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Conditional Correlations between Stock Index, Investment Grade Yield, High Yield and Commodities (Gold and Oil) during Stable and Crisis Periods

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Abstract

We analyzed the conditional correlation between the returns of five assets (S&P 500, investment grade bond, high-yield bond, crude oil and gold). The results obtained with the AGDCC model lead to several conclusions. The correlations between the assets retained are feeble during stable periods. In periods of financial crisis with sustained economic growth, adding gold, crude oil, high-yield bonds and investment-grade bonds in a portfolio can improve the benefit of this portfolio. However, investors should adjust their portfolio when concerns about the economic growth appear as crude oil is negatively correlated with the returns of the S&P 500 and the high-yield bond during crisis periods, but it is positively correlated with those assets' returns when the crisis is coupled with economic recession. Regarding the high yield bond, it losses less value than stock index during bear market and it appreciates as much as stock index during bull market. As for the gold, it is a strong safe haven during periods characterized by fears of recession, concerns regarding the credit markets, target rate cuts, as well as uncertainties regarding inflation rate. Thus, gold was not a safe haven during the Asian and the Russian crises, whereas it was a weak safe haven during the dot-com crisis and a strong safe haven during the subprime crisis. During these crises, due to the "flight-to-quality" gold value appreciated strongly compared to the other assets retained. Furthermore, with the aggravation of the economic and financial situation the negative impacts of the subprime crisis have spread from stock market and high-yield bonds to other financial markets (contagion), except to the gold market.

Keywords: conditional correlation, DCC Model, financial crisis, stock index, high-yield bond, investment-grade bond, crude oil, gold

1. Introduction

The benefits of portfolio diversification depend strongly on the correlation between the returns on the assets composing the portfolio. Lesser are correlated assets composing a portfolio, more effective is the risk reduction of loss of this portfolio and then better is the benefit of diversification. Correlations change over time in response to their fundamentals, and are mainly related to economic/monetary and financial integration as well as the economic and financial situation (Erb et al., 1994; Longin and Solnik, 1995; Goetzmann et al., 2005). Investors need constantly to determine the correlations across asset classes and readjust their portfolios in order to improve the trade-off between risk and returns, mainly during financial crises when the risk reduction of loss and the improvement of benefits of diversification are needed most.

The analysis of the benefit of a portfolio diversification is then based on the examination of the correlations across different assets' returns composing a portfolio. In the empirical literature, authors have mainly considered the interdependence between two asset classes, and particularly between government bonds and stock indices (Note 1). Few authors have been attracted by the correlation between stock index (or equities) and crude oil (Jones and Kaul, 1996; Faff and Brailsford, 1999; Sadorsky, 1999) or by the correlation between stock index (or equities) and gold (Jaffe, 1989; Johnson and Soenen, 1997; Davidson et al., 2003). In order to complete the existing studies,

we examine in this paper the correlation across five US assets; which are the high yield bond, the investment grade bond, the S&P 500, crude oil and gold. Compared to several authors who considered government bonds in their studies only few authors, such Briere et al., (2008), Reilly et al., (2009), have retained high-yield bonds and investment-grade bonds. As we will see in this article adding these both bonds in a portfolio can improve the benefit of a portfolio.

High-yield bonds (HY bond), called junk bonds with credit ratings below BBB (S&P) or Baa3 (Moody's), are a combination of equity and riskless bonds. Empirically it is shown that correlation coefficients consistently show that straight HY bonds trade very much like stocks as pure debt instruments (Bookstaber and Jacob, 1986; Blume and Keim, 1991; Cornell and Green, 1991; Ramaswami, 1991; SEI Capital Markets Research, 1994; Shane, 1994). However, the correlation between HY bonds and equities (stock indices) tend to rise sharply when equities are characterized by negative returns due to the fact that much of the return of HY bonds is a result of default risk associated with equities. Nevertheless, the returns of HY bonds might decrease less than those of equities (or stock index) as HY bonds offer lower overall risk than equities/stock since bondholders are paid ahead of shareholders in case of bankruptcy. Furthermore, the "riskadjusted" returns of portfolios of HY bonds might be high compared to equities/stocks. Thus, the credit risk of these bonds is more compensated for by their higher yields. In sum, adding HY bonds in a portfolio might reduce losses in periods of crisis.

