cross-sectionally regress realized returns over the option life $[t, T]$ on implied standard deviations:

$$R_{i,[t,T]} - r_{f,[t,T]} = \gamma_{0t} + \gamma_{1t}\ \sigma_{i,[t,T]} + \varepsilon_{it}, \tag{5}$$

where $\sigma_{i,[t,T]}$ is the implied standard deviation of underlying stock i over the option life ($[t, T]$). Table 5 shows that the time-series averages$(\bar{\gamma}_1)$ of the month-by-month CSR coefficient estimates on the implied volatility variable are significantly negative in all maturity groups. When the firm characteristic variables are included in the model, this negative significance is maintained (not reported). Since the implied standard deviation represents forward-looking anticipated total risk level over the period $[t, T]$, these results also show the volatility feedback effect. Table 5 also represents the CSR estimation results when implied returns, $\mu_{i,[t,T]}$, are used to explain realized returns as follows:

$$R_{i,[t,T]} - r_{f,[t,T]} = \gamma_{0t} + \gamma_{1t}\ \mu_{i,[t,T]} + \varepsilon_{it}. \tag{6}$$

[23] When the Buss and Vilkov (2012) implied beta is used, the estimated coefficient ($\bar{\gamma}_1$) is negative and statistically significant only for the cases of using all maturities and one month maturity. The results are available upon request.

As in the case of the implied standard deviation, the time-series averages of the month-by-month CSR estimates of γ_{1t} are significantly negative in all maturity groups. Based on the results from Table 3 that implied returns are significantly positively related with implied betas, implied returns can be a proxy for forward-looking risk. Thus, the results for implied returns in Table 5 are consistent with the volatility feedback effect. Overall, the results in Tables 4 and 5 indicate that implied risk is priced in ex post basis.

5.4. Intertemporal Predictability of Implied Variables for Realized Returns and Volatilities

Since implied variables contain forward-looking information for the coming period, it would be interesting to examine the intertemporal predictability of implied returns and volatilities for realized returns and volatilities. To do this, we first estimate the following time-series regressions of realized returns measured over the option life $[t,\ T]$ on implied returns or implied standard deviation for each underlying stock in each maturity group.

$$R_{[t,T]} = a_0 + a_1\, \mu_{[t,T]} + \varepsilon_t, \tag{7a}$$

and

$$R_{[t,T]} = b_0 + b_1\, \sigma_{[t,T]} + \varepsilon_t. \tag{7b}$$

Panels A and B of Table 6 present the distribution (averages, medians, and several percentile points) of the slope coefficient estimates on the implied mean and standard deviation variables, $\hat{a}_1$ and $\hat{b}_1$, of equations (7a) and (7b), respectively, for all stocks in each maturity group. The averages of $\hat{a}_1$ in the seven maturity groups are all negatively significant. They are -0.35 (t-statistic of -6.44), -0.63 (t-statistic of -7.35), -1.14 (t-statistic of -11.69), -1.37 (t-statistic of -12.22), -1.23 (t-statistic of -9.54), -1.19 (t-statistic of -6.21), and -1.39 (t-statistic of -6.68), respectively. The averages of $\hat{b}_1$ are more negatively significant. Their magnitude and statistical significance are greater than those of $\hat{a}_1$. These results indicate that forward-looking implied risk tends to be negatively related with realized returns over time. That is, high risk anticipated over the period drives stock price down and so the return decreases. This is consistent with the volatility feedback effect. To confirm the volatility feedback effect using all realized data, we also regress realized returns on historical realized volatility:

$$R_{[t,T]} = c_0 + c_1\, s_{[t,T]} + \varepsilon_t, \qquad (7c)$$

where $s_{[t,T]}$ is the historical standard deviation computed by using continuously compounded daily returns over the option life $[t,\ T]$. Consistent with the volatility feedback effect hypothesis, most of the slope coefficient estimates, $\hat{c}_1$, are significantly negative (reported in Panel C of Table 6).

To examine how the implied return and volatility are related with historical realized volatility, we also estimate the following time-series regressions for each underlying stock in each maturity group.

$$s_{[t,T]} = d_0 + d_1\, \mu_{[t,T]} + \varepsilon_t, \qquad (7d)$$

and

$$s_{[t,T]} = e_0 + e_1 \sigma_{[t,T]} + \varepsilon_t. \qquad (7e)$$

Panels C and D of Table 6 present the distribution of the slope coefficient estimates, $\hat{d}_1$ and $\hat{e}_1$, of equations (7d) and (7e), respectively, for all stocks in each maturity group. The averages of both slope coefficient estimates are all positively significant in all maturity groups. Moreover, the percentages of positive $\hat{d}_1$ and $\hat{e}_1$ among all slope coefficient estimates are about 80 percent and more than 90 percent, respectively. These results suggest that these implied variables contain forward-looking information about risk to be realized. In particular, the positive estimate of d_1 indicates that implied returns contain forward-looking information more about risk rather than about return. This is consistent with the results of equation (7a). If implied returns contain forward-looking information more about return, it would be expected to have negative estimate of d_1 because of the leverage effect.[24]

5.5. Do *Ex Ante* Market Risk Premia Estimates Contain Forward-Looking Information on Macroeconomic Conditions?

[24] A decrease in stock price (negative return) induces high financial leverage. This makes the stock riskier and increases its volatility. Thus, return and volatility show a negative relation [see Black (1976), Christie (1982), Engle and Ng (1993), Bates (1997), Bakshi, Cao, and Chen (1997) among others].

Based on the statistical significance of the ex ante market risk premium estimates in equation (3), we have argued that market betas are priced on an ex ante basis. To further investigate the pricing ability of market betas on an ex ante basis, we examine their economic significance in addition to their statistical significance. Investors' ex ante expected returns reflect their forward-looking expectation for individual stocks and the market as a whole. To test whether our CSR estimate of ex ante market risk premium (presented in Table 3) has economic significance, we examine whether the ex ante market risk premium estimates contain forward-looking information on macroeconomic conditions. To do so, we regress ex ante market risk premia estimates on future macroeconomic variables. That is, we estimate the following time-series regression model:

$$\hat{\gamma}_{1t} = b_0 + b_1\mathrm{TB}_{t+1,t+L} + b_2\mathrm{TERM}_{t+1,t+L} + b_3\mathrm{DEF}_{t+1,t+L} + b_4\mathrm{DIV}_{t+1,t+L} + b_5\mathrm{CONSUME}_{t+1,t+L} + b_6\mathrm{GDP}_{t+1,t+L} + b_7\mathrm{LABOR}_{t+1,t+L} + \varepsilon_t, \quad (8)$$

where $\hat{\gamma}_{1t}$ is the coefficient estimates of the CSR at month t of the whole-period implied betas on implied returns in equation (3) (the implied beta variable alone in the model), $\mathrm{TB}_{t+1,t+L}$ 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.[25] The value of each macroeconomic variable is its geometric average (i.e., compounded value) over L forward-looking months from $t+1$ to $t+L$.[26]

[25] 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).
[26] 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.

Table 7 presents the estimation results of equation (8) that regresses the ex ante market risk premium estimates in each maturity group on future macroeconomic variables with L = 1 month, 2 months, 4 months, and 6 months, respectively. The estimation results show that the ex ante market risk premium estimates are significantly associated with future macroeconomic conditions. When all maturities are used and the forward-looking period (L) is one month, the slope coefficient estimates of equation (8) are 1.09 (t-statistic of 6.00) on TB, 1.00 (t-statistic of 2.02) on TERM, 3.81 (t-statistic of 4.40) on DEF, -0.68 (t-statistic of -0.15) on DIV, -3.08 (t-statistic of -2.12) on CONSUME, -0.29 (t-statistic of -0.51) on GDP, and -0.50 (t-statistic of -1.63) on LABOR.[27] Even with a longer forward-looking period, the magnitude and statistical significance of the coefficient estimates are similarly preserved. The R-squares are 0.357, 0.356, 0.325, and 0.338, respectively, for the forward-looking period of L = 1, 2, 4, and 6 months.

