ARTICLE IN PRESS
ECMODE-03654; No of Pages 12
Economic Modelling xxx (2015) xxx–xxx
Contents lists available at ScienceDirect
Economic Modelling
journal homepage: www.elsevier.com/locate/ecmod

The impact of financial crises on the risk–return tradeoff and the leverage effect ☆

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ARTICLE INFO

Article history:
Accepted 5 March 2015
Available online xxxx

Keywords:
FIEGARCH-M
Financial crises
Financial leverage
International markets
Long memory
Risk–return tradeoff
Stock returns
Volatility feedback

ABSTRACT

We investigate the impact of financial crises on two fundamental features of stock returns, namely, the risk–return tradeoff and the leverage effect. We apply the fractionally integrated exponential GARCH-in-mean (FIEGARCH-M) model for daily stock return data, which includes both features and allows the co-existence of long memory in volatility and short memory in returns. We extend this model to allow the financial parameters governing the volatility-in-mean effect and the leverage effect to change during financial crises. An application to the daily U.S. stock index return series from 1926 through 2010 shows that both financial effects increase significantly during crises. Strikingly, the risk–return tradeoff is significantly positive only during financial crises, and insignificant during non-crisis periods. The leverage effect is negative throughout, but increases significantly by about 50% in magnitude during financial crises. No such changes are observed during NBER recessions, so in this sense financial crises are special. Applications to a number of major developed and emerging international stock markets confirm the increase in the leverage effect, whereas the international evidence on the risk–return tradeoff is mixed.

1. Introduction

Financial crises are times of simultaneous increases in risk and great losses in portfolio values. At face value, this basic observation may suggest that the risk–return relation during crisis periods is negative, and thus of opposite sign compared to the classical Merton (1973, 1980) positive risk compensation tradeoff. Negative volatility–return relations have been suggested in connection with the financial leverage and volatility feedback effects. The argument behind the financial leverage effect of Black (1976) and Christie (1982) is that an initial price drop increases the debt–equity ratio and hence expected risk. The volatility feedback effect is that increases in risk lead to higher discount rates and thus losses of value, e.g., Campbell and Hentschel (1992)—see also Black (1976 p. 179). More recently, Ang et al. (2006) have argued for a negative relation between volatility innovations and returns: Since volatility innovations are largest during crisis periods, stocks that comove with volatility pay off in bad states, and should thus require a smaller risk premium. The empirical evidence on these effects has been mixed, both regarding sign and significance, see, e.g., the discussion in Bollerslev and Zhou (2006) and the review by Lettau and Ludvigson (2010), and there has (to the best of our knowledge) been no systematic investigation of the possible changes in these effects during crisis periods.

In this paper, we show that the basic intuition described above appears to be wrong. Indeed, we show that the empirical relation between return and volatility turns positive exactly during financial crises, whereas it is negative or close to zero during normal periods. At the same time, the financial leverage effect increases by about 50% in magnitude during crisis periods. These changes are observed whether we focus on the recent subprime crisis or include all major financial crises starting with the Great Depression. On the other hand, the same changes in the financial effects (the risk–return relation and the leverage effect) are not observed during NBER recessions, suggesting that financial crises are somehow special.

We conduct our analysis in the framework of an extended version—with the financial parameters potentially changing during crises—of the FIEGARCH-M (or FIEGARCH-in-mean) model of Christensen et al. (2010), who generalize the FIEGARCH (fractionally integrated exponential generalized autoregressive conditional heteroskedasticity) model introduced by Bollerslev and Mikkelsen (1996). Many of the salient features of daily stock returns are well described by the FIEGARCH model. Thus, in addition to time-varying volatility and volatility clustering

☆ We are grateful to Fabio Canova, Jesus Gonzales, Eric Hillebrand, John Maheu, and seminar participants at CREATES/Aarhus University, Leibniz Universität Hannover, and the 2012 CFE conference for useful comments, and to the Canada Research Chairs program, the Social Sciences and Humanities Research Council of Canada (SSHRC), the Danish Social Science Research Council, and the Center for Research in Econometric Analysis of Time Series (CREATES, funded by the Danish National Research Foundation) for financial support.

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http://dx.doi.org/10.1016/j.econmod.2015.03.006
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Please cite this article as: Christensen, B.J., et al., The impact of financial crises on the risk–return tradeoff and the leverage effect, Econ. Model. (2015), http://dx.doi.org/10.1016/j.econmod.2015.03.006

(the ARCH and GARCH effects, as in Engle (1982) and Bollerslev (1986)), and the resulting unconditional excess kurtosis or heavier than normal tails, the model accounts for both long memory in volatility (fractional integration, as in the FIGARCH model of Baillie, Bollerslev and Mikkelsen (1996)) and the leverage effect, i.e., asymmetric volatility reaction to positive and negative return innovations (the exponential feature as in Nelson's (1991) EGARCH model). The FIEGARCH-M introduces a filtered volatility-in-mean generalization of the FIEGARCH model. The generalization allows a risk–return relation effect of changing conditional volatility on conditional expected stock returns, and generates unconditional skewness. Following recent literature (Ang et al. (2006) and Christensen and Nielsen (2007)), it is the change in volatility that enters the return equation. The filtering of volatility when entering it in the return specification implies that the long memory property of volatility (the fractionally integrated feature) does not spill over into returns, which would be theoretically and empirically unwarranted. Christensen et al. (2010) show that the FIEGARCH-M model dominates the original FIEGARCH model as well as many other GARCH-type models (including EGARCH, GARCH-M, Spline-GARCH, etc.) according to standard criteria.

