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On the Impacts of Crisis on the Risk Premium: Evidence from the US Stock Market using a Conditional CAPM

Arouri Mohamed El Hédi
EDHEC Business School

Jawadi Fredj
Amiens School of Management, LEO Université d''Orléans

Abstract

This article investigates the evolution of the US risk premium in periods of crisis. First, we estimate a conditional CAPM with time-varying systematic risk and price of risk using a multivariate GARCH-in-Mean model. Second, we study the structural breaks in the risk premium we obtain. Finally, we relate our results to important facts and economic events. Our findings show that the US risk premium increased significantly during periods of crisis and that the last 2007-2009 financial crisis has had the largest impact.

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1- Introduction

Periods of economic and financial crisis are often characterized by high stock market volatility and financial instability. Moreover, during periods of crisis a higher risk aversion seems to be very reasonable given the excessive fear of market participants about what is going on in the markets. Thus, averse invertors should require a larger risk premium during economic troughs than during expansionary phases of the business cycle.

For example, consider the recent subprime crisis. The latter has caused an international economic and financial crisis that has affected the US market and those of most developed and emerging countries. Several theoretical and empirical studies have discussed the origins and consequences of this crisis [Allen and Gale (2007), Greenlaw *et al.* (2008), Mian and Sufi (2008), Reinhart and Rogoff (2008), Shiller (2008), and Jawadi (2009) among others]. According to these studies, the origins of the crisis were mainly: subprime credit strategies, asset and firm evaluation methods, securitization, derivative products, as well as key macroeconomic factors such as interest rate and exchange rate variations. As for the consequences of the global 2007-2009 crisis, the above papers report high financial instability, significant contagion effects and volatility spillovers between national stock markets, and interestingly, large lack of confidence in financial markets and government policies.

The present paper attempts to contribute to the debate about the impacts of crises on stock markets by focusing on the evolution of the expected risk premium during periods of crisis. The risk premium is defined as the additional remuneration required by investors to invest in risky assets. Investigating the evolution of risk premium over time is particularly interesting since it constitutes an important key for investment and capital budgeting decisions. Thus, this yields some sights regarding the investment evolution and strategy in the post-period of this global financial crisis, as well as the evolution of investors' confidence and the effectiveness of financial regulations and government policies. To the best of our knowledge, none of the previous studies has investigated empirically the impacts of the recent global economic and financial crisis on the expected stock market risk premium and compared its effects with those of previous important crises.

Methodologically, we develop a dynamic conditional version of the capital asset pricing model (CAPM), which allows for time-varying quantity and price of risk and investigate the evolution of the US stock market risk premium over the last three decades. In addition, we study the structural breaks in the price of risk, the US systematic risk and risk premium. Overall, our findings show that the US risk premium increased significantly in periods of crisis and that the last subprime crisis has had the largest impact on the US risk premium over the last three decades. Indeed, this crisis was associated with the highest risk aversion and systematic risk.

The remainder of the article is organized as follows. Section 2 presents the methodology. Section 3 describes the data and discusses the main empirical results. Concluding remarks are summarized in section 4.

2- Methodology

The CAPM predicts that the expected excess return on an asset is proportional to its nondiversifiable risk, measured by its covariance with the market portfolio. Under the hypotheses of stock market integration and purchasing power parity, a conditional version of the CAPM can be written as follows [Adler and Dumas (1983), and Harvey (1991)]:

$$E\left(R_{it} \mid \Omega_{t-1}\right) = \delta_{w,t-1} Cov\left(R_{it}, R_{wt} \mid \Omega_{t-1}\right), \quad \forall i, \tag{1}$$

where R_{it} and R_{wt} are respectively the excess returns on asset *i* and on the world market, $\delta_{w,t-1}$ is the price of world market risk. Expectations are taken with respect to the set of information variables Ω_{t-1} available on (t-1).

Next, consider the econometric methodology. Equation (1) has to hold for both the US and world markets. Under rational expectations, we can write:

$$\begin{aligned} R_{us,t} &= \delta_{w,t-1} h_{us,w,t} + \varepsilon_{us,t}, \\ R_{w,t} &= \delta_{w,t-1} h_{wt} + \varepsilon_{w,t}, \end{aligned} \tag{2}$$

where $\varepsilon_t = (\varepsilon_{us,t}, \varepsilon_{w,t})' \mid \Omega_{t-1} \sim \mathrm{N}(0, \mathrm{H}_t)$, H_t is the (2×2) conditional covariance matrix of returns, $h_{us,w,t}$ is the conditional covariance between US and world markets (the US systematic risk), and $h_{w,t}$ is the conditional variance of the world market.