The estimated coefficients of equation (8) in Table 7 contain important economic implication. The ex ante market risk premium estimates have a significant positive relation with future default premium (DEF). This indicates that investors' ex ante risk premium *proactively* increases as the default premium increases in the future (at least one month through six months later). They also have a significant positive relation with interest rate (TB) and term premium (TERM). Since the coefficient on TERM represents 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 as well as short-term interest rates. On the other hand, the ex ante market risk premium estimates have generally a negative relation with the future growth of real economic activity as measured by consumption, GDP, and labor income (CONSUME, GDP, and LABOR) and with future dividends. 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.

[27] The regressors in our model are persistent. As Stambaugh (1999) and Ferson, Sarkissian, and Simin (2003) point out, the regressions could be spurious in this case. To reduce spurious regressions in the inference, we report t-statistics, which are adjusted by Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors with lag of 4.

In fact, the three macroeconomic variables, TB, DEF, and TERM, are related with discount rates (or risk premium) for future cash flows, while the other four macroeconomic variables, DIV, CONSUME, GDP, and LABOR, are related with future cash flows. The findings that the ex ante market risk premium estimates are positively related with discount rates (the denominator in the present value equation) and negatively related with cash flows (the numerator in the present value equation) indicate that high ex ante risk premium is related with high discount rates and low future cash flows and results in low realized returns. A negative relation between ex ante risk premium and realized returns is induced. Thus, the above results are consistent with the previously-mentioned volatility feedback effect. 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 conventional economic wisdom.[28] These results support that the CSR estimates have economic significance as well as statistical significance.

To further examine the information implication of ex ante market risk premium estimates on future macroeconomic condition, we use implied market returns instead of ex ante market risk premium estimates from the CSR. Note that implied market returns are also an estimate of ex ante market risk premium. To do this, we regress

$$\mu_{mt} = b_0 + b_1 \mathrm{TB}_{t+1,t+L} + b_2 \mathrm{TERM}_{t+1,t+L} + b_3 \mathrm{DEF}_{t+1,t+L} + b_4 \mathrm{DIV}_{t+1,t+L} + b_5 \mathrm{CONSUME}_{t+1,t+L} + b_6 \mathrm{GDP}_{t+1,t+L} + b_7 \mathrm{LABOR}_{t+1,t+L} + \varepsilon_t, \quad (9)$$

μ_{mt} is the implied market return on Standard & Poors 500 Index option close price observed at the 3rd Friday of month t. Table 8 presents the estimation results of the time-series regression model of equation (9) with forward-looking period (L) of 1, 2, 4, and 6 months in each of the seven maturity groups. The results are slightly stronger but overall similar to those from using the CSR ex ante market risk premium estimates (in Table 7). The implied market returns are positively associated with the future activities of the macroeconomic variables related with discount rates, TB, TERM, and DEF, while are negatively associated with the future activities of the macroeconomic variables related with cash flows. Thus, these results are also consistent with the volatility feedback effect.

[28] Chen, Chung, and Tsai (2016) also report that the risk premium on the option-implied beta contains information about future macroeconomic variables. These authors use five variables (DEF, DIV, TERM, TB, and CONSUME) among the seven variables used in this study.

In sum, our estimates of ex ante market risk premium, the implied market returns from Standard & Poors 500 Index option and the CSR estimates, have significant economic implications.

To compare the predictability of our ex ante market risk premium estimates with that of the ex post market risk premium, we regress ex post realized market returns on those forward-looking macroeconomic variables:

$$R_{mt} = b_0 + b_1\mathrm{TB}_{t+1,t+L} + b_2\mathrm{TERM}_{t+1,t+L} + b_3\mathrm{DEF}_{t+1,t+L} + b_4\mathrm{DIV}_{t+1,t+L} + b_5\mathrm{CONSUME}_{t+1,t+L} + b_6\mathrm{GDP}_{t+1,t+L} + b_7\mathrm{LABOR}_{t+1,t+L} + \varepsilon_t, \quad (10)$$

where R_{mt} is the CRSP value-weighted market returns. The estimation results of equation (10) are reported in Table 9 with forward-looking period of 1, 2, 3, 4, 5 and 6 months. Almost all estimated coefficients are insignificant, and the R-squares are quite low. Meanwhile, using the ex ante market risk premium estimates, most of the estimated coefficients in equations (8) and (9) are significant and the R-squares are relatively large (in Tables 7 and 8). For example, for forward-looking period of 1, 2, 4, and 6 months, the R-squares from using the ex post realized market returns in equation (10) are 0.096, 0.086, 0.084, and 0.083, respectively, while those from using the implied market returns in one month maturity group are 0.388, 0.414, 0.436, and 0.450, respectively. It is difficult to say, therefore, that the realized market returns contain information on future macroeconomic conditions.

6. 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 betas. As a proxy for ex ante expected returns, we use implied returns obtained from the risk-adjusted option pricing model. 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, past returns, and EP ratio. This supports that market beta is priced on an ex ante basis. However, since the intercept estimates are also significant, these results indicate that market beta may not be a unique ex ante risk measure. We also find that implied betas are significantly negatively related with realized returns in the cross-section. This negative relation indicates that if investors anticipate more risk for the coming period and risk is priced, they would require more risk premium, which drives stock price down and so does the return for the period. This is consistent with the volatility feedback effect.

To further investigate whether our CSR estimates of ex ante market risk premium contain forward-looking information on future macroeconomic conditions, we regress the CSR ex ante market risk premia estimates on the future macroeconomic variables. The regression coefficient estimates on the macroeconomic variables are statistically significant in most cases. Specifically, the CSR ex ante risk premium estimates have a significant positive relation with Treasury yield, default premium, and term premium, while they have a significantly negative relation with dividend yield, GDP, consumption growth rate, and labor income growth rate. This indicates that the CSR estimates of the ex ante market risk premium contain information about future economic conditions. When implied market returns (from Standard & Poors 500 Index options) are used instead of the CSR ex ante market risk premium estimates, we also obtain overall 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 information on future macroeconomic conditions.

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Appendix

To compute the beta, β_{cs}, of equation (6), we need to compute the variance of stock, $\mathrm{Var}(S_T)$, and the covariance between the stock and the option, $\mathrm{Cov}(C_T, S_T)$. We first compute the components of the variance and the covariance. The expected values of S_T and C_T are

$$E(S_T) = e^{\mu_s(T-t)}\, S_t, \quad \text{(A1)}$$

$$\begin{aligned} E(C_T) &= e^{\mu_c(T-t)}\, C_t \\ &= S_t e^{\mu_s(T-t)}\, N(h_1) - K\, N(h_2). \quad \text{(using equation (4))} \quad \text{(A2)} \end{aligned}$$

The expected value of the product of C_T and S_T is computed as

$$\begin{aligned} E(S_T C_T) &= \int_0^{\infty} S_T \max(S_T - K, 0)\, \phi(S_T)\, d\,S_T \\ &= \int_K^{\infty} S_T^2\, \phi(S_T)\, d\,S_T - K \int_K^{\infty} S_T\, \phi(S_T)\, d\,S_T \\ &= S_t^2\, e^{(2\mu_s + \sigma_s^2)(T-t)} N(h_3) - K S_t\, e^{\mu_s(T-t)} N(h_1). \quad \text{(A3)} \end{aligned}$$

From the moment generating function of a Gaussian variable and by using equations (A1), (A2) and (A3), the variance of S_T is

$$\begin{aligned} \mathrm{Var}(S_T) &= \mathrm{E}(S_T^2) - [\mathrm{E}(S_T)]^2 \\ &= S_t^2\, e^{(2\mu_s + \sigma_s^2)(T-t)} - S_t^2\, e^{2\mu_s(T-t)} \\ &= S_t^2\, e^{2\mu_s(T-t)} \left[e^{\sigma_s^2(T-t)} - 1\right], \quad \text{(A4)} \end{aligned}$$

and the covariance between C_T and S_T is computed as

$$\begin{aligned} \mathrm{Cov}(S_T, C_T) &= E(S_T C_T) - E(S_T)\, E(C_T) \\ &= S_t^2\, e^{(2\mu_s + \sigma_s^2)(T-t)} N(h_3) - K S_t\, e^{\mu_s(T-t)} N(h_1) \\ &\quad - S_t\, e^{\mu_s(T-t)} \left[S_t\, e^{\mu_s(T-t)} N(h_1) - K N(h_2)\right] \\ &= S_t^2\, e^{2\mu_s(T-t)} \left[e^{\sigma_s^2(T-t)} N(h_3) - \frac{K}{S_t}\, e^{\mu_s(T-t)} \{N(h_1) - N(h_2)\} - N(h_1) \right]. \quad \text{(A5)} \end{aligned}$$