Compared to HY bonds, investment-grade bonds (IG) are less risky since their risks are more related to the interest rate risk like government bonds than to default risk like equities or HY bonds. Thus, IG bonds tend to evolve in the same direction than government bonds and then their correlations with other assets should present similar pattern than the correlations between government bonds and other assets. In general, the correlation between high-quality fixed income (government bond, investment grade bond) and equity is very feeble in normal times, while during equity market crashes stocks and high-quality tend to decouple due to the "flight-to-quality" from risky assets, such equities/stocks and HY, to less risky assets, such government bonds and IG bonds (Gulko, 2002; Stivers and Sun, 2002, Connolly et al., 2005; Cappiello et al., 2006; Andersson et al., 2008; Briere et al., 2008; Baele et al., 2010; Aslanidis and Christiansen, 2010). For instance, since the outbreak of the subprime crisis one could observe that IG bonds have risen when stock markets have rise and those bonds have been down slightly when stocks have decreased; which is important from a portfolio diversification perspective. Moreover, IG bonds have generally outperformed HG bonds and equities/stocks in periods of economic recession and underperformed HG bonds in periods of economic recovery (Weiner, 2005). In a typical recessionary cycle, the Central Bank reduces its target rates in order to stimulate the economy, the high-quality bond prices rise as a result of this reduction; therefore, IG bonds generate relatively strong returns during a recession. By contrast, as HY bonds are more correlated to equities, they have similar sensitivities to corporate earnings. As a result, HY bonds typically underperform IG bonds during an economic contraction. However, after recessionary periods, HY bonds have the potential for strong price appreciation as the economy begins to recover and corporate earnings improve. Thus, during episodes of great uncertainty in the economic and financial situations, IG bonds can be a weak safe haven and then reduce the losses and improve the benefits of a portfolio containing such bonds.

Regarding the correlation between equity returns (respectively bond yields) and commodity returns, authors have mainly considered the crude oil price as a commodity. Several authors have examined the long-run relation between crude oil and stock indices (Huang et al., 1996; Jones and Kaul, 1996; Ciner, 2001; Sadorsky, 1999, 2003; Nandha and Faff, 2007; Kilian and Park, 2009) and between crude oil and macroeconomic variables, such as gross domestic product, unemployment rate, inflation rate (Hamilton, 1983; Gisser and Goodwin, 1986; Mork, 1989; Lee et al., 1995; Daniel, 1997; Cunadua and Gracia, 2005). Most of these studies have shown that higher crude oil price influences negatively stock indices. Indeed, more expensive crude oil translates into higher transportation, production, and heating costs, which can have negative impact on corporate earnings. Furthermore, a higher fuel prices can also stir up concerns about inflation and impacts negatively consumers' spending. However, rising crude oil price can also be associated with a booming economy. Indeed, higher fuel prices could reflect stronger business performance and then a higher demand for fuel. Thus, the correlation between crude oil and stock market is not defined clearly (Pescatori and Mowry, 2008). Nevertheless, during economic recession periods this correlation might be positive as during these episodes crude oil price and stock indices should likely decline. During these periods one would probably observe a reallocation of funds towards assets such government bonds and IG bonds as they outperform crude oil, HY bonds and stock indices. This "flight-to-quality" is characterized by negative correlations between safer assets and risky assets.

The second commodity is gold. This commodity has attracted great attention from both academic and practical perspectives, mainly since the outbreak of the subprime crisis, as its price kept rising to record levels since 2007. This commodity price evolved differently during the subprime crisis compared to its behavior during financial crises occurred in the past. Furthermore, gold can be set apart from other commodities. Indeed, gold prices are not correlated to exogenous variables (such as GDP, inflation and interest rates) that are subject to the business cycle, whereas returns on mainstream financial assets (stock returns and bond yield) and other commodity prices (such as aluminium, oil and zinc) are correlated to those exogenous variables (Lawrence, 2003). Moreover, returns on gold are not (or are slightly) correlated with returns on equity, corporate bonds (HY and IG bonds) and Treasury bonds than are returns on other commodities (Smith, 2002). Finally, gold is highly liquid, fungible and easily stored. For these reasons, gold plays an important role as a store of value or a good hedge, especially in times of political, economic and financial uncertainty. Thus, benefits of diversified portfolios with gold are higher than without gold (Jaffe, 1989; Chua et al., 1990; Johnson and Soenen, 1997; Davidson et al., 2003). However, according to Baur and Lucey (2010), gold was a hedge against stocks and a safe haven in extreme stock market conditions, but for only very short periods.