H_t is given by:

$$\mathrm{H}_t = C'C + aa' * \varepsilon_{t-1}\varepsilon'_{t-1} + bb' * \mathrm{H}_{t-1}, \tag{3}$$

where C is a (2×2) lower triangular matrix and a and b are (2×1) vectors.

Finally, turn to the price of risk. The evidence in Harvey (1991) and De Santis and Gerard (1997) suggests that the price of risk is time-varying. Furthermore, Merton (1980) and Adler and Dumas (1983) show the price of world market risk to be equal to the world aggregate risk aversion coefficient. Since most investors are risk averse, the price of risk must be positive. In this paper, we follow previous works to specify the evolution of price of risk [Harvey (1991) and Carrieri *et al.* (2007)]. This price is modelled as a positive function of information variables: $\delta_{w,t-1} = \exp(\kappa'_w Z_{t-1})$, where Z is a set of global variables included in Ω_{t-1}. The quasi-maximum likelihood (QML) method is used to estimate the model.

Once the time-varying price of risk, systematic risk, and risk premium become available, we test for structural breaks. Let x_t be the variable under consideration (*i.e.* the price of risk, systematic risk, and risk premium). We consider the following mean-shift model with *m* breaks, $(T_1, T_2, \ldots, T_m)$:

$$x_t = \theta_j + \xi_t, \qquad t = T_{j-1} + 1, \ldots, T_j, \tag{4}$$

for $j = 1, \ldots, m+1$, $T_0 = 0$ and $T_{m+1} = T$. θ_j are the regression coefficients with $\theta_i \neq \theta_{i+1}$ $(1 \le i \le m)$, and ξ_t is the error-term. The estimation method developed by Bai and Perron (1998) is based on the ordinary least-squares principle. It consists in estimating the regression coefficients θ_j, and the break dates $(T_1, T_2, \ldots, T_m)$ under the condition that $T_i - T_{i-1} \ge [\varepsilon T]$, where ε is an arbitrary small positive number and [.] denotes integer part of argument.

In practice, we employ the selection procedure proposed by Bai and Perron (2003) in order to estimate the number of breaks. More precisely, we first look at the results of tests $UD\max F_T$ or $WD\max F_T$,[1] to see if at least one structural break exists. Then, the number of breaks is determined based upon a sequential examination of a test $\sup F_T(l+1/l)$.[2] Finally, we choose *m* break dates such that the test $\sup F_T(l+1/l)$ is not significant for any $l \ge m$.[3]

[1] The hypothesis of no break versus an unknown number of changes given a maximum number of breaks *M* for *m* is tested.
[2] This test tests the null hypothesis of *l* breaks against its alternative of the presence of an additional break.
[3] For more details about the application of this test procedure, see Bai and Perron (2003), and Arouri and Jouini (2009).

3- Data and Empirical Results

We first introduce the data we use. Then, we discuss the empirical results we obtain and run some robustness tests. Finally, we test for structural breaks in the price of risk, the US systematic risk and the US risk premium and investigate the evolutions of these variables in times of crisis.

Data

We use monthly stock returns for the US and world markets over the period January 1970–October 2009. This sample period includes different crisis (oil shocks, the US monetary crisis, October 1987 crash, the Internet bubble, and the subprime crisis, among others). Stock returns include dividend yields and are computed in excess of the US T-bill rate.

The price of risk is modeled as a function of a certain number of instruments, which are designed to capture expectation about business cycle fluctuations. The logic that justifies the use of these instruments is that investors become more risk averse during economic troughs while the market price of risk decreases during expansionary phases of the business cycle. However, the CAPM is a partial equilibrium model and it does not specify state variables that can explain the observed dynamics of the prices of risk. In order to preserve the comparability between this study and others studies, the choice of information variables is mainly drawn from previous empirical literature in international asset pricing [Harvey (1991) De Santis *et al.* (2003)]. Thus, the set of global information includes a constant, the MSCI world dividend price ratio in excess of the 30-day Eurodollar deposit rate (WDY), the change in the US term premium spread (DUSTP), the US default premium (USDP) and the change on the one month Eurodollar deposit rate (DWIR). The data we use are obtained from DataStream International and MSCI databases.