Finally, combining equations (A4) and (A5) yields equation (6); that is,

$$\begin{aligned} \beta_{cs} &= \left(\frac{S_t}{C_t}\right) \frac{\mathrm{Cov}(C_T, S_T)}{\mathrm{Var}(S_T)} \\ &= \left(\frac{S_t}{C_t}\right) \left\{ \frac{e^{\sigma_s^2(T-t)}\, N(h_3) - (K/S_t) e^{-\mu_s(T-t)} [N(h_1) - N(h_2)] - N(h_1)}{e^{\sigma_s^2(T-t)} - 1} \right\}. \end{aligned}$$

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. The implied returns ($\mu_{[t,T]}$) and standard deviations ($\sigma_{[t,T]}$) of individual stocks are computed with option prices of various maturities observed at the 3rd Friday of each month over the sample period from January 1996 to December 2014. Implied betas are the whole-period betas. "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, and that of the implied standard deviation is the annualized sample standard deviation over the option life. "NSAM" is the number of all firm-month observations.

Implied variable	Maturities	Mean	Standard deviation	Correl-ation	Min	1%	10%	Median	90%	99%	Max	NSAM
	All maturities	0.290	0.198	-0.045	0.001	0.026	0.098	0.236	0.569	0.931	1.500	353,327
	1 month	0.440	0.222	-0.044	0.001	0.061	0.183	0.404	0.757	1.029	1.500	130,107
Implied	2 months	0.288	0.145	-0.072	0.001	0.014	0.116	0.270	0.490	0.657	1.500	42,587
return	3 months	0.233	0.109	-0.104	0.001	0.018	0.102	0.219	0.385	0.507	1.220	45,037
($\mu_{i,[t,T]}$)	4 months	0.208	0.089	-0.114	0.001	0.023	0.099	0.201	0.331	0.428	1.484	31,986
	6 months	0.177	0.074	-0.113	0.001	0.019	0.088	0.171	0.277	0.362	1.500	53,053
	9 months	0.149	0.060	-0.132	0.001	0.013	0.079	0.146	0.228	0.301	0.387	22,329
	> 9 months	0.111	0.041	-0.127	0.001	0.009	0.061	0.109	0.163	0.216	0.328	28,228
	All maturities	0.489	0.230	0.669	0.010	0.139	0.228	0.441	0.859	1.000	1.000	353,327
	1 month	0.524	0.248	0.687	0.033	0.141	0.240	0.470	0.965	1.000	1.000	130,107
Implied	2 months	0.488	0.229	0.702	0.035	0.141	0.228	0.442	0.851	1.000	1.000	42,587
standard	3 months	0.479	0.220	0.709	0.010	0.145	0.228	0.438	0.816	1.000	1.000	45,037
deviation	4 months	0.485	0.219	0.699	0.010	0.141	0.231	0.448	0.818	1.000	1.000	31,986
($\sigma_{i,[t,T]}$)	6 months	0.469	0.217	0.680	0.029	0.136	0.223	0.430	0.793	1.000	1.000	53,053
	9 months	0.442	0.204	0.668	0.029	0.132	0.213	0.406	0.730	1.000	1.000	22,329
	> 9 months	0.419	0.190	0.545	0.029	0.132	0.205	0.385	0.682	1.000	1.000	28,228
	All maturities	1.198	0.616		0.007	0.202	0.614	1.095	1.861	3.287	14.21	339,905
	1 month	0.787	0.506		0.002	0.024	0.207	0.752	1.300	2.593	5.909	101,729
Implied	2 months	0.996	0.657		0.000	0.047	0.320	0.912	1.729	3.435	7.544	30,240
betas	3 months	0.893	0.516		0.004	0.049	0.301	0.840	1.501	2.526	5.796	33,772
($\beta^{imp}_{[t,T]}$)	4 months	0.739	0.431		0.001	0.053	0.276	0.688	1.259	2.225	3.645	21,669
	6 months	0.581	0.397		0.002	0.023	0.176	0.494	1.103	1.953	3.768	39,880
	9 months	0.534	0.307		0.001	0.021	0.198	0.494	0.931	1.538	2.970	15,069

> 9 months	0.464	0.313		0.011	0.034	0.142	0.416	0.813	1.618	2.914	23,191

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

For each individual stock option whose close price is observed at the 3rd Friday of each month, we compute the implied return and standard deviation of Standard & Poors 500 Index Option based on the close price observed at the same date whose maturity is matched with that of the individual stock option. This table presents the basic statistics of the pooled implied return and standard deviation of those Standard & Poors 500 Index Options. Since individual stock options and Standard & Poors 500 Index Options correspond one-to-one, the number of implied data of Standard & Poors 500 Index Options is equal to that of individual stock options in Table 1. The sample period is January 1996 to December 2014.

Implied variable	Maturities	Mean	Standard deviation	Min	1%	10%	Median	90%	99%	Max	#Observation
	All maturities	0.162	0.088	0.004	0.044	0.081	0.144	0.256	0.506	1.500	353,327
	1 month	0.212	0.101	0.084	0.092	0.121	0.188	0.324	0.654	1.500	130,107
	2 months	0.151	0.072	0.064	0.064	0.084	0.130	0.221	0.506	0.654	42,587
return	3 months	0.143	0.062	0.048	0.060	0.076	0.129	0.217	0.382	0.382	45,037
$(\mu_{m,[t,T]})$	4 months	0.143	0.063	0.044	0.052	0.076	0.135	0.210	0.315	0.588	31,986
	6 months	0.133	0.062	0.036	0.040	0.073	0.121	0.197	0.294	0.555	53,053
	9 months	0.118	0.05	0.024	0.032	0.066	0.111	0.183	0.261	0.482	22,329
	> 9 months	0.094	0.036	0.004	0.034	0.057	0.087	0.144	0.190	0.383	28,228
	All maturities	0.212	0.101	0.069	0.100	0.116	0.192	0.313	0.688	1.000	353,327
	1 month	0.216	0.112	0.069	0.090	0.110	0.195	0.320	0.779	1.000	130,107
standard	2 months	0.209	0.110	0.100	0.100	0.114	0.185	0.304	0.791	0.791	42,587
deviation	3 months	0.212	0.097	0.095	0.105	0.120	0.191	0.299	0.682	0.722	45,037
$(\sigma_{m,[t,T]})$	4 months	0.211	0.089	0.101	0.109	0.118	0.196	0.305	0.488	0.740	31,986
	6 months	0.212	0.088	0.104	0.106	0.120	0.197	0.301	0.531	0.731	53,053
	9 months	0.202	0.078	0.105	0.111	0.122	0.181	0.295	0.481	0.691	22,329
	> 9 months	0.213	0.087	0.106	0.110	0.126	0.191	0.318	0.470	0.648	28,228
#days to maturity	All maturities	124	142	5	29	29	92	218	764	1,065	353,327

Table 3 Time-Series Averages of Cross-Sectional Regression Coefficients of *Ex Ante* Implied Returns on Implied Beta Estimates

This table presents the time-series averages (in percent) of the month-by-month cross-sectional regression coefficients of implied returns in excess of the risk-free yield on implied beta estimates of individual underlying stocks. Whole-period implied betas (Panel A) are estimated by regressing all implied returns of the stock on implied market returns over the whole-sample period. Rolling-over implied betas (Panel B) are obtained by regressing the previous 3-years' implied returns available up to the CSR estimation month t on the corresponding implied market returns. Monthly implied betas (Panel C) are obtained by regressing weekly implied returns measured at every Friday from the 3rd Friday of month $t-1$ to the 2nd Friday of month t. The control variables are as follows: ME is the market value of common equity measured one month before the CSR estimation month t, BM and EP ratio are the book-to-market ratio and the earnings–price ratio, respectively, which are most recently available six months before the CSR estimation month t, and "Past return" is the stock return over the past six months from month t-7 to month t-2. Numbers in parentheses indicate t-statistics, which are adjusted by Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors with lag of 4. The sample period is from January 1996 to December 2014.