As the interdependence of financial markets is a serious concern for investors looking to diversify their portfolio, especially during financial crises, the purpose of this article is then to analyze the conditional correlations across different assets during calm and financial crises periods. The examined assets are the S&P 500, the high-yield bond, the investment-grade bond, the crude oil and the gold. We examine the conditional correlations between the S&P 500 return and the commodities returns on the period from 2 January 1997 to 31 August 2011. As we could not get data for the HY and the IG bonds in the period prior to 1 October 2005, the correlations across the five retained assets is analyzed on the period from 1 October 2005 to 31 August 2011. We do the former analysis in order to check whether the correlations between the commodity prices and the S&P 500 evolve in the same way during the different crises that occurred between 1997 and 2011 (the Asian crisis, the Russian crisis, the dot-com burst and the subprime crisis). Thus, we can check whether gold has been a safe haven during all these crises or only during some crises as shown by Coudert and Raymond-Feingold (2011).

Correlations are not observable and must be estimated. Multivariate GARCH (MGARCH) models are developed to study the dynamic correlations between financial time-series. However, general MGARCH models typically suffer the curse of the dimensionality problem in estimation as the number of time-series increases. In order to alleviate this latter problem, Engle (2002) proposes the Dynamic Conditional Correlation (DCC) mode. Cappiello et al., (2006) generalized the DCC model by taking into account the possibility of having asymmetric impacts of positive and negative innovations on the dynamics of the conditional correlations, which is called the asymmetric generalized DCC model (AG-DCC). The DCC model type enables us to detect possible changes in conditional correlations over time, which allows us to detect dynamic investor behaviour in response to news and innovations as well as their behaviour during calm and crisis periods in financial markets. Since their introduction, such models have been used in order to determine the correlation between assets' returns and then to optimize portfolio selection as well as to analyze the spillover/contagion effects and the "flight-to-quality" during financial crises (Corsetti et al., 2005; Boyer et al., 2006; Chiang et al., 2007). Indeed, according to Forbes and Rigobon (2002), there is a financial contagion from one country to another country when there is a significant increase in correlation after a shock to one country. Similarly, there is a financial contagion from one market to another one within a country when there is a significant rise in correlation after a shock to one market. By contrast, in case of "flight-to-quality" the conditional correlation between two asset classes decreases since the prices of those assets evolve in opposite directions (Briere et al., 2008; Baur and Lucey, 2010). In this study, we then investigate the dynamic conditional correlations between the selected assets through the DCC model types in order to examine their interdependence in normal time as well as to analyze the contagion and "flight-to-quality" effects across these assets during financial crisis.

This article is organized as follows. Data used in this article are presented and described statistically in section 2. The methodological design of our econometric analysis is set out in section 3. Section 4 presents the results obtained. Finally, we conclude in section 5.

2. Data

The aim of this article is to analyze the conditional correlations across five US assets' returns; these assets are the investment grade bond, the high-yield bond, the S&P 500, crude oil and gold. The S&P 500 index, the crude oil price and the gold price are extracted from Datastream and the investment grade bond price and the high yield bond price are retrieved from FINRA-Bloomberg. The S&P index level and both the commodity prices are daily and range from January 2 1997 to 31 August 2011, a period covering several financial crises (the Asian crisis, the Russian crisis, the dot-com burst and the subprime crisis) as well as expansionary and recessionary periods. As for the HY bond and IG bond prices, they are also daily and range from 1 October 2005 to 31 August 2011. We could not get data for these latter prices in the period prior to 1 October 2005. In this article, we first evaluate and analyze the conditional correlations between these five assets' returns in the period from 1 October 2005 to 31 August 2011. In a second step, the conditional correlations between the S&P 500 index and both the commodities are considered. We do this latter analysis in order to check whether the correlation between the commodity prices and the S&P 500 evolves in the same way during the different crises that occurred between 1997 and 2011. It could be more efficient if we could do this analysis by taking into account also the HY and IG bond prices. However, as we outlined earlier, we could not get data on the period prior to October 2005.