Descriptive statistics for returns and information variables are presented in Table I. Panel A reveals a number of interesting facts. The US and world stock markets have very similar behaviors. Skewness is negative and kurtosis is above three. The Jarque-Bera test statistic (JB) strongly rejects the normality hypothesis and the Ljung-Box test shows significant autocorrelation of order 12 for the return squared. These facts support our decision to use the quasi-maximum likelihood (QML) approach of Bollerslev and Wooldridge (1992) to estimate the multivariate GARCH-in-Mean model. As a check for multicollinearity, the statistics displayed in Panel B show that the correlations among the information variables are low. This evidence suggests that our proxy of the information set contains no redundant variables.

Estimates results

Table II contains parameter estimates and diagnostic tests. The ARCH and GARCH coefficients reported in panel B are significant for all assets. This is in line with previous results in the literature. The estimations of the coefficient ***a*** are relatively small in size, which indicates that conditional volatility does not change very rapidly. However, those of the coefficient ***b*** are large, indicating gradual fluctuations over time. Panel A shows the mean equation parameter estimates, Panel C presents standardized residual diagnostics and Panel D reports a specification test. Most information variables are significant and the average price of market risk is equal to 2.64 and is highly significant, which is consistent with the findings by earlier studies. On the other hand, the conditional version of the model implies that investors update their strategy using the new available information. Thus, there is no reason to believe that the equilibrium price of risk will stay constant. The robust Wald test for the time-varying parameters in the price of world market risk rejects the null hypothesis at any standard level. Finally, diagnostics of standardized residuals show that compared to returns series, the non-normality is reduced and there is no residual autocorrelation.

Robustness tests

Next, we consider a number of robustness tests. To address this issue, we estimate an augmented version of the model that includes, in addition to market risk, a country specific constant and the instrumental variables Z :

$$\begin{aligned} R_{us,t} &= \alpha_{us} + \delta_{w,t-1} h_{us,w,t} + \varphi Z_{t-1} + \varepsilon_{us,t}, \\ R_{w,t} &= \alpha_{w} + \delta_{w,t-1} h_{wt} + \varepsilon_{w,t}, \end{aligned} \tag{5}$$

The inclusion of the country-specific constants can be interpreted as a measure of mild segmentation or as an average measure of other factors that cannot be captured by the model like differential tax treatment. The inclusion of information variables can be interpreted as a way to test whether any predictability is left in these variables after they have been used to model the dynamics of the US risk prices.

The test results are reported in Table III. The Wald test indicates that the country intercepts are not jointly different from zero. On the other hand, the null hypothesis that the coefficients of information variables are jointly equal to zero cannot be rejected at any standard level. Taken together, our findings support the stock market integration hypothesis and show that the CAPM is suitable for modeling the US stock returns. These results are consistent with the findings of De Santis and Gerard (1997) and Gerard *et al.* (2003).

Structural Breaks

Finally, we explore changes in patterns of the world price of risk, the US systematic risk and the US risk premium. In our framework, fluctuations in the risk premium have two distinct sources: both the covariance of the US with the world market (the US systematic risk, $Cov(R_{us,t}, R_{w,t} \mid \Omega_{t-1})$) and the risk price ($\delta_{w,t-1}$) are allowed to vary over time. Figures 1, 2 and 3 plot the time-varying price of risk, US systematic risk and US risk premium respectively. The later (the US risk premium) is defined as follows: $MRP_{us,t} = \delta_{w,t-1} Cov(R_{us,t}, R_{w,t} \mid \Omega_{t-1})$.

Figure 1 plots the estimated price of world market risk. As in earlier studies, the point estimates are very noisy. Since we are especially interested in the trend in the series, the Hodrick and Prescott (HP) filter is used to separate the short-term components from the long-term component.

Risk averse investors should demand higher expected returns at times of high expected risk in the economy. Thus, at times of uncertainty, the price of risk should be higher than at times of calm, which seems to be confirmed in Figure 1. In fact, the spikes in the conditional price of risk in Figure 1 are associated with the oil crisis (1973-1974), the monetary experiment (1979-1982), the Gulf wars (1991-2003), crises in emerging markets (1992,1993, 2001) and the terrorist attacks on US (2001). More importantly, the most recent economic and financial crisis (2007-2009) has caused a sharp peak in the world price of risk suggesting a sensible lack of confidence in the future of financial markets. Furthermore, Figure 2 shows that the US systematic risk was higher in periods of previous crisis and that the largest systematic risk was observed during the subprime crisis (2007-2009). Consequently, the US risk premium increased during periods of crisis as shown by Figure 3.