Maturity	Intercept	$\hat{\beta}_i^{\text{imp}}$	Control Variables			
			log (ME)	log(BM)	Past return	EP ratio
Panel A: Using whole-period implied betas						
All maturities	19.62 (38.88)	5.75 (14.52)				
1 month	29.04 (51.67)	10.00 (16.46)				
2 months	19.93 (42.18)	5.20 (10.73)				
3 months	15.72 (34.93)	3.63 (10.75)				
4 months	12.87 (32.06)	3.81 (12.00)				
6 months	10.48 (37.13)	2.84 (13.83)				
9 months	8.87 (21.33)	2.67 (9.68)				
> 9 months	4.11 (13.10)	2.35 (8.30)				
All maturities	60.45 (62.43)	3.61 (7.56)	-4.43 (-40.27)	-1.45 (-8.99)	1.00 (2.41)	-5.21 (-7.50)
1 month	72.95 (35.29)	7.54(10.40)	-4.92 (-19.68)	-1.86 (-9.14)	1.46 (2.56)	-7.75 (-6.82)
2 months	43.74 (30.26)	3.74 (7.51)	-2.67 (-17.09)	-1.26 (-8.06)	1.09 (1.86)	-7.00 (-4.41)
3 months	32.65 (31.19)	2.60 (7.59)	-1.94 (-17.11)	-1.01 (-6.28)	0.92 (1.63)	-4.70 (-4.47)
4 months	26.48 (24.17)	2.54 (7.98)	-1.52 (-12.35)	-1.03 (-7.30)	0.38 (0.76)	-5.08 (-4.19)
6 months	21.01 (24.16)	2.28 (8.14)	-1.18 (-13.16)	-0.85 (-8.46)	0.20 (0.40)	-3.44 (-4.35)
9 months	14.80 (12.21)	2.17 (9.68)	-0.77 (-7.29)	-0.79 (-6.32)	0.52 (1.24)	-5.57 (-2.26)
> 9 months	8.16 (8.96)	2.08 (7.09)	-0.48 (-6.85)	-0.56 (-9.00)	0.33 (1.81)	-2.60 (-2.03)
Panel B: Using rolling-over implied betas						
All maturities	20.77 (22.69)	3.36 (22.32)				
1 month	31.32 (23.92)	5.61 (15.81)				
2 months	20.93 (25.89)	2.98 (13.28)				
3 months	16.92 (26.92)	1.81 (11.36)				
4 months	13.89 (24.73)	2.12 (15.17)				
6 months	10.06 (27.97)	1.90 (18.15)				
9 months	8.68 (25.99)	1.81 (11.88)				
> 9 months	4.30 (22.58)	1.67 (12.03)				
All maturities	60.05 (48.34)	1.84(13.18)	-4.25 (-31.99)	-1.36 (-8.39)	0.74 (1.83)	-5.34 (-7.82)
1 month	72.59 (38.15)	4.03(13.13)	-4.60 (-16.86)	-1.67 (-8.53)	1.58 (2.93)	-8.27 (-7.20)
2 months	43.10 (29.75)	2.13 (9.41)	-2.49 (-14.43)	-1.16 (-6.98)	1.19 (2.12)	-6.25 (-4.42)
3 months	32.94 (26.92)	1.63 (8.87)	-1.85 (-14.70)	-0.96 (-6.01)	0.79 (1.33)	-5.53 (-5.08)
4 months	26.12 (23.62)	1.39 (8.71)	-1.40 (-10.33)	-1.03 (-6.95)	0.40 (0.80)	-4.99 (-3.57)
6 months	21.02 (25.50)	1.35 (9.91)	-1.11 (-11.94)	-0.88 (-8.49)	0.19 (0.39)	-3.73 (-4.70)
9 months	15.11 (13.45)	1.29 (7.42)	-0.68 (-5.97)	-0.70 (-5.61)	0.48 (1.19)	-7.05 (-2.97)

> 9 months	8.47 (10.15)	1.33 (8.92)	-0.43 (-5.65)	-0.49 (-7.22)	0.22 (1.22)	-3.03 (-2.28)
Panel C: Using implied monthly beta obtained from weekly-measured implied returns						
All maturities	15.35 (26.43)	4.19(18.68)				
1 month	21.23 (20.28)	8.22(19.37)				
2 months	19.82 (29.89)	2.76(11.35)				
3 months	16.18 (26.21)	1.80 (7.94)				
4 months	13.83 (25.32)	1.65 (7.90)				
6 months	11.60 (26.74)	1.11 (7.23)				
9 months	9.44 (26.90)	1.07 (7.22)				
> 9 months	5.80 (25.05)	0.57 (5.92)				
All maturities	52.18 (46.60)	2.50(12.38)	-3.69 (-30.62)	-1.34 (-9.11)	0.97 (2.27)	-4.32 (-4.21)
1 month	60.46 (30.28)	6.24(15.38)	-4.05 (-16.65)	-1.91 (-8.81)	1.00 (1.57)	-5.64 (-3.24)
2 months	45.89 (27.04)	1.43 (5.46)	-2.68 (-14.02)	-1.28 (-6.95)	1.05 (1.65)	-9.17 (-3.49)
3 months	35.25 (26.45)	0.88 (4.16)	-2.00 (-14.35)	-1.00 (-5.96)	1.10 (1.92)	-8.49 (-5.06)
4 months	28.47 (20.78)	0.89 (4.76)	-1.56 (-9.55)	-0.99 (-6.30)	0.59 (1.01)	-6.68 (-2.81)
6 months	23.17 (22.27)	0.47 (3.76)	-1.23 (-10.72)	-0.90 (-8.83)	0.46 (0.96)	-6.11 (-5.52)
9 months	18.53 (12.69)	0.41 (3.17)	-0.86 (-6.64)	-0.58(-2.23)	0.93 (2.23)	-11.52 (-2.45)
> 9 months	10.49 (14.84)	0.29 (3.44)	-0.49 (-7.25)	-0.60 (-7.88)	0.38 (1.95)	-3.30 (-2.40)
Panel D: Using implied betas from Buss and Vilkov (2012)						
All maturities	12.43 (7.81)	8.62 (8.24)				
1 month	19.88 (9.38)	10.94 (6.58)				
2 months	13.44 (6.58)	12.57 (7.30)				
3 months	11.81 (7.60)	8.85 (8.40)				
4 months	10.43 (6.79)	8.90 (8.69)				
6 months	9.57 (6.36)	8.13 (8.82)				
9 months	9.69 (6.77)	6.75 (8.23)				
> 9 months	9.71 (6.88)	6.58 (7.86)				
All maturities	66.66 (25.13)	6.56 (6.78)	-3.18 (-33.11)	-0.786 (-6.47)	1.51 (2.23)	-5.72 (-4.64)
1 month	50.52 (8.61)	10.02 (5.64)	-2.37 (-6.67)	-1.65 (-7.20)	2.24 (1.85)	-12.88 (-3.86)
2 months	52.25 (9.96)	11.38 (6.24)	-2.32 (-8.66)	-1.06 (-6.54)	2.11 (2.40)	-5.94 (-3.46)
3 months	59.89 (21.18)	7.34 (6.89)	-2.83 (-26.47)	-0.59 (-5.32)	2.05 (3.48)	-4.90 (-3.84)
4 months	59.21 (19.91)	7.06 (6.80)	-2.85 (-26.48)	-0.59 (-4.90)	1.93 (3.48)	-4.04 (-3.33)
6 months	67.53 (21.73)	5.75 (6.68)	-3.37 (-27.16)	-0.53 (-4.57)	0.96 (1.50)	-3.85 (-2.50)
9 months	78.92 (20.46)	3.99 (6.18)	-4.01 (-20.08)	-0.40 (-3.03)	0.90 (1.36)	-3.73 (-2.11)
> 9 months	83.92 (19.38)	3.65 (6.15)	-4.30 (-18.06)	-0.38 (-2.75)	0.82 (1.16)	-3.57 (-2.01)

Table 4 Time-Series Averages of Cross-Sectional Regression Coefficients of Realized Returns on the Predictive Implied Betas

This table presents the time-series averages (in percent) of the month-by-month cross-sectional regression coefficients of continuously compounded realized returns in excess of the risk-free yield over the option life on implied beta estimates of individual underlying stocks. Rolling-over implied betas (Panel A) and monthly implied betas are defined in Table 3. The control variables are as follows: ME is the market value of common equity measured one month before the CSR estimation month, BM and EP ratio are the book-to-market ratio and the earnings–price ratio, respectively, which are most recently available six months before the CSR estimation month, and "Past return" is the stock return over the past six months from month t-7 to month t-2. Numbers in parentheses indicate t-statistics, which are adjusted by Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors with lag of 4.