The returns of these five assets are calculated as follows: rt = 100.ln(pt/pt−1), where pt is the price level on date t. Table 1 presents the descriptive statistics of these returns. According to the results of the ADF test and the Zivot & Andrew (1992) test, we can reject the null hypothesis of unit root for the first difference of the logarithm on any of these assets' prices/level. The results obtained with Box-Pierce, Ljung-Box and LM statistics reveal that the first difference of the logarithm of all these assets demonstrates significant serial correlation. Furthermore, the distribution of all assets' returns is asymmetric and has fat tails. Indeed, for all of them their skewness is significantly different from 0 and their kurtosis is different from 3. All the returns have negative skewness, implying that the left tail of the distribution is fatter than the right tail. This finding reveals that the distribution of the retained first difference of the logarithm of the assets' prices level is non-normal and asymmetric.

3. Dynamic Conditional Correlation Model

Let $r_t = [r_{1t}, r_{2t}, ..., r_{Nt}]$ denote an N_{x1} vector of N asset returns at time t, assumed to be conditionally normal.

$$E(r_t/I_{t-1}) = 0 \quad (1)$$

$$E(r_t r'_t/I_{t-1}) = H_t \quad (2)$$

Where H_t is an N_xN matrix with time varying conditional covariance and I_{t-1} is the information set at time $t-1$. As any covariance matrix is positive definite by definition, H_t can be decomposed as $H_t = D_tR_tD_t$, where D_t is an N_xN diagonal matrix with the square root of the conditional variances on the diagonal i.e. ($D_t = diag(\sqrt{\text{h1t}}, ..., \sqrt{\text{hnt}})$. R_t is the N_xN time varying correlation matrix. Engle (2002) and Engle and Sheppard (2001) proposed to model the dynamic of this conditional correlation with the model named DCC (Dynamic Conditional Correlation model), which is presented in what follow (Note 2).

Table 1. Descriptive statistics(2005–2011)

	IG price	HY price	SP500	GOLD	OIL
Mean	0,000	-0,005	-0,001	0,091	0,020
Max.	4069	6806	10424	6841	16414
Min.	-2735	-9556	-13259	-7852	-12827
Mediane	0,002	0,020	0,073	0,076	0,069
stand error	0,262	0,670	1532	1377	2651
LB					
1	210.04**	519.19**	48.53**	11.45	104.4
10	246.28**	1075.84**	1091.02**	293.28	897.11
BP					
1	209.48**	517.79**	48.4**	11.41	104.12
10	245.56**	1071.43**	1084.31**	291.64	892.24
LM					
1	209.48**	517.81**	48.42**	11.42	104.12
10	222.84**	594.05**	396.31**	157.12	296.79
Zivot and Andrews					
model A	-24.5**	-14.26**	-31.06**	-27.16**	-20.69**
model B	-23.64**	-13.17**	-30.51**	-27.09**	-20.33**
model C	-24.5**	-14.26**	-31.05**	-27.16**	-20.68**
ADF					
model 0	-23.61**	-19.27**	-30.47**	-26.91**	-27.85**
model 1	-0.24**	-0.12**	-0.02**	2.51**	0.31**
model 2	-0.75**	-0.54**	-0.01**	0.24**	-0.02**
PP					
NT-t-stat	-32262	-28223	-45809	-38252	-38520
rho	0,174	0,300	-0,174	0,005	-0,002
WT-t-stat	-32266	-28219	-45793	-38241	-38507
rho	0,173	0,300	-0,174	0,005	-0,002

** and * indicate that the corresponding coefficient is statistically significant at the 5% and 10% level, respectively.

NT: No Trend and WT: With Trend.

$$R_t = [\rho_{ij,t}] = Q_t^{*,-1}\ Q_t\ Q_t^{*,-1} \tag{3}$$

With $Q_t = \bar{Q}(1-a-b) + a\varepsilon_{t-1}\varepsilon'_{t-1} + bQ_{t-1}$.

