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The joint cross-sectional variation of equity returns and volatilities[☆]

Ana González-Urteaga[a], Gonzalo Rubio[b,*]

[a] Universidad Pública de Navarra, Spain
[b] Universidad CEU Cardenal Herrera, Spain

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ABSTRACT

This paper analyzes the determinants of the simultaneous cross-sectional variation of return and volatility risk premia. Independently of the model specification employed, the estimated risk premium associated with the default premium beta is always positive and statistically different from zero. Moreover, the risk premium of the market volatility risk premium beta is negative and statistically significant. However, both risk factors are priced economically and statistically differently in the volatility and return segments of the market. On average, common factors in both segments explain 90% of the variability of volatility risk premium portfolios, but only 65% of the variability of equity return portfolios.

1. Introduction

This paper analyzes one clear and well defined question. Does a specific factor model of the stochastic discount factor work for both returns and volatilities? We answer this question using two complementary empirical strategies. We first analyze the joint cross-sectional variation of return and volatility risk premia. Then, we provide a market segmentation test in the return and volatility segments of the market. Although we find strong signs of commonality between return and volatility risk premia, we formally reject the pricing integration of both segments and reject joint pricing models.

Understanding this simultaneous pricing, but also the statistical and economic differences in the drivers of risk premia in both the return and volatility segments of the market is the main contribution of this paper. Moreover, the use of new data to test asset pricing models alleviates the possibility that data mining drives the results. To the best of our knowledge, this is the first paper to address joint estimation of return and volatility risk premia on the same set of assets, and it presents new evidence regarding market segmentation between the return and volatility sections of the market. This joint analysis may allow discarding some risk factors proposed in the literature in explaining the average equity return premium, or the volatility premium, while providing supporting empirical evidence for other factors.

The inclusion of volatility risk premia at the joint cross-sectional variation of average returns and volatilities is a very different approach from previous studies, in which volatility is shown to be a relevant aggregate risk factor in the cross-section of expected returns.[1] We therefore argue that not only is aggregate stock market volatility priced, but also shocks to idiosyncratic volatility are priced in the cross-section. This justifies cross-sectional analysis of not only average equity return premia, but also the simultaneous cross-section of volatility risk premia. The most recent theoretical motivation for the cross-sectional pricing of idiosyncratic volatility is provided by Herskovic et al., (2016) who show that firms' idiosyncratic volatility presents a strong factor structure.[2] Their common idiosyncratic volatility

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* Corresponding author.
E-mail address: gonzalo.rubio@uch.ceu.es (G. Rubio).

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[1] The seminal paper of Ang, Hodrick, Xing, and Zhang (2006) shows that volatility risk is priced in the cross-section of equity returns. Along these lines, see also the consistent evidence provided by Campbell, Giglio, Polk, and Turley (2014), and Bali and Zhou (2016).

[2] Duarte, Kamara, Siegel, and Sun (2014) also show that the pricing of the U.S. idiosyncratic volatility risk is due to a common idiosyncratic factor that explain about a third of the variability in idiosyncratic volatility. At the international level,

(*CIV*) factor is related to income risk faced by households in a model with incomplete markets and heterogeneous agents. In this context, higher idiosyncratic volatility is shown to raise the average household's marginal utility. Indeed, González-Urteaga and Rubio (2016) analyze the determinants of the cross-sectional variation of the average volatility risk premia for a set of 20 portfolios sorted by volatility risk premium betas. The market volatility risk premium and, in particular, the default premium are shown to be key determinant risk factors in the cross-sectional variation of average volatility risk premium payoffs. The cross-sectional variation of risk premia reflects the different uses of volatility swaps in hedging default and the financial stress risks of the underlying components of the sample portfolios.

We assume that the stochastic discount factor (SDF), which jointly prices returns and volatility risk premia is a linear function of a set of aggregate risk factors and we test competing specifications. Using the estimation methodology recently proposed by Kan et al., (2013), we show that beta with respect to market volatility risk premia and the default premium beta have statistically significant risk premia that help to explain the joint cross-sectional variation of average return and volatility risk premia. The cross-sectional $\hat{R}^2$ of the two-factor model is 30.2% and is statistically different from zero. The default premium factor whose estimated risk premium related to the default premium beta is as high as 7.2% on annual basis, seems to be the key factor in explaining the joint cross-section of returns and volatilities. These empirical results hold even if we allow for errors-in-variable and potential misspecification of the models.

We also consider extensions of the two-factor model using the leverage factor of Adrian et al., (2014) and alternative measures of funding liquidity. In particular, we consider the TED spread and the funding liquidity proxy of Fontaine and García (2012). Although these measures help to explain the cross-sectional variation of returns and volatilities, it is important to note that, in all cases, both the market volatility risk premium and the default premium remain statistically different from zero.