Maturity	Intercept	$\hat{\beta}_i^{\text{imp}}$	Control variables			
			log (ME)	log(BM)	Past return	EP ratio
			Panel A: Using whole-period implied betas			
All maturities	6.35 (1.67)	-5.29 (-3.27)				
1 month	6.13 (1.24)	-5.27 (-2.84)				
2 months	6.53 (1.37)	-6.46 (-2.95)				
3 months	5.72 (1.46)	-5.43 (-2.43)				
4 months	5.45 (0.11)	-5.56 (-2.88)				
6 months	5.51 (1.39)	-6.40 (-2.85)				
9 months	4.83 (0.98)	-7.72 (-2.83)				
> 9 months	5.94 (1.11)	-6.09 (-2.45)				
All maturities	-13.24 (-1.27)	-3.16 (-2.14)	1.95 (2.15)	1.03 (0.66)	2.38 (0.63)	18.70 (3.71)
1 month	-13.34 (-1.13)	-3.34 (-1.93)	1.91 (1.80)	0.20 (0.11)	3.69 (0.84)	20.52 (3.15)
2 months	-12.68 (-1.21)	-2.33 (-1.03)	1.71 (1.93)	0.88 (0.44)	3.82 (0.84)	25.33 (2.36)
3 months	-14.20 (-1.47)	-3.37 (-1.47)	2.08 (2.30)	1.89 (1.09)	3.94 (0.92)	37.63 (3.71)
4 months	-22.59 (-2.13)	-1.41 (-0.64)	2.66 (3.03)	2.97 (1.42)	5.00 (1.22)	44.57 (2.44)
6 months	-17.29 (-1.98)	-3.91 (-2.03)	2.45 (3.14)	2.00 (1.16)	3.06 (0.77)	26.50 (3.62)
9 months	-19.12 (-1.85)	-3.71 (-1.59)	2.68 (2.86)	3.83 (2.00)	9.57 (2.50)	24.58 (1.31)
> 9 months	-18.55 (-1.57)	- 3.21 (-1.47)	2.82 (3.41)	3.02 (2.18)	0.12 (0.06)	10.76 (1.05)
			Panel B: Using rolling-over implied betas			
All maturities	2.66 (0.74)	-2.61 (-2.67)				
1 month	2.61 (0.55)	-3.23 (-2.73)				
2 months	1.81 (0.40)	-2.79 (-2.14)				
3 months	1.87 (0.47)	-2.41 (-2.02)				
4 months	-0.06 (-0.01)	-3.36 (-2.45)				
6 months	1.27 (0.37)	-2.35 (-2.25)				
9 months	-1.25 (-0.32)	-2.30 (-2.17)				
> 9 months	5.38 (2.30)	-4.61 (-2.00)				
All maturities	-24.74 (-2.29)	-1.66 (-2.02)	2.94 (3.07)	1.31 (0.78)	1.63 (0.78)	24.15 (3.95)
1 month	-26.65 (-2.13)	-1.85 (-1.67)	3.20 (2.88)	0.56 (0.29)	2.12 (0.49)	28.95 (4.40)
2 months	-25.07 (-2.32)	-0.57 (-0.43)	2.84 (2.85)	1.13 (0.54)	4.75 (0.54)	4.54 (0.36)
3 months	-23.89 (-2.45)	-1.06 (-0.92)	2.81 (3.06)	1.98 (1.11)	4.53 (1.00)	42.64 (3.40)
4 months	-30.10 (-2.81)	-1.41 (-0.96)	3.53 (3.75)	3.28 (1.47)	3.09 (0.72)	43.45 (2.24)
6 months	-27.11 (-3.04)	-0.71 (-0.55)	3.17 (3.90)	2.24 (1.24)	3.82 (0.92)	34.75 (3.36)
9 months	-29.17 (-2.76)	-0.08 (-0.04)	3.31 (3.40)	10.77 (2.88)	10.77 (2.88)	35.76 (1.32)
> 9 months	-32.03 (-3.55)	-0.84 (-0.47)	3.38 (3.95)	2.82 (1.96)	2.64 (1.24)	18.48 (1.46)

	Panel C: Using implied monthly beta obtained from weekly-measured implied returns					
All maturities	6.04 (1.47)	-3.22 (-3.09)				
1 month	5.72 (1.08)	-2.41 (-2.07)				
2 months	4.03 (0.80)	-2.82 (-2.22)				
3 months	6.34 (1.34)	-4.17 (-2.78)				
4 months	2.17 (0.41)	-2.84 (-2.15)				
6 months	4.90 (1.19)	-4.09 (-3.35)				
9 months	3.76 (0.81)	-3.62 (-2.73)				
> 9 months	3.13 (1.27)	-2.69 (-2.80)				
All maturities	-13.00 (-1.07)	-1.98 (-2.44)	1.91 (1.85)	1.00 (0.61)	0.29 (0.07)	28.24 (2.44)
1 month	-12.98 (-1.21)	-1.69 (-1.53)	0.88 (0.70)	0.03 (0.01)	0.17 (0.04)	24.78 (1.85)
2 months	-14.92 (-1.00)	-1.51 (-1.07)	1.97 (1.58)	0.66 (0.34)	1.91 (0.39)	50.75 (1.80)
3 months	-33.29 (-2.62)	-1.83 (-1.53)	3.53 (3.07)	0.22 (0.11)	2.86 (0.65)	70.28 (3.10)
4 months	-34.64 (-2.80)	-0.13 (-0.12)	3.82 (3.55)	2.47 (1.00)	1.79 (0.37)	27.66 (0.85)
6 months	-27.87 (-2.50)	-1.87 (-1.86)	3.49 (3.57)	3.03 (1.64)	1.72 (0.42)	43.72 (2.66)
9 months	-35.94 (-2.78)	-1.23 (-0.93)	4.22 (3.72)	3.98 (1.55)	1.25 (1.02)	36.10 (1.07)
> 9 months	-19.22 (-2.21)	-1.35 (-1.68)	2.46 (3.08)	2.71 (2.00)	0.43 (0.20)	20.40 (1.29)

Table 5 Time-Series Averages of Cross-Sectional Regression Coefficients of Realized Returns on Implied Returns and Volatilities

This table presents the time-series averages of the month-by-month cross-sectional regression coefficients of (annualized) continuously compounded realized returns in excess of the risk-free yield over the option life $[t, T]$ on implied standard deviations ($\sigma_{i,[t,T]}$) or implied returns ($\mu_{i,[t,T]}$) of individual underlying stocks. Numbers in parentheses indicate t-statistics, which are adjusted by Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors with lag of 4. The sample period is from January 1996 to December 2014.