Where a and b are scalar parameters. ε_t corresponds to a N_x1 vector with standardized residuals (ε_t = rit/ $\sqrt{\text{hijt}}$) and Q_t and $\bar{Q}$ are the covariance matrix of the standardized residuals and the unconditional covariance matrix of those standardized residuals, respectively. In this DCC model, it is assumed that positive and negative shocks have symmetric effects on the conditional correlations as well as all correlations are driven by the same dynamic pattern (a and b) which is hard to justify as the number of time series grows. In order to cope with this later limitation, a generalized form of the DCC model was proposed by Franses and Hafner (2003) with series specific parameters (G-DCC); a1, a2,...,aN and b1, b2,...,bN instead of a and b. Regarding the asymmetric effect of positive and negative shocks, Cappiello et al., (2006) proposed a scalar asymmetric DCC (ADCC) model as well as an asymmetric generalized DCC model (AGDCC), that allows conditional correlations to increase more when both returns are falling. In the AGDCC model, the covariance matrix of the standardized residuals (Q) can be expressed as follow (Note 3):$\bar{Q}$

$$Q_t = (\bar{Q} - A'\bar{Q}A - B'\bar{Q}B - G'\bar{N}G) + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'Q_{t-1}B + G'n_{t-1}n'_{t-1}G \tag{4}$$

Where A, B and G are NxN parameters matrices; these matrices contain series specific parameters (a_{ij}, ..., b_{ij}, ..., g_{ij} ...). $n_{t-1} = I[\boldsymbol{\varepsilon_t} < 0]\ \boldsymbol{\varepsilon_t}$ and I[.] is a Nx1 dummy variable that takes the value one if $\boldsymbol{\varepsilon_t} < 0$. $\bar{\boldsymbol{N}}$ represents the unconditional covariance matrix of the negative standardized residuals and nt the conditional covariance matrix of negative standardized residuals.

When G = 0, the AG-DCC is reduced to the generalized DCC model (G-DCC). In the ADCC model the matrix A, B and G are supposed to be scalar: a, b and g. The latter parameter g is equal to 0 in the DCC model. In the AG-DCC model, a sufficient condition for Qt to be positive definite for all possible realizations is that the intercept, $\bar{Q} - A'\bar{Q}A - B'\bar{Q}B - G'\bar{Q}G$, is semi-definite and the initial covariance matrix Q0 is positive definite (Note 4).

4. Empirical Results

The estimation of the conditional correlations across assets' returns with the DCC model types necessitates first the choice for each series the model which best formalizes their dynamics, and then the evaluation, in the second step, of the conditional correlations by taking into account the results obtained in the first step. The results obtained for the models used in the first step as well as the results of the models considered in the second step are presented and discussed in what follows. After these discussions, the results regarding the conditional correlations are described.

4.1 Choice of the Models

4.1.1 Choice of the Univariate Volatility Model

As recommended by Cappiello et al., (2006), it is important to select first the model which best fits each series. As the most interesting aspect of asset returns variations is that these variations tend to cluster, GARCH-type models enable us to formalize this feature of those variations perfectly (Note 5). Moreover, GARCH type models have been used by several authors to determine the standardized residuals, which are used to evaluate the conditional correlation with DCC type models (Engle, 2001; Engle and Sheppard, 2002; Franses and Hafner, 2003; Cappiello et al., 2006). We evaluate the dynamic of each series with the following models: 1) GARCH model proposed by Bollerslev (1986), 2) Exponential GARCH model (EGARCH) proposed by Nelson (1991), and 3) Asymmetric GARCH model (GJR), proposed by Glosten et al., (1993). The specifications of these models are described in what follows: $\boldsymbol{\varepsilon}^2_{t\text{-}1}$

$$h_t = \omega + \alpha\boldsymbol{\varepsilon}^2_{t-1} + \beta h_{t-1} \tag{5}$$

$$h_t = \omega + \alpha\boldsymbol{\varepsilon}^2_{t-1} + \lambda\boldsymbol{\varepsilon}^2_{t-1}(I[\varepsilon_{t-1} > 0]) + \beta h_{t-1} \tag{6}$$

$$ln(h_{t-1}) = \omega + \alpha\boldsymbol{\varepsilon}_{t-1} + \lambda(|\boldsymbol{\varepsilon}_{t-1}| - E(|\varepsilon_{t-1}|)) + \beta ln(h_{t-1}) \tag{7}$$

Compared to the classical GARCH model (eq. 5), the EGARCH and GJR models take into account the sign of the shocks on the conditional volatility. In the EGARCH model (eq. 7), negative shocks have an impact (α−λ) on the log of the conditional variance, whereas the effect of positive shocks is (α+λ). In the GJR model (eq. 6), I[.] is an indicator function. In this model, negative shocks have an impact (α) on the conditional variance, whereas the effect of positive shocks is ($\alpha + \lambda$). Furthermore, in the EGARCH model, any conditions need to be put in order to guarantee the non-negativeness of the conditional variance. In the GARCH model, however, the conditions $w > 0$; $\alpha > 0$and$\beta \geq 0$ should be held in order to guarantee this nonnegativeness. Similarly, in the GJR model, the following conditions are required: $w > 0$, $(\alpha + \lambda)/2 \geq 0$ and $\beta > 0$.

In order to select the specification that best fits for each series, we use the Bayesian Information Criterion (BIC). According to the BIC (Appendix I), the models selected for the S&P 500, the HY bond and crude oil include significant asymmetry in the sense that positive and negative shocks do not have the same effect on the conditional volatility of these assets. The EGARCH model fits well for the crude oil price and the GJR model for the HY bond and the S&P index. Regarding the IG bond return and the gold return, their volatilities are better modelled with a GARCH model, without asymmetry. As expected, our results suggest that the negative shocks tend to increase the conditional variance of the S&P 500 index return, the HY bond return and the crude oil return more than the positive shocks (Table 2). For instance, in the case of the S&P 500 index, the impact of a negative shocks is 0.16 (α), whereas the impact of a positive shock is 0.024 ($= \alpha + \lambda$) (Table 2).

We also estimate the dynamics of the S&P 500 index, the gold and the crude oil with the three GARCH model types retained on the period from 2 January 1997 to 31 August 2011. In line with the results relative to the period from 2 October 2005 to 31 August 2011 described in the previous paragraph, Table A.1 in the Appendix reveals also that asymmetric GARCH model fits best for the dynamic of the S&P 500 and the crude oil. By contrast to the earlier results, the model selected for the gold return include also significant asymmetric.

4.1.2 Choice of the Dynamic Conditional Correlation Model

The dynamics of the correlation are formalized with four different specifications; 1) the classical DCC model, 2) the generalized DCC (GDCC) model, 3) the asymmetric DCC model (ADCC) and 4) the asymmetric generalized DCC model (AG-DCC), which are presented in section 3. Table 3 shows that all the estimated parameters of the DCC, GDCC, ADCC and AG-DCC models are significantly different from zero. According to the likelihood ratio test, the AG-DCC model fits better for the conditional correlation of our five series over the period from 2 October 2005 to 31 August 2011. Similar findings are obtained for the conditional correlations between the returns of the S&P 500 and the both commodities (gold and crude oil) over the period from 2 January 1997 to 31 August 2011. All the estimated parameters of the four DCC model types are significantly different from zero (Table 3), and the AG-DCC is the selected model.

Table 2. Univariate GARCH/EGARCH/GJR models (2005-2011)

	IG	HY	S&P 500	GOLD	OIL
ω	0.0021**	0.0027**	0.0204**	0.0156**	-0.087**
	(-5.79)	(-4.45)	(-4.28)	(-2.43)	(−7.10)
α	0.1358**	0.3387**	0.1663**	0.0576**	0.1435**
	(-15.46)	(-7.66)	(-7.26)	(-6.78)	(-8.4)
β	0.8161**	0.7448**	0.9127**	0.9356**	0.9842**
	(48.88)	(27.93)	(70.6)	(95.24)	(229.62)
λ		-0.1466**	-0.199**		-0.072**
		(-4.47)	(-7.18)		(-5.59)
Positif chocs effect		0.1921	-0.0236		0.0712
Negative chocs effect		0.3387	0.1663		0.2157

** and * indicate that the corresponding coefficient is statistically significant at the 5% and 10% level, respectively.

The dynamic conditional correlations, deduced from the AG-DCC model estimation, between the assets examined here are plotted in Figures 1-6. We first present and discuss the general trend of these conditional correlations in the next subsection. The behaviour of these conditional correlations during the subprime crisis and the other crises occurred since 1997 are presented and analyzed latter.

4.2 General Trend of the Conditional Correlations

Figure 2 reveals that the conditional correlation between the HY bond return and the S&P 500 return is similar to the correlation between the HY bond return and the IG bond return, except during financial crisis or during great uncertainty periods in financial markets. This finding is in line with the results obtained by Blume and Klein (1991), but it deviates from the results obtained by some authors such as Altman (1992), Fridson (1994) and Shane (1994), who showed that although the return of the HY bonds was correlated with those of the IG bonds and Treasury bonds, the HY bond returns had a significantly stronger relationship to the returns on stocks. However, the conditional correlation between the returns of the HY bond and the S&P 500 is stronger on average than the correlation between the returns of the HY bond and the IG bond for the whole period examined, including stable and unstable periods (10/2005-08/2011). Indeed, the means of these correlation are 0.31 (HY/S&P 500) and 0.23 (HY/IG) for the whole period. In sum, if we do not distinguish between stable and unstable periods and then the average conditional correlation on the whole period of this study, our results are in agreement with the findings of Altman (1992), Fridson (1994) and Shane (1994). Another reason which could explain our finding is based on the credit rating of HY bonds. The difference between the credit rating of the HY bonds studied by these latter authors and the HY considered in this article can also explain our different findings during stable periods. Indeed, studies that examined the correlations of HY bonds with other assets found significant differences in the correlations among the three different credit rating classes of HY bonds. Specifically, the returns on Ba-rated (Moody's) or BB (S&P and Fitch) bonds are highly sensitive to changes in Treasury yields, while the returns on B (Moody's, S&P and Fitch) and Caarated (Moody's) or CCC (S&P and Fitch) bonds are less affected by Treasury interest rate changes, but highly correlated with the returns on common stocks (Reilly et al., 2009) (Note 6). In sum, the higher is the credit rating of a bond, the lesser is the correlation between this bond return and the stock return. Our results illustrate this fact and Figures 1 and 2 reveal that the average correlation between the IG bond return and the S&P 500 return is - 0.056 in a stable period (4/10/2005-31/12/2005), whereas the average correlation between the returns of the HY bond and the S&P 500 is 0.261. Indeed, the IG bond is higher quality and less risky than the HY corporate bond and is closer to the government bond than to the stock index.

Table 3. DCC, ADCC, GDCC and AGDCC models

	a2	b2	a2	b2	g2
10/2005-08/2011					
IG	0.0053**	0.9619**	0.0027**	0.9511**	0.0145**
	(-3.24)	(-73.52)	(-2.48)	(-84.83)	(-2.67)
HY	0.0087**	0.981**	0.0021**	0.9937**	0.0156**
	(-4.85)	(-120.26)	(-3.18)	(-765.36)	(-5.77)
SP	0.0188**	0.967**	0.0142**	0.9621**	0.0105**
	(-5.73)	(-164.48)	(-6)	(-194.71)	(-3.44)
GOLD	0.0062**	0.992**	0.0094**	0.9928**	0.0085**
	(-4.56)	(-206.75)	(-5.4)	(-303.79)	(-3.13)
OIL	0.0645**	0.9288**	0.0493**	0.09449**	0.0156**
	(−5.85)	(−99.76)	(−7.19)	(−167.36)	(−3.30)
Scalar Model	0.0151**	0.9680**	0.0133**	0.9682**	0.0052**
	(−21.43)	(−425.63)	(−13.64)	(−418.6)	(−3.22)
01/1997-08/2011					
SP	0.009**	0.984**	0.010**	0.951**	0.069**
	(−8.18)	(-274.37)	(-4.6)	(-164.19)	(-6.67)
GOLD	0.004**	0.989**	0.013**	0.955**	0.004**
	(−4.91)	(-238.63)	(-3.84)	(-93.52)	(−2.17)
OIL	0.087**	0.936**	0.030**	0.979**	0.009**
	(−10.00)	(-147.96)	(-5.97)	(-213.73)	(-5.35)
Scalar Model	0.017**	0.976**	0.015**	0.977**	0.003**
	(−18.86)	(-694.43)	(-13.1)	(-710.81)	(-2.18)

** and * indicate that the corresponding coefficient is statistically significant at the 5% and 10% level, respectively.

In line with the findings of several authors, our results suggest that the conditional correlation between the returns of the S&P 500 and the crude oil is negative, except during periods marketed by uncertainty in the financial markets and concerns about economic growth (Figure 4). Thus, higher crude oil price impacts negatively the corporate earnings through its effect on the transportation, production, and heating costs. Due to the fact that the risk associated with the HY bond is mainly related to the stock market, the prices of these bonds depend strongly on the condition of the stock market. This fact can explain our result (Figure 4) revealing that the conditional correlations between the HY bond return and the crude oil return present a similar pattern to the correlations between the S&P 500 return and the crude oil return until the summer 2008.

In the same line, the conditional correlation between the IG bond return and the crude oil return was most of the time negative and remained in the range [0;−0.1], except for some very short periods (Figure 4). This finding, which is in line with our expectation, can be explained by the fact that the IG bonds are high-quality assets like Treasury bonds and their risk depends mainly on the interest rate risk as Treasury bonds. If crude oil prices rally strongly, that is a negative for the Treasury bond prices as well as for the IG bonds, due to notions that inflationary pressures could reignite and become problematic for the economy and then cause an increase of the interest rates, which would negatively affect the prices of the T-bonds and IG bonds. By contrast, when the oil price is in a downtrend the prices of IG bonds and government bonds should increase as the decline of the oil price influence negatively the future inflation rate. This latter situation can also occurred during economic recession episodes as we described in the introduction. In sum, in a portfolio containing the S&P 500 index (or another stock index) and/or HY bonds and/or crude oil, the introduction of IG bonds in this portfolio can be efficient as these IG bonds are not or slightly correlated with the former assets and commodity.

As expected, the return of the gold was feebly correlated with the returns of the S&P 500, the HY bond and the IG bond, except during some financial crises (Figure 3). This finding can be explained by the fact that gold does not depend on exogenous variables like the latter assets (Lawrence, 2003). Furthermore, the conditional correlations between the gold return and the S&P 500 return evolved closely to the correlation between the return of the HY bond and the gold. Regarding the correlation between the returns of the IG bond and gold, it presented similar pattern than the correlations SP500/gold and HY/gold during stable periods, but not during crisis period (Figure 3). Regarding the relation with crude oil, the conditional correlation between the gold return and the crude oil return was relatively low and oscillated around 0.10 until the end of 2004 (see Figure 6). Thereafter, this correlation has been on an upward trend.

In sum, the retained assets are feebly correlated in stable periods. Thus, a portfolio containing these assets could be efficient in stable periods. It is important now to determine how the conditional correlations amongst the examined assets' returns move during financial crises. In the next subsection, we will present and discuss our results about these correlations during the subprime crises and compare our findings with the results obtained during the other past crises.

4.3 During the Subprime Crises

With the aggravation of the economic and financial situation the negative impacts of the subprime crisis have spread from stock market and HY bonds to other financial markets, such IG bonds and crude oil, within the USA as well as to foreign markets (financial crisis contagion). Furthermore, the "flight-to-quality" from risky assets to riskless assets has accentuated when this crisis has deepened. The contagion of this crisis and the "flight-to-quality" are detailed in what follow.

In summer 2007, the world economy entered into a significant global adjustment caused by the outbreak of the subprime crisis. Investors started to realize the seriousness of this crisis only in October 2007 when some financial institutions started to reveal enormous losses and the US government proposed a "super fund" of $100 billion to purchase mortgage-backed assets whose market value plunged strongly. Furthermore, the Fed's chairman, Ben Bernanke, and the Treasury Secretary, Hank Paulson, expressed alarm about the dangers that resulted from the bursting housing bubble. Investors then started to reallocate their funds towards less risky assets such as Treasury bonds, IG bonds and gold, which explains the increase of the IG bond price, the decline of the stock index level and the HY bond price after a period of hesitation (July-October 2007). These observations can explain our results, suggesting a decrease of the conditional correlation between the IG bond return and the S&