Table IV summarizes the results of the structural break procedure for M = 5 and ε = 0.10 applied to the world price of risk, the US systematic risk and premium series. The null hypothesis of stability is rejected since the Bai-Perron’s test detects breakpoints for the three series. Four break dates are obtained for the world price of risk and the US systematic risk and five break dates for the US risk premium. The detected breaks can be related to important economic crises and facts: oil shocks and the monetary experiment (1979-1982), the Internet bubble (1999-2000), the Gulf war (2003). More interestingly, the last international financial crisis (2007-2008) has significantly increased the US risk premium by increasing both the world price of risk (reflecting a lack of confidence in the future of financial markets) and the US systematic risk (reflecting a high instability of financial markets).

4- Conclusion

In this article, we investigate the evolution of the US risk premium over the period: January 1970-November 2009. First, we use a multivariate GARCH-M model and estimate a conditional CAPM with time-varying systematic risk and price of risk. Second, we study the structural breaks in the US risk premium using the Bai and Perron procedure. Finally, we reconciliate between the obtained results and some important facts and economic events. Mainly, our results show that the US risk premium increased significantly in periods of crisis and that the last subprime crisis has had the largest impact on the US risk premium over the last three decades.

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Table I: Descriptive statistics

Monthly equity returns are in US dollar and computed in excess of the T-bill rate. The sample covers the period January 1970 – October 2009. The test for Kurtosis coefficient has been normalized to zero. B-J is the Bera-Jarque test for normality based on excess skewness and Kurtosis. Q is here the Ljung-Box test for autocorrelation of order 12 for the returns and for the returns squared. Global information variables are the MSCI world dividend price ratio in excess of the T-bill rate (WDY), the change in the US term premium spread (DUSTP), the US default premium (USDP) and the change on the one month Eurodollar deposit rate (DWIR).

Panel A: Excess returns

Summary Statistics

	Mean (% per year)	Std. Dev. (% per year)	Skewness	Kurtosis	B-J	$Q(z)_{12}$	$Q(z^2)_{12}$
USA	3.868	54.273	-0.426*	1.842*	82.115*	12.662	39.841*
World	3.821	52.107	-0.573*	1.727*	85.606*	21.334**	49.329*

Unconditional correlations of excess returns

	Mexico	World
Mexico	1.000	
World	0.866	1.000

Panel B: Information Variables

World information variables

	WDY	DUSTP	USDP	DWIR
Mean	-3.462	0.009	1.114	-0.016
Std. Dev.	2.880	0.525	0.475	0.507

Unconditional correlations of conditional variables

	WDY	DUSTP	USDP	DWIR
WDY	1.000			
DUSTP	0.011	1.000		
USDP	0.098	0.156	1.000	
DWIR	-0.067	-0.359	-0.091	1.00
LDY	0.043	-0.108	-0.163	0.056

*Note: *, ** and *** denote statistical significance at the 1%, 5% and 10%..*

<u>Table II</u>: QML estimates - Model (2)

<u>Panel A</u>: Mean equations

	Const.	**WDY**	**DUSTP**	**USDP**	**DWIR**
Price of market risk	1.089*	0.220*	-0.044	0.251*	-0.615*
	(0.025)	*(0.066)*	*(0.028)*	*(0.041)*	*(0.028)*

<u>Panel B</u>: GARCH process

	USA	**World**
A	0.020*	0.055*
	(0.008)	*(0.011)*
b	0.694*	0.521*
	(0.187)	*(0.104)*

<u>Panel C</u>: Standardized residual diagnostics

	USA	**World**
Skewness	-0.422*	-0.569*
Kurtosis	1.837*	1.586*
J.B.	82.073*	70.025*
$Q(z)_1$	10.984	12.503
$Q(z^2)_{12}$	12.135	10.767

<u>Panel D:</u> Specification test

Null hypothesis	χ^2	***df***	***p-value***
Is the price of world risk constant? $H_0: \ \delta_{w,j}=0 \quad \forall j>1$	710.58	4	0.000

Note: **, ** and *** denote significance at 1%, 5% and 10%.. QML robust standard errors are in parentheses. Q is the Ljung-Box test for autocorrelation of order 12 for the standardized residuals and for the standardized residuals squared. In order to preserve space, estimates of C are not reported.*

<u>Table III:</u> Robustness tests – Model (5)

Null hypothesis	χ^2	***df***	***p-value***
Are country-specific constants all equal to zero? $H_0: \ \alpha_i = 0 \quad \forall i$	0.177	2	0.914
Are the local information variable coefficients jointly equal to zero? $H_0: \ \phi_i = 0 \quad \forall i$	1.320	4	0.861

