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Leverage and asymmetric volatility: The firm-level evidence☆

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ABSTRACT

The relative statistical and economic significance of the leverage and feedback effects on firm-level equity volatility remain an open issue. We use a dynamic panel vector autoregression framework to investigate both effects simultaneously for all firms in CRSP and COMPUSTAT from 1971 to 2013. Crucially, we allow financial leverage, volatility and risk premia to influence each other over time. We find a much larger leverage effect than reported in Christie (1982). Importantly, we find that a change in leverage has a prolonged effect on volatility. The cumulative leverage effect is up to five times larger in twelve quarters than a static model would predict for one quarter.

1. Introduction

Although there is a considerable literature on the modeling of equity volatility, the relative importance of the various theoretically identified determinants is still an open controversy. In particular, the importance of the leverage effect identified by Black (1976) is not yet fully understood. The leverage effect refers to the increase in stock volatility due to an increase in financial leverage. For example, a drop in equity value leads to an increase in financial leverage and thus an increase in equity volatility. An alternative explanation put forward for the negative correlation between equity return and future volatility relates to the time-variability of risk premia. In this paper, we provide additional evidence on the importance of the leverage effect based on a large-scale firm-level study of equity volatility in an econometric model that allows for dynamic linkages between firm-specific equity volatility, financial leverage, and time-varying risk premia.

Our main finding is that financial leverage is an economically much more significant determinant of equity volatilities than previous work has documented. Furthermore, we find that a change in financial leverage affects equity volatility for several periods and its impact on volatility accumulates over time. Our study suggests that past results may be due to not fully allowing

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for the endogenous nature of the relationship between leverage and volatility — the choice of leverage and business risk is a joint decision for a firm.

Christie (1982) documents that equity variance has a strong positive association with financial leverage and that the negative elasticity of volatility with respect to the level of stock prices should be ascribed to financial leverage to a significant degree. This result is not without controversy. Figlewski and Wang (2000) use both returns and directly measured leverage to examine the effect of financial leverage as it applies to the individual stocks in the S&P 100 (OEX) index, and to the index itself. They find a strong asymmetry associated with falling stock prices, but also numerous anomalies that call into question financial leverage changes as a viable explanation. The authors conclude that the "leverage effect" is instead a "down market effect" that may have little direct connection to firm capital structure.

An alternative explanation for the observed relationship between stock price levels and volatility is attributed to time-varying risk premia. Following an increase in volatility priced by investors, required equity returns should increase, thus leading to an immediate drop in the equity value. This story, which argues a causality in the opposite direction to that predicted by the financial leverage effect, has garnered support in the literature.[1]

Bekaert and Wu (2000) argue that the leverage explanation is, in itself, not sufficient and that the alternative explanation, often known as the volatility feedback effect, is supported by the data. Duffee (1995) studies the relationship between returns and volatility in a large sample of U.S. firms. He finds that the leverage effect is mainly due to the positive contemporaneous correlation between firm stock returns and firm stock return volatility; the correlation between returns and future volatility appears to be weak. In a dynamic general equilibrium model, Aydemir et al. (2007) find that leverage contributes more to the dynamics of stock return volatility at the firm level.[2]

Given the mixed results in the literature, we construct a model that allows for both channels between stock prices and volatility. To do so, we rely on a panel vector autoregressive framework to describe the dynamics of financial leverage, equity volatility, and risk premia. Our sample, an unbalanced panel of 7754 firms, contains 201,381 firm quarters during the period 1971–2013.[3] To the best of our knowledge, this is the first study at the individual firm level to consider both volatility feedback and a leverage measure computed using firms' debt and equity data. In addition, we believe the scale of the study to be unprecedented, particularly in the context of a dynamic econometric model.

To establish a benchmark, we begin by estimating a bivariate panel vector autoregression (PVAR) that nests the Christie (1982) model. Unlike asymmetric GARCH-type or stochastic volatility modeling of asymmetric response, our model explicitly considers the relationship between volatility and firm level leverage ratios. In doing so, we document a stronger relationship between equity volatility and the debt ratio than that shown in Christie (1982). The coefficient estimates behave similarly across leverage quartiles, but they are economically more significant than in his study.

Our model imposes no structure on the VAR system and allows for a bidirectional relationship between leverage and volatility, thus permitting dynamic endogeneity between the two firm-level choice variables, i.e., capital structure and business risk. We find that this is important because the effect on volatility of a change in leverage is long lasting and accumulates over time.

Although the focus of our study lies on the relationship between leverage and volatility, we study the extent to which our results are dependent on the exclusion of time-varying risk premia from the system. We are reassured to find that our parameter estimates are robust to allowing for this alternative explanation for the link between stock price levels and volatility.

Theory suggests that expected returns, asset volatilities, and leverage dynamics are jointly determined. Our PVAR model allows the study of the contemporaneous correlation of unexpected changes in these variables. It also allows measuring cumulative effect of such changes.

To measure the cumulative effect of shocks to leverage, firm volatility and expected returns, we use impulse response functions. Consider, for example, the lowest leverage quartile: the immediate effect of a one standard deviation shock to leverage is that the annualized volatility increases by about 3.5%. However, the cumulative effect of the same shock to leverage over the next 12 quarters exceeds 10% annualized volatility. In the highest leverage quartile, the cumulative effect can exceed 40% annualized volatility. The cumulative effect can easily multiply the direct impact of a leverage shock by 5 times.

We study volatility feedback at the firm level. In the literature, volatility feedback denotes the asymmetric effect on required returns determined by an asymmetric response in the covariance risk (see e.g. Bekaert and Wu (2000), page 6). Covariance asymmetry can be generated by risk factor volatility asymmetry, equity volatility asymmetry, or correlation asymmetry. We limit ourselves to studying the feedback arising from the equity volatility channel. We refer to this as firm volatility feedback and all discussions on volatility feedback below refer to this notion unless otherwise specified. We find supporting evidence for firm volatility feedback.[4]

Lagged volatility does have a positive effect on the risk premium, but the effect does not accumulate over time in the way that the effect of financial leverage does. In addition, we find a small but significant negative contemporaneous correlation between the risk premium and the volatility.

[1] Brown et al. (1988) show that stock price reactions to unfavorable news events tend to be larger than reactions to favorable events, and attribute their findings to volatility feedback. Poterba and Summers (1986), on the other hand, argue against volatility feedback by pointing out that changes in volatility are too short-lived to have a major effect on stock prices.

[2] For recent advances on market level volatility asymmetry see e.g., Bollerslev et al. (2006), Smith (2007), Hibbert et al. (2008), Tim et al. (2012), Smith and Yamagata (2011), and Ait-Sahalia et al. (2013).

[3] The unbalanced structure of the data set mitigates any potential sample selection biases.

[4] See Section 2.2 for a more detailed discussion.