The extension in the present paper of the FIEGARCH-M model allows for a change in the financial parameters, in particular, the volatility-in-mean effect and the leverage effect, during financial crises. An application to CRSP value-weighted cum-dividend stock index return series from 1926 through 2010 for the U.S. shows that both financial effects increase significantly during crises. Strikingly, the risk–return tradeoff is significantly positive only during financial crises, and insignificant during non-crisis periods. The leverage effect is negative throughout, but increases significantly by about 50% in magnitude during financial crises. Again, since no such changes are observed during NBER recessions, financial crises are special in this sense. Applications to a number of major developed and emerging international stock markets confirm the increase in the leverage effect, whereas the international evidence on the risk–return tradeoff is mixed.

Our results suggest that a given increase in the debt/equity ratio leads to a greater increase in expected risk during crisis periods than during normal periods. Under the volatility feedback interpretation, the results suggest that a given increase in risk increases the discount rate more during financial crisis than during normal periods. This is consistent with an increase in the (positive) risk–return relation during crises, which is what we also find.

It is noteworthy that our empirical results do not stem simply from the fact that financial crises are periods of negative returns and increased risk. Specifically, by itself, this basic empirical relation would suggest a negative risk–return relation, particularly during crisis periods, whereas we find the opposite. Of course, a naïve analysis, just regressing the return (or its sign) on the indicator variable for crisis periods, would yield a negative coefficient. So would a regression of the return (or its sign) on volatility measures not correcting for financial leverage or volatility feedback. This is the well-known identification issue that leverage or feedback may induce a negative bias in the measured risk–return relation. Our contribution is that the best-fitting model considered includes the interaction of a leverage or feedback effect in the volatility equation and a volatility-in-mean effect in the return equation, with both effects increasing during financial crises. In particular, as the coefficient on volatility changes in the estimated return equation goes from negative or near zero during normal periods to positive (consistent with the classical equilibrium asset pricing risk–return relation) during crisis periods, the result is opposite of that from the naïve analysis, or from the literature plagued by identification issues.

In statistical terms, as the interacting leverage and volatility-in-mean effects and the changes in these during crises are jointly significant in our preferred model, all these features appear to be identified. In economic terms, it is clear that, firstly, the basic observation that negative returns and increases in risk go hand in hand during financial crises is captured in our model by the leverage effect that furthermore increases during crisis periods, rather than by a negative risk–return relation. Secondly, when a negative return according to the leverage idea leads to increased debt/equity ratio and therefore increased risk and ultimately increased expected future return, or, according to the volatility feedback interpretation, when an increase in risk leads to an increased discount rate and hence lower price, i.e., a negative return, then under both interpretations the maintained economic rationale is in fact positive risk compensation. This corresponds to our empirical finding that the estimated negative volatility–return relation in the volatility equation (interpreted as leverage or feedback) and the strengthening of this during crises is paralleled by a positive volatility-in-mean effect in the return equation, kicking in exactly during financial crisis periods.

In the next section, we present the FIEGARCH-M model with changing financial parameters, which incorporates all the above mentioned features. Section 3 describes the data and presents the empirical results, first for the U.S. and then for the other countries considered. Section 4 concludes.

2. The FIEGARCH-M model with changing financial parameters

The finding that volatility exhibits long memory is well established in the recent empirical literature[1], and financial theory may accommodate long memory in volatility as well, see Comte and Renault (1998). Many of the studies of long memory in volatility use GARCH-type frameworks, but to the best of our knowledge the only such model that includes a volatility-in-mean specification, i.e., a parametric relation across conditional means and variances, is the FIEGARCH-M model of Christensen et al. (2010). This model generalizes the FIEGARCH model of Bollerslev and Mikkelsen (1996) by introducing volatility into the return equation along the lines of the GARCH-M literature, following Engle et al. (1987). Since long memory in volatility introduced into the return equation in a linear fashion generates long memory in returns, which is neither theoretically nor empirically warranted, it is the change in volatility rather than the volatility level that enters the in-mean specification and induces a volatility–return relation. This follows Ang et al. (2006) and Christensen and Nielsen (2007).

In this section, we consider an extension of the FIEGARCH-M model to allow for changes in the financial parameters, in particular, the volatility-in-mean effect and the financial leverage effect, during financial crises.

2.1. Time-varying volatility-in-mean effect

Let the daily continuously compounded returns on the stock or stock market index be given by

$$r_t = ln(P_t) - ln(P_{t-1}), \tag{1}$$

where t is the daily time index and P_t is the stock price or index level at time t. We use the conditional mean specification

$$r_t = \mu + \lambda_1 h_t + \lambda_{11} D_t h_t + \varepsilon_t, \tag{2}$$

where volatility changes enter in the form of h_t, defined in Eq. (5) below as the filtered (fractionally differenced) conditional variance, and D_t is an indicator variable taking the value 1 if a financial crisis is ongoing as of $t-1$ (when the conditional mean is formed), and 0 otherwise. In the original FIEGARCH-M model, $\lambda_{11} = 0$, and in the FIEGARCH model, $\lambda_1 = \lambda_{11} = 0$. Thus, the specification allows for a volatility–return relation through the parameter λ_1, and in the extended model of this paper, λ_{11} represents the change in this relation during financial crises. It is assumed that D_t is in the information set $\mathcal{F}_{t-1}$ at time $t-1$,

[1] See, e.g., Baillie et al. (1996), Bollerslev and Mikkelsen (1996), Ding and Granger (1996), Breidt et al. (1998), Robinson (2001), Andersen et al. (2003), and the references therein.