Maturity	$r_{i,[t,T]} = \gamma_{0t} + \gamma_{1t}\, \sigma_{i,[t,T]} + \varepsilon_{it}$		$r_{i,[t,T]} = \gamma_{0t} + \gamma_{1t}\, \mu_{i,[t,T]} + \varepsilon_{it}$	
	$\bar{\bar{\gamma}}_0$	$\bar{\bar{\gamma}}_1$	$\bar{\bar{\gamma}}_0$	$\bar{\bar{\gamma}}_1$
All maturities	22.43 (5.26)	-47.01 (-4.09)	2.08 (0.98)	-13.37 (-1.53)
1 month	23.75 (4.37)	-48.66 (-3.65)	4.32 (0.92)	-16.77 (-2.53)
2 months	23.78 (4.64)	-48.75 (-3.78)	5.15 (1.14)	-23.06 (-2.36)
3 months	25.02 (4.98)	-52.26 (-4.05)	4.20 (1.62)	-28.81 (-2.41)
4 months	29.00 (5.29)	-62.55 (-4.42)	4.42 (1.45)	-41.40 (-2.87)
6 months	25.01 (5.38)	-56.24 (-4.54)	6.56 (3.00)	-56.21 (-4.35)
9 months	26.98 (5.54)	-61.99 (-4.75)	6.45 (2.44)	-71.52 (-3.78)
> 9 months	14.55 (4.38)	-33.42 (-3.17)	4.34 (1.51)	-57.32 (-3.33)

Table 6 Distributions of the Slope Coefficient Estimates of Time-Series Regressions for All Individual Underlying Stocks

This table presents the cross-sectional averages and distributions of the slope coefficient estimates of each time-series regression for all individual underlying stocks. $R_{[t,T]}$ is the realized (annualized) continuously compounded return of an underlying stock i over the option life ($[t, T]$) from the 3rd Friday of each month t to maturity T, $s_{[t,T]}$ is the realized standard deviation computed by using continuously compounded daily returns over the option life, and $\mu_{[t,T]}$ and $\sigma_{[t,T]}$ are the implied return and implied standard deviation, respectively, measured at time t (the 3rd Friday of each month). '%Neg' ('%Pos') indicates the percentage of negative (positive) estimates among all time-series regression slope coefficient estimates. '#obs' is the number of the estimated slope coefficients.

Maturity	Average	1%	10%	Median	90%	99%	%Neg	%Pos	#obs
Panel A: $R_{[t,T]} = a_0 + a_1\, \mu_{[t,T]} + \varepsilon_t$									
1 month	-0.35 (-6.44)	-7.33	-3.09	-0.22	2.17	6.16	0.559	0.441	2146
2 months	-0.63 (-7.35)	-11.02	-3.83	-0.38	2.15	6.00	0.592	0.408	1199
3 months	-1.14 (-11.69)	-12.48	-4.86	-0.67	1.86	5.89	0.642	0.358	1144
4 months	-1.37 (-12.22)	-12.96	-5.50	-1.06	2.36	7.33	0.663	0.337	1050
6 months	-1.23 (-9.54)	-15.96	-5.92	-0.92	2.80	9.00	0.643	0.357	1069
9 months	-1.19 (-6.21)	-20.16	-6.02	-0.74	2.83	9.93	0.601	0.399	639
> 9 months	-1.39 (-6.68)	-22.92	-6.82	-1.17	2.93	8.37	0.658	0.342	1178
Panel B: $R_{[t,T]} = b_0 + b_1\, \sigma_{[t,T]} + \varepsilon_t$									
1 month	-0.65 (-7.62)	-11.47	-3.62	-0.35	2.08	6.49	0.591	0.409	2146
2 months	-0.57 (-7.51)	-7.98	-2.92	-0.33	1.62	3.62	0.588	0.412	1199
3 months	-0.87 (-12.63)	-8.24	-3.18	-0.54	1.02	3.41	0.698	0.302	1144
4 months	-1.01 (-11.74)	-8.05	-3.68	-0.65	0.94	3.23	0.702	0.298	1050
6 months	-0.93 (-12.82)	-8.15	-3.51	-0.69	1.05	4.10	0.703	0.297	1069
9 months	-1.23 (-10.29)	-8.99	-4.40	-0.61	0.76	2.71	0.734	0.266	639
> 9 months	-1.38 (-14.17)	-9.25	-3.09	-0.51	1.02	3.21	0.705	0.295	1178
Panel C: $R_{[t,T]} = c_0 + c_1\, s_{[t,T]} + \varepsilon_t$									
1 month	-1.98 (-41.38)	-7.68	-4.74	-1.92	0.55	3.63	0.853	0.147	2146
2 months	-1.80 (-36.01)	-6.46	-3.98	-1.74	0.21	2.41	0.877	0.123	1199
3 months	-1.80 (-45.01)	-5.64	-3.60	-1.72	-0.24	1.24	0.925	0.075	1144
4 months	-1.71 (-44.39)	-4.88	-3.33	-1.67	-0.27	1.40	0.927	0.073	1050
6 months	-1.69 (-42.85)	-4.99	-3.30	-1.66	-0.31	1.62	0.926	0.074	1069
9 months	-1.44 (-29.45)	-4.78	-2.90	-1.35	-0.16	1.40	0.920	0.080	639
> 9 months	-1.30 (-20.74)	-4.99	-2.51	-1.02	0.40	2.05	0.938	0.062	1178
Panel D: $s_{[t,T]} = d_0 + d_1\, \mu_{[t,T]} + \varepsilon_t$									
1 month	0.26 (23.46)	-1.00	-0.24	0.27	0.74	1.56	0.224	0.776	2146
2 months	0.58 (25.01)	-1.17	-0.11	0.56	1.18	2.31	0.123	0.877	1199
3 months	0.94 (27.29)	-1.51	-0.04	0.86	1.89	3.64	0.103	0.897	1144
4 months	1.23 (21.20)	-1.99	-0.26	1.13	2.67	6.15	0.117	0.883	1050
6 months	1.04 (20.78)	-2.49	-0.54	0.95	2.54	5.91	0.180	0.820	1069
9 months	1.50 (13.07)	-3.00	-0.62	1.33	3.72	9.04	0.179	0.821	639
> 9 months	1.43 (11.84)	-3.52	-0.77	0.91	4.37	10.72	0.340	0.660	1178
Panel E: $s_{[t,T]} = e_0 + e_1\, \sigma_{[t,T]} + \varepsilon_t$									
1 month	1.03 (51.64)	-0.15	0.42	0.91	1.36	2.46	0.017	0.983	2146
2 months	0.80 (52.48)	0.01	0.40	0.74	1.23	2.40	0.008	0.992	1199
3 months	0.86 (50.02)	-0.05	0.40	0.79	1.36	2.62	0.012	0.988	1144
4 months	0.96 (38.54)	-0.15	0.42	0.85	1.62	3.22	0.012	0.988	1050
6 months	0.90 (41.87)	-0.41	0.33	0.81	1.59	3.05	0.026	0.974	1069
9 months	1.06 (27.09)	-0.10	0.35	0.89	1.91	3.41	0.016	0.984	639
> 9 months	0.75 (18.66)	-0.93	0.04	0.60	1.35	4.58	0.080	0.920	1178

Table 7 Relationships Between the CSR Coefficient Estimates and Forward-Looking Macroeconomic Variables

This table presents the estimation results of the time-series regression model of the CSR coefficient estimates on forward-looking macroeconomic variables:

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

where $\hat{\gamma}_{1t}$ is the coefficient estimate at month t of the CSR of the whole-period implied betas on implied returns. 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. Numbers in parentheses indicate t-statistics, which are adjusted by Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors with lag of 4. The sample period is from January 1996 to December 2014.

