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Roughing up beta: Continuous versus discontinuous betas and the cross section of expected stock returns☆

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ABSTRACT

We investigate how individual equity prices respond to continuous and jumpy market price moves and how these different market price risks, or betas, are priced in the cross section of expected stock returns. Based on a novel high-frequency data set of almost 1,000 stocks over two decades, we find that the two rough betas associated with intraday discontinuous and overnight returns entail significant risk premiums, while the intraday continuous beta does not. These higher risk premiums for the discontinuous and overnight market betas remain significant after controlling for a long list of other firm characteristics and explanatory variables.

1. Introduction

The idea that only systematic market price risk should be priced represents one of the cornerstones of finance. Even though numerous studies over the past half-century have called into question the ability of the capital asset pricing model (CAPM) to fully explain the cross section of expected stock returns, the beta of an asset arguably remains the most commonly used systematic risk measure in financial practice. Early work by Fama, Fisher, Jensen, and Roll (1969) and Blume (1970) generally supports the CAPM. Subsequent prominent empirical studies that call into question the explanatory power of market betas for satisfactorily explaining the cross section of expected returns include Basu (1977, 1983), Roll (1977), Banz (1981), Stattman (1983), Rosenberg, Reid, and Lanstein (1985), Bhandari (1988), and Fama and French (1992). Meanwhile,

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more recent empirical evidence pertaining to the equity risk premium and the pricing of risk at the aggregate market level suggests that the expected return variation associated with discontinuous price moves, or jumps, is priced higher than the expected continuous price variation.[1]

Set against this background, we propose a general pricing framework involving three separate market betas: a continuous beta reflecting smooth intraday co-movements with the market and two rough betas associated with intraday price discontinuities, or jumps, during the active part of the trading day and the overnight close-to-open return, respectively. The seminal paper by Merton (1976) hypothesizes that jump risks for individual stocks are likely to be nonsystematic. Empirical evidence of increased cross-asset correlations for higher (in an absolute sense) returns shown in Ang and Chen (2002), among many others, indirectly suggests nonzero systematic jump risk, as does the downside risk asset pricing model recently explored by Lettau, Maggiori, and Weber (2014). Consistent with the idea that investors view intraday smooth and that easier to hedge price moves differently from intraday rough and day-to-day overnight price changes, we find that the risk premiums associated with the two jump betas are both statistically significant and indistinguishable, while the continuous beta does not appear to be priced in the cross-section.[2]

The theoretical framework motivating our empirical investigations and the separate cross-sectional pricing of continuous and discontinuous market price risks is very general and merely assumes the existence of a generic pricing kernel along the lines of Duffie, Pan, and Singleton (2000). Importantly, we make no explicit assumptions about the pricing of other nonmarket price risks. As such, our setup includes the popular long-run risk model of Bansal and Yaron (2004), the habit persistence model of Campbell and Cochrane (1999), and the rare disaster model of Gabaix (2012), as special cases obtained by further restricting the functional form of the pricing kernel, the set of other priced risk factors, and the connections with fundamentals.

The statistical theory underlying our estimation of the separate betas builds on recent advances in financial econometrics related to the use of high-frequency intraday data and so-called realized volatilities. Bollerslev and Zhang (2003), Barndorff-Nielsen and Shephard (2004a), and Andersen, Bollerslev, Diebold, and Wu (2005, 2006), in particular, have explored the use of high-frequency data and the asymptotic notion of increasingly finer sampled returns over fixed time intervals for more accurately estimating realized betas. In contrast to these earlier studies, which do not differentiate among different types of market price moves, we rely on the theory originally developed by Todorov and Bollerslev (2010) for explicitly estimating separate continuous and discontinuous betas for the open-to-close active part of the trading day, together with overnight betas for the close-to-open returns.[3]

Our actual empirical investigations are based on a novel high-frequency data set of all the 985 stocks included in the Standard & Poor's (S&P) 500 index over the 1993–2010 sample period. We begin by estimating the three separate betas as well as a standard CAPM regression-based beta for each of the individual stocks on a rolling one-year basis. Consistent with the basic tenets of the simple CAPM, we find that sorting the stocks in our sample on the basis of their betas results in a positive return differential between the high- and low-beta quintile portfolios for all of the four different beta estimates. However, even though all of the return differentials are large numerically, the difference in the monthly returns between the high- and low-beta portfolios constructed on the basis of the standard CAPM betas is not significantly different from zero at conventional levels. Similarly, sorting by our continuous beta estimates, the monthly long–short excess return for the high- minus low-beta quintile portfolios is not significantly different from zero. Sorting stocks on the basis of their discontinuous and overnight betas, as well as their relative betas defined by the difference between either of the two jump betas and the standard beta, results in significantly positive risk-adjusted returns on the high–low portfolios.[4] More important from a practical perspective, we show that these same significant contemporaneous return differentials carry over to a predictive setting, in which we compare the subsequent realized monthly returns of the quintile portfolios based on grouping the stocks according to their past rolling one-year beta estimates.

These predictive return differentials associated with the discontinuous and overnight betas remain statistically significant in double portfolio sorts designed to control for a number of other firm characteristics and risk factors previously associated with the cross section of expected returns, including firm size, book-to-market ratio, momentum, short-term reversal, idiosyncratic volatility, maximum daily return, illiquidity, and various measures of skewness and kurtosis. Standard predictive Fama–MacBeth regressions further corroborate the idea that only rough market risks are priced. While the estimated risk premiums associated with the intraday discontinuous and overnight betas are both significant after simultaneously controlling for a long list of firm characteristics and other risk factors, the estimated risk premium associated with the continuous beta is not.

Our main empirical findings rely on a relatively coarse 75-minute intraday sampling frequency for the one-year

[1] Empirical evidence based on aggregate equity index options in support of this hypothesis is presented by Pan (2002), Eraker, Johannes, and Polson (2003), Bollerslev and Todorov (2011), and Gabaix (2012), among others.

[2] Optimally managing market diffusive and jump price risks require the use of different hedging tools and derivative instruments; see, e.g., the theoretical analysis in Liu, Longstaff, and Pan (2003a, 2003b). The increased availability of short-maturity out-of-the-money options, which provide a particular convenient tool for managing jump tail risk, also directly speaks to the practical importance of separately accounting for these different types of risks.

[3] Branch and Ma (2012), Cliff, Cooper, and Gulen (2008), and Berkman, Koch, Tuttle, and Zhang (2012) also show distinctly different return patterns during trading and non-trading hours.

[4] As discussed further in Section 5.2, this contrasts with the recent results in Frazzini and Pedersen (2014), who report an almost flat security market line and highly significant positive CAPM alphas for portfolios betting against beta.