



A new approach to measuring riskiness in the equity market: Implications for the risk premium



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ABSTRACT

We introduce a new approach to measuring riskiness in the equity market. We propose option implied and physical measures of riskiness and investigate their performance in predicting future market returns. The predictive regressions indicate a positive and significant relation between time-varying riskiness and expected market returns. The significantly positive link between aggregate riskiness and market risk premium remains intact after controlling for the S&P 500 index option implied volatility (VIX), aggregate idiosyncratic volatility, and a large set of macroeconomic variables. We also provide alternative explanations for the positive relation by showing that aggregate riskiness is higher during economic downturns characterized by high aggregate risk aversion and high expected returns.

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1. Introduction

Aumann and Serrano (2008) introduce an economic index of *riskiness* of gambles based on risk aversion. According to their definition, whether or not an individual takes a gamble depends on how risky the gamble is and how averse the individual is to risk. Hence, increases in risk should affect more risk-averse individuals more than they do less risk-averse individuals. This suggests that appropriate definitions of increases in risk and risk aversion should be closely linked. Aumann and Serrano (2008) define the riskiness of a gamble as a function of the risk-aversion of an individual who is indifferent between accepting and rejecting that gamble. Their riskiness index is positively homogeneous, continuous, and sub-additive; respects first- and second-order stochastic dominance; and indicates that less-averse individuals accept riskier gambles.

According to Aumann and Serrano (2008), if a gamble g is sure to yield more than h , it cannot be considered riskier. For risk-averse investors who prefer less risky alternatives (all else equal), riskiness and desirability are not in conflict, i.e., a less risky gamble is not always more desirable. That depends on the investor and on other parameters in addition to riskiness, such as the mean, maximum loss, opportunities for gain, and so on. Indeed, the decision depends on the whole distribution. Desirability is subjective: depending on the investor, one may prefer gamble g to gamble h , whereas another prefers h to g . Riskiness, however, is objective: it is the same for all individuals. Given two gambles, a more risk-averse individual may well prefer the less risky gamble, whereas a less risk-averse individual may find that the opportunities provided by the riskier gamble outweigh the risk involved.

In asset pricing literature, there is still an ongoing debate on how to quantify risk and how investors choose among risky assets. Indeed, Aumann and Serrano (2008, p. 811) points out “The concept of risky investment is commonplace in financial discussions and seems to have clear conceptual content. But when one thinks about it carefully and tries to pin it down, it is elusive. Can one measure riskiness objectively – independently of the person or entity taking the risk?”.

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In this paper, we relate expected future returns to riskiness, based on the conceptualization in [Aumann and Serrano \(2008\)](#). We show that equity investments become less desirable when riskiness in the equity market rises, and hence investors are less willing to hold equity or they demand extra compensation in the form of higher expected return to accept equity investments in riskier times. Therefore, we expect a positive relation between riskiness and expected returns.

We introduce a generalized measure of physical riskiness that nests the empirical measure proposed by [Aumann and Serrano \(2008\)](#) based on the assumption of normality. Since the distribution of market returns is typically skewed, peaked around the mean (leptokurtic) and has fat tails, we propose a measure of aggregate riskiness for the U.S. equity market based on the mean, standard deviation, and higher order moments of the empirical return distribution of the S&P 500 index.

In addition to the generalized measure of physical riskiness under the objective probability measure, we propose option implied measures of riskiness based on the risk-neutral distribution of market returns. We provide a model-independent measure of riskiness that can be obtained from the prices of S&P 500 index options and does not rely on any particular assumptions about the return distribution. Suppose an investor needs to find a one-month ahead expected riskiness of a stock market portfolio. Under the physical measure, riskiness can only be obtained from the past historical data (e.g., daily returns over the past one year) and the investor has to use this historical measure to proxy for future riskiness. However, this physical (or historical) measure may not provide an accurate characterization of the market's expectation of future riskiness. Using the prices of S&P 500 index options in the calculation of riskiness solves this problem by making future riskiness observable because index option prices incorporate the market's expectation of future return distribution.