	Maturity							
	All maturities	1 month	2 months	3 months	4 months	6 months	9 months	> 9 months
	Forward-looking period (L) = 1 month							
Intercept	-0.01 (-0.47)	0.12 (3.40)	-0.03 (-1.42)	0.02 (1.10)	0.00 (0.06)	-0.02 (-1.21)	0.03 (0.93)	0.03 (1.14)
TB	1.09 (6.00)	0.19 (0.66)	1.35 (5.60)	0.71 (4.57)	0.79 (4.48)	0.58 (4.61)	0.46 (1.81)	0.17 (0.50)
TERM	1.00 (2.02)	-0.22 (-0.26)	0.94 (1.45)	0.74 (1.74)	0.94 (2.46)	0.67 (2.34)	0.85 (1.91)	0.81 (1.92)
DEF	3.81 (4.40)	3.27 (2.11)	4.00 (4.14)	2.16 (2.54)	2.17 (2.36)	2.32 (3.18)	0.71 (0.57)	0.57 (0.55)
DIV	-0.68 (-0.15)	-14.39 (-1.55)	6.60 (1.04)	-15.01(-3.20)	-7.13(-1.09)	1.18 (0.49)	-15.99(-2.05)	-17.10 (-3.09)
CONSUME	-3.08 (-2.12)	-6.68 (-2.83)	-5.01 (-2.61)	-3.54(-1.89)	-1.05(-0.99)	-0.37 (-0.45)	-0.90(-0.82)	0.31 (0.39)
GDP	-0.29 (-0.51)	-0.87 (-0.77)	0.03 (0.04)	-0.28(-0.54)	-0.18(-0.30)	0.11 (0.24)	-0.10(-0.14)	-0.29 (-0.55)
LABOR	-0.50 (-1.63)	-0.41 (-0.93)	-0.40 (-1.31)	-0.20(-0.81)	-0.54(-1.62)	-0.24(-1.12)	-0.45(-1.34)	-0.19 (-0.80)
Adj R^2	0.357	0.201	0.257	0.234	0.160	0.213	0.124	0.201
	Forward-looking period (L) = 2 months							
Intercept	0.02 (0.78)	0.16 (4.28)	0.00 (0.10)	0.02 (1.08)	0.02 (0.88)	-0.01 (-0.48)	0.05 (1.50)	0.05 (1.80)
TB	0.41 (4.86)	-0.10 (-0.66)	0.50 (4.79)	0.30 (3.60)	0.32 (3.71)	0.24 (3.92)	0.25 (2.37)	0.03 (0.23)
TERM	0.37 (1.50)	-0.32 (-0.75)	0.31 (0.99)	0.29 (1.25)	0.41 (2.09)	0.31 (2.17)	0.47 (2.37)	0.37 (2.36)
DEF	2.22 (4.84)	2.05 (2.13)	2.60 (4.29)	1.34 (2.92)	1.58 (2.26)	1.27 (3.16)	0.38 (0.65)	0.50 (1.08)
DIV	-8.23 (-2.28)	-19.45 (-2.74)	-8.86 (-1.79)	-9.20 (-2.69)	-13.62 (-3.42)	-2.65 (-1.34)	-13.95 (-2.91)	-15.11 (-3.98)
CONSUME	-1.56 (-2.25)	-3.83 (-3.64)	-2.30 (-2.58)	-1.87 (-1.91)	-0.25 (-0.48)	-0.13 (-0.21)	-0.16 (-0.24)	0.12 (0.27)
GDP	-0.04 (-0.14)	-0.33 (-0.51)	0.16 (0.39)	0.09 (0.27)	0.00 (0.01)	0.05 (0.20)	-0.11 (-0.27)	-0.04 (-0.15)
LABOR	-0.26 (-1.61)	-0.21 (-0.93)	-0.16 (-0.96)	-0.14 (-1.17)	-0.20 (-0.90)	-0.06 (-0.63)	-0.35 (-1.54)	-0.14 (-1.14)
Adj R^2	0.356	0.225	0.243	0.206	0.190	0.205	0.167	0.286

	All maturities	1 month	2 months	3 months	4 months	6 months	9 months	> 9 months
	Forward-looking period (L) = 4 month							
Intercept	0.02 (0.64)	0.20 (3.70)	0.02 (0.50)	0.04 (1.77)	0.03 (1.10)	-0.00 (-0.24)	0.08 (2.66)	0.07 (3.17)
TB	0.19 (4.08)	-0.09 (-0.99)	0.21 (3.53)	0.10 (2.51)	0.11 (1.91)	0.11 (3.51)	0.05 (1.01)	-0.02 (-0.39)
TERM	0.20 (1.69)	-0.17 (-0.77)	0.16 (1.08)	0.11 (1.05)	0.18 (1.79)	0.18 (2.50)	0.20 (2.13)	0.17 (2.76)
DEF	1.10 (4.65)	1.03 (2.16)	1.29 (3.69)	0.81 (3.73)	0.70 (2.20)	0.67 (3.25)	0.10 (0.36)	0.33 (1.67)
DIV	-4.90 (-1.58)	-13.91 (-2.40)	-7.05 (-1.81)	-8.28 (-2.94)	-7.25 (-2.97)	-2.85 (-1.93)	-9.56 (-3.99)	-10.79 (-5.43)
CONSUME	-0.41 (-0.48)	-1.89 (-1.34)	-0.63 (-0.66)	-0.66 (-1.12)	-0.18 (-0.26)	0.14 (0.25)	-0.26 (-0.80)	0.25 (0.83)
GDP	0.02 (0.11)	-0.15 (-0.43)	0.09 (0.36)	0.13 (0.79)	0.09 (0.48)	0.02 (0.19)	-0.14 (-0.77)	0.03 (0.33)
LABOR	-0.18 (-1.55)	-0.17 (-1.13)	-0.14 (-1.03)	-0.14 (-1.86)	-0.13 (-1.08)	-0.00 (-0.06)	-0.16 (-1.61)	-0.12 (-1.65)
Adj R^2	0.325	0.204	0.214	0.226	0.160	0.197	0.206	0.405
	Forward-looking period (L) = 6 months							
Intercept	0.04 (1.20)	0.23 (3.81)	0.07 (1.60)	0.05 (1.75)	0.05 (1.96)	0.02 (0.83)	0.09 (3.46)	0.08 (4.03)
TB	0.08 (1.96)	-0.11 (-1.64)	0.06 (1.06)	0.05 (1.59)	0.05 (1.48)	0.05 (2.01)	0.02 (0.64)	-0.01 (-0.35)
TERM	0.11 (1.36)	-0.14 (-0.99)	0.05 (0.48)	0.07 (0.99)	0.12 (1.81)	0.11 (2.21)	0.12 (2.05)	0.13 (2.94)
DEF	0.90 (4.15)	0.87 (2.19)	1.07 (3.33)	0.64 (3.51)	0.46 (2.22)	0.43 (3.50)	0.08 (0.47)	0.21 (1.61)
DIV	-6.68 (-2.74)	-13.93 (-3.44)	-10.79 (-3.47)	-6.92 (-3.20)	-6.48 (-4.40)	-3.75 (-3.07)	-7.38 (-5.00)	-8.05 (-6.43)
CONSUME	-0.10 (-0.13)	-1.35 (-1.19)	-0.38 (-0.52)	-0.48 (-0.96)	-0.03 (-0.05)	0.28 (0.61)	-0.09 (-0.34)	0.34 (1.41)
GDP	0.12 (0.84)	0.01 (0.03)	0.16 (0.83)	0.15 (1.12)	0.16 (1.48)	0.02 (0.21)	-0.00 (-0.04)	0.04 (0.53)
LABOR	-0.14 (-1.51)	-0.13 (-1.06)	-0.09 (-0.72)	-0.09 (-1.19)	-0.18 (-2.17)	-0.02 (-0.41)	-0.20 (-2.49)	-0.12 (-1.87)
Adj R^2	0.338	0.213	0.248	0.234	0.190	0.214	0.231	0.464

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

This table presents the estimation results of the time-series regression model of implied market returns and forward-looking macroeconomic variables:

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

where μ_{mt} is the implied market return on S&P500 Index option obtained from the option close price at the 3rd Friday 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. Numbers in parentheses indicate t-statistics, which are adjusted by Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors with lag of 4. The sample period is from January 1996 to December 2014.