Even more importantly, once the joint evidence is established, we also test for market segmentation, and analyze whether the risk premia of priced factors are equal in both the volatility and return segments of the market. We show that both the default and market volatility risk factors are priced economically and statistically differently in both segments. Moreover, the profitability factor of Fama and French (2015) is significantly priced in the volatility segment but not in the equity return section of the market. In addition, when sorting assets by the volatility risk premium beta to create 40 volatility and return portfolios, we find that, on average, common factors in both segments explain 90% of the variability of the volatility risk premium portfolios, but only 65% of the variability of the equity return portfolios. When we do the reverse exercise and sort assets by the stock market beta to create the 40 portfolios generating market beta spread, common factor explains, on average, 82% of the variability of the volatility risk premium portfolios, but only 59% of the variability of return portfolios. Interestingly, these results do not seem to depend on the way we sort portfolios to generate either volatility or market beta spread. Overall, our evidence implies that we reject the null hypothesis of market integration.

This paper proceeds as follows. Section 2 describes the pricing framework and the alternative asset pricing models that we employ in studying the joint cross-sectional variation of average return and volatility risk premia. Section 3 describes the data. Section 4 briefly discusses the model-free implied variance and the estimation of the volatility risk premium (*VRP*) at the portfolio level. Section 5 presents the basic characteristics of the 20 *VRP* beta-sorted portfolios and the corresponding 20 equity return portfolios. Section 6 discusses the econometric strategy and reports our simultaneous empirical findings for equity returns, and both volatility and variance risk premia. Section 7 discusses market segmentation, and the sources of pricing of our 40 portfolios distinguishing the effects from the 20 volatility and return portfolios. Finally, Section 8 presents our conclusions.

Bekaert, Hodrick, and Zhang (2012) show that idiosyncratic volatility is significantly correlated across countries due to growth opportunities, U.S. market volatility, and the risk sensitivity to business cycles.

2. Linear factor models of the stochastic discount factor for equity returns and volatilities

In a volatility swap, the buyer of a forward contract receives at expiration a payoff equals to the difference between the annualized volatility of stock returns and the fixed swap rate. The swap rate is chosen such that the contract has zero present value, which implies that the volatility swap rate represents the risk–neutral expected value of the realized return volatility:

$$E_t^Q\left(RV_{t,t+\tau}^a\right) = SW_{t,t+\tau}^a \tag{1}$$

where $E_t^Q(\cdot)$ is the time t conditional expectation operator under some risk–neutral measure Q, $RV_{t,t+\tau}^a$ is the realized volatility of asset (or portfolio) a between t and $t+\tau$, and $SW_{t,t+\tau}^a$ is the delivery price for the volatility or the volatility swap rate on the underlying asset a. The volatility risk premium of asset a is defined as

$$VRP_{t,t+\tau}^a = E_t^P\left(RV_{t,t+\tau}^a\right) - E_t^Q\left(RV_{t,t+\tau}^a\right) \tag{2}$$

where $E_t^P(RV_{t,t+\tau}^a)$ is the expected value of volatility under the physical measure P.

The fundamental pricing equation under the same SDF. $M_{t,t+\tau}$, prices equity return and volatility risk premia:

$$E_t^P\left[M_{t,t+\tau}\left(RVRP_{t,t+\tau}^a\right)\right] = 0 \tag{3}$$

where $RVRP_{t,t+\tau}^a$ is a vector containing both the return and volatility risk premia of asset a. We assume that the SDF, which jointly prices return and volatility risk premia is a linear function of a set of aggregate risk factors:

$$M_{t,t+\tau} = a + b_1 F_{1t,t+\tau} + b_2 F_{2t,t+\tau} + \ldots + b_K F_{Kt,t+\tau}. \tag{4}$$

Our empirical strategy employs the classic beta specification given by

$$E\left(RVRP_{t,t+\tau}^a\right) = \lambda_0 + \lambda_1\beta_1^a + \lambda_2\beta_2^a + \ldots + \lambda_K\beta_K^a \tag{5}$$

where $E(RVRP_{t,t+\tau}^a)$ is the unconditional expected value vector of both return and volatility risk premia of asset a, and β_k^a is a vector containing the exposures of the return and volatility risk premia to factor risk k. The main idea of the paper is to test whether the same factor model of the SDF prices simultaneously returns and volatilities (and variances). The chosen factors are based on the previous empirical evidence regarding both the cross-sectional behavior of average returns, and the recent results about the cross-sectional variation of volatility risk premia.

Regarding the cross-section of equity returns, under linear empirical pricing models, Maio and Santa Clara (2012) show that a three-factor model with market excess return, high-minus-low (*HML*) factor of Fama and French (1993, FF hereafter), and momentum factor (*MOM*) of Carhart (1997) consistently meet the ICAPM restrictions across alternative sorting portfolio procedures. The risk premium associated with the beta of the small-minus-big (*SMB*) factor of FF (1993) is not statistically different from zero in their sample. Kan et al., (2013, KRS hereafter) favor the three-factor model of FF (1993) and the five-factor ICAPM model of Petkova (2006), which, in addition to excess market return, includes aggregate dividend yield, one-month Treasury bill rate, slope of the Treasury yield curve, and corporate bond default spread or default