After introducing the option implied and physical measures of riskiness, we investigate their performance in predicting future returns on the U.S. equity market. The intertemporal relation between risk and return in the aggregate stock market has been one of the most extensively studied topics in financial economics. Most asset pricing models postulate a positive relation between the market portfolio's expected return and risk, which is often defined by the variance or standard deviation of market returns. In his seminal paper, [Merton \(1973\)](#) shows that the conditional expected return on the aggregate stock market is a linear function of its conditional variance plus a hedging demand component that captures investors' motive to hedge against unfavorable shifts in the investment opportunity set. Despite the importance of the risk-return tradeoff and the theoretical appeal of Merton's result, the asset pricing literature has not yet reached an agreement on the existence of such a positive risk-return tradeoff.

This paper examines the intertemporal relation between the newly proposed measures of riskiness and future returns on the aggregate stock market. We generate time-varying measures of aggregate riskiness for the U.S. equity market based on the objective and risk-neutral probability measures. The physical measures of aggregate riskiness are estimated using the empirical return distribution of the S&P 500 index. The risk-neutral measures of aggregate riskiness are obtained from the prices of S&P 500 index options. The predictive regressions indicate a positive and significant relation between time-varying riskiness and expected market returns. This result is somewhat stronger for the option implied measures of aggregate riskiness compared to the physical measures. The significantly positive link between riskiness and equity premium remains intact after controlling for the S&P 500 index option implied volatility, aggregate idiosyncratic volatility of individual stocks, and a large set of macroeconomic and financial variables associated with business cycle fluctuations.

A large number of studies also investigate the intertemporal relation between macroeconomic variables and market returns: Expected returns are found to be related to business cycle fluctuations (e.g., [Keim and Stambaugh \(1986\)](#), [Campbell and Shiller \(1988\)](#), [Fama and French \(1988, 1989\)](#), [Fama \(1990\)](#), [Kandel and Stambaugh \(1990\)](#) and [Ferson and Harvey \(1991\)](#)). Earlier studies find that risk premia on stocks covary negatively with current economic activity: investors require higher (lower) expected returns in recessions (booms). As a supporting evidence for the counter-cyclical behavior of expected returns, average stock returns are found to be higher during periods of lower economic growth and after stock market declines.

We present a theoretical framework that justifies the positive link between aggregate riskiness and equity premium. Our empirical results not only confirm the positive theoretical relation between riskiness and market returns, but they also provide evidence that increases in riskiness and risk aversion are closely linked, consistent with the theoretical arguments of [Aumann and Serrano \(2008\)](#). In addition to the theoretical framework, we provide an alternative, macroeconomic based explanation for the strong positive relation between riskiness and market risk premium by testing whether aggregate riskiness is higher during economic downturns characterized by lower economic activity and higher expected returns. The results indicate a significantly positive relation between time-varying measures of riskiness and lower economic activity defined by the Chicago Fed National Activity Index and the [Aruoba et al. \(2009\)](#) business conditions index. We also find that aggregate riskiness is higher when (i) the growth rate of nominal and real GDP is lower; (ii) the unemployment rate is higher; and (iii) aggregate default risk is higher. These results provide a macroeconomic based explanation for our empirical finding that time-varying measures of riskiness positively predict future returns on the aggregate stock market.

Another potential explanation for the positive relation between aggregate riskiness and expected market returns can be based on a time-varying or state-dependent nature of investors' risk aversion. During large falls of the market and periods of poor economic growth, aggregate risk aversion increases due to short sale, liquidity, or financing constraints that hurt especially on the downside. The increased risk aversion implies higher expected returns next period. In addition to the story due to constraints, the consumption-based asset pricing model of [Campbell and Cochrane \(1999\)](#), the time-varying risk of rare economic disasters introduced by [Barro \(2006, 2009\)](#), and the psychological factors or behavioral biases proposed by [Black \(1988\)](#) provide further theoretical support for our empirical findings.

The remainder of the paper is organized as follows. Section 2 provides the original, physical measure of riskiness developed by [Aumann and Serrano \(2008\)](#). Section 3 presents a generalized measure of physical riskiness. Section 4 introduces a risk-neutral option implied measure of riskiness. Section 5 provides a theoretical framework that justifies the positive relation between aggregate riskiness and equity premium. Section 6 contains the data and variable definitions. Section 7 investigates the significance of an intertemporal relation between aggregate riskiness and expected market returns. Section 8 tests whether aggregate riskiness is higher during periods of lower economic activity. Section 9 concludes the paper.

2. The original concept of riskiness

[Aumann and Serrano \(2008\)](#) assume a von Neumann–Morgenstern utility function for money which is strictly monotonic, strictly concave, and twice continuously differentiable, and

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