	Maturity						
	1 month	2 months	3 months	4 months	6 months	9 months	> 9 months
	Forward-looking period (L) = 1 month						
Intercept	0.09 (1.61)	0.04 (0.96)	0.04 (1.19)	0.01 (0.14)	0.01 (0.32)	0.01 (0.20)	0.06 (1.31)
TB	2.46 (4.19)	2.27 (5.90)	2.45 (6.40)	2.63 (6.38)	2.62 (6.29)	2.45 (6.39)	0.35 (0.52)
TERM	1.21 (0.91)	0.95 (1.01)	0.81 (0.97)	1.11 (1.35)	0.95 (1.17)	1.07 (1.55)	-0.08 (-0.07)
DEF	10.43 (5.12)	8.15 (5.66)	6.73 (5.93)	8.26 (6.42)	8.02 (4.80)	6.49 (5.28)	5.49 (2.71)
DIV	-32.33 (-2.69)	-12.85 (-1.71)	-13.16 (-1.84)	-12.67 (-1.58)	-15.84 (-1.89)	-12.98 (-1.63)	-11.97 (-1.82)
CONSUME	-7.62 (-3.05)	-6.74 (-3.73)	-4.87 (-2.73)	-4.64 (-2.45)	-6.38 (-2.14)	-4.25 (-2.11)	-0.40 (-0.22)
GDP	-0.07 (-0.05)	-0.39 (-0.43)	-0.46 (-0.59)	-0.64 (-0.81)	-0.89 (-1.17)	-0.71 (-1.18)	-0.20 (-0.20)
LABOR	-0.30 (-0.49)	-0.20 (-0.53)	-0.26 (-0.75)	-0.25 (-0.75)	-0.11 (-0.28)	-0.24 (-0.87)	0.72 (1.85)
Adj R^2	0.388	0.509	0.573	0.584	0.598	0.598	0.141
	Forward-looking period (L) = 2 months						
Intercept	0.15 (2.55)	0.08 (2.07)	0.08 (2.35)	0.01 (0.34)	0.05 (1.17)	0.02 (0.47)	0.08 (1.73)
TB	0.91 (3.42)	0.90 (5.21)	1.00 (5.99)	1.21 (5.89)	1.11 (5.78)	1.13 (5.83)	0.08 (0.23)
TERM	0.28 (0.44)	0.26 (0.56)	0.20 (0.50)	0.46 (1.11)	0.27 (0.67)	0.43 (1.26)	-0.13 (-0.23)
DEF	6.14 (5.23)	4.68 (5.37)	3.94 (6.00)	4.44 (5.79)	4.53 (5.17)	3.46 (5.17)	2.96 (2.65)
DIV	-35.45 (-3.71)	-20.40 (-3.39)	-20.30 (-3.23)	-9.83 (-1.37)	-18.60 (-2.86)	-9.50 (-1.27)	-12.09 (-2.10)
CONSUME	-3.99 (-2.49)	-3.58 (-2.83)	-2.40 (-2.28)	-2.55 (-2.25)	-3.07 (-2.15)	-2.26 (-2.21)	0.18 (0.13)
GDP	0.25 (0.29)	0.01 (0.01)	-0.13 (-0.29)	-0.17 (-0.36)	-0.30 (-0.69)	-0.30 (-0.83)	-0.18 (-0.31)
LABOR	-0.12 (-0.36)	-0.09 (-0.46)	-0.09 (-0.49)	-0.10 (-0.50)	-0.08 (-0.42)	-0.12 (-0.75)	0.51 (2.02)
Adj R^2	0.414	0.519	0.589	0.577	0.602	0.595	0.149

	1 month	2 months	3 months	4 months	4 months	9 months	> 9 months
			Forward-looking period (L) = 4 month				
Intercept	0.22 (3.85)	0.11 (2.35)	0.12 (2.98)	0.07 (1.82)	0.07 (1.60)	0.07 (1.94)	0.09 (1.64)
TB	0.29 (2.48)	0.37 (4.37)	0.40 (5.26)	0.46 (5.90)	0.48 (5.10)	0.44 (6.47)	0.02 (0.12)
TERM	0.04 (0.13)	0.11 (0.49)	0.06 (0.33)	0.13 (0.72)	0.11 (0.57)	0.13 (0.93)	-0.06 (-0.20)
DEF	3.46 (5.58)	2.48 (5.54)	2.12 (5.73)	2.59 (6.88)	2.38 (6.52)	2.08 (6.99)	1.53 (2.46)
DIV	-29.39 (-4.66)	-15.67 (-3.12)	-16.08 (-3.62)	-14.77 (-3.32)	-13.62 (-2.61)	-12.97 (-3.23)	-7.17 (-1.57)
CONSUME	-1.58 (-0.86)	-1.07 (-0.69)	-0.50 (-0.39)	-0.64 (-0.56)	-0.63 (-0.48)	-0.70 (-0.86)	0.24 (0.20)
GDP	0.17 (0.35)	0.05 (0.18)	-0.05 (-0.16)	-0.07 (-0.27)	-0.14 (-0.54)	-0.15 (-0.80)	-0.25 (-0.65)
LABOR	-0.07 (-0.35)	-0.10 (-0.68)	-0.10 (-0.85)	-0.05 (-0.36)	-0.16 (-1.00)	-0.04 (-0.34)	0.49 (2.31)
Adj R^2	0.436	0.489	0.578	0.597	0.598	0.621	0.157
			Forward-looking period (L) = 6 months				
Intercept	0.27 (3.93)	0.16 (2.95)	0.17 (3.64)	0.11 (2.59)	0.10 (2.20)	0.09 (2.56)	0.10 (1.54)
TB	0.12 (1.28)	0.17 (2.90)	0.20 (3.98)	0.24 (5.23)	0.26 (5.29)	0.25 (6.99)	-0.00 (-0.01)
TERM	-0.00 (-0.00)	0.05 (0.33)	0.01 (0.12)	0.07 (0.62)	0.05 (0.49)	0.09 (1.11)	-0.04 (-0.17)
DEF	2.56 (5.34)	1.87 (4.74)	1.57 (5.16)	1.90 (6.20)	1.85 (5.39)	1.55 (6.37)	1.04 (2.25)
DIV	-25.98 (-5.18)	-16.20 (-4.30)	-15.92 (-4.64)	-14.48 (-4.63)	-13.72 (-4.24)	-12.08 (-4.54)	-6.04 (-1.40)
CONSUME	-0.81 (-0.55)	-0.46 (-0.37)	0.13 (0.13)	-0.18 (-0.19)	-0.20 (-0.20)	-0.39 (-0.63)	0.28 (0.25)
GDP	0.11 (0.31)	0.10 (0.40)	0.00 (0.01)	-0.04 (-0.21)	-0.07 (-0.31)	-0.15 (-1.02)	-0.24 (-0.71)
LABOR	0.06 (0.36)	-0.03 (-0.23)	-0.08 (-0.76)	0.01 (0.07)	-0.05 (-0.59)	0.07 (0.92)	0.43 (2.22)
Adj R^2	0.450	0.500	0.596	0.612	0.622	0.640	0.151

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

This table presents the estimation results of the time-series regression model of realized market returns on forward-looking macroeconomic variables:

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

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. Numbers in parentheses indicate *t*-statistics, which are adjusted by Newey-West heteroscedasticity and autocorrelation consistent (HAC) standard errors with lag of 4. The sample period is from January 1996 to December 2014.

	Forward-looking period (L)					
	L = 1 month	L = 2 months	L = 3 months	L = 4 months	L = 5 months	L = 6 months
Intercept	-0.00 (-0.02)	-0.01 (-0.28)	-0.00 (-0.06)	0.00 (0.14)	0.00 (0.05)	0.00 (0.12)
TB	-0.25 (-1.04)	-0.06 (-0.60)	-0.02 (-0.29)	-0.01 (-0.25)	0.01 (0.26)	0.01 (0.42)
TERM	-0.02 (-0.04)	0.10 (0.48)	0.11 (0.77)	0.09 (0.92)	0.10 (1.31)	0.09 (1.45)
DEF	-0.49 (-0.35)	-0.49 (-0.97)	-0.52 (-1.65)	-0.49 (-2.39)	-0.53 (-3.22)	-0.51 (-3.26)
DIV	-1.53 (-0.24)	0.97 (0.26)	0.78 (0.24)	0.47 (0.16)	1.48 (0.61)	1.50 (0.75)
CONSUME	4.18 (1.86)	1.76 (1.24)	1.32 (1.56)	0.95 (1.69)	0.74 (1.52)	0.53 (1.04)
GDP	0.99 (1.92)	0.51 (2.06)	0.20 (1.05)	0.11 (0.67)	0.04 (0.27)	0.02 (0.11)
LABOR	0.57 (1.59)	0.25 (1.47)	0.17 (1.45)	0.12 (1.21)	0.07 (0.78)	0.05 (0.60)
Adj R^2	0.096	0.086	0.084	0.084	0.085	0.083