<u>Table IV</u>: Dates of significant structural breaks

Break Dates	$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$	$\hat{T}_5$
Price of risk	1979:12 [1978:06-1981:03]	1980:06 [1980:04-1980:12]	1982:08 [1982:06-1983:04]	2009:02 [2008:06-2009:07]	
Systematic risk	2000:11 [2000:06-2000:11]	2003:07 [2003:06-2003:09]	2008:08 [2008:02-2008:12]	2009:05 [2009:01-2009:06]	
Risk premimum	1979:12 [1979:09-1980:02]	1980:08 [1980:06-1981:04]	2008:02 [2007:06-2008:03]	2008:11 [2008:06-2008:12]	2009:03 [2009:02-2009:07]

Note: The breakpoint procedure of Bai and Perron (1998, 2003) is based on the Bayesian Information Criteria (BIC). First, we arbitrarily set the maximum number of breaks to be 5. If the effective number of breaks is equal to 5 a higher number of breaks will be chosen. None of our variables has more than 6 breakpoints. 95% confidence intervals are reported into parentheses.

Figure 1: The world price of risk

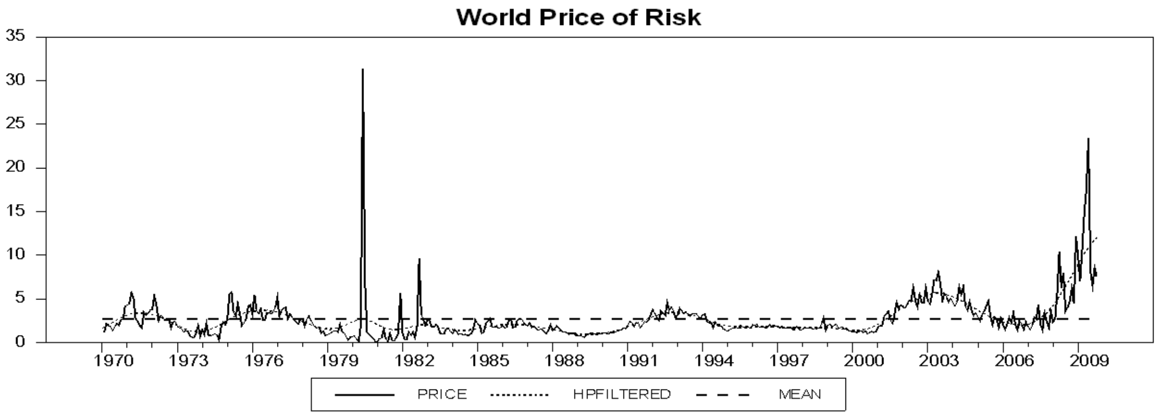

Figure 2: The US systematic risk

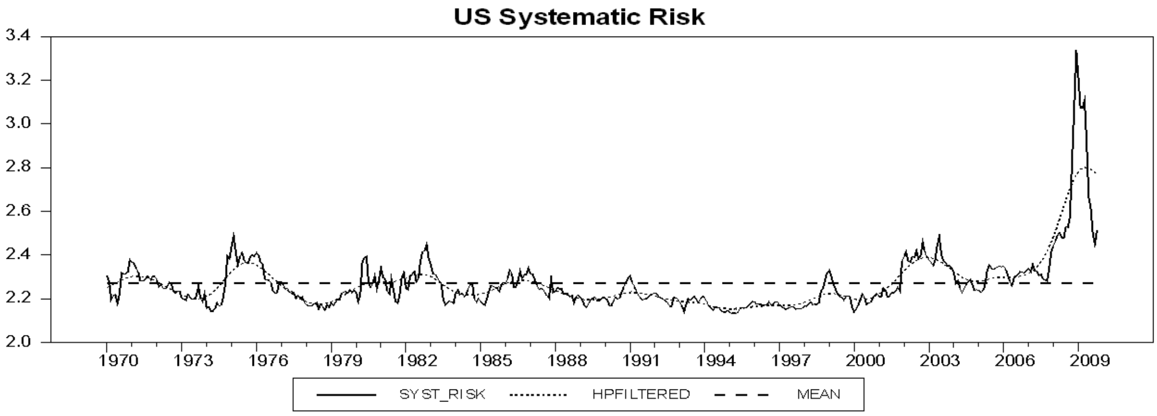

Figure 3: The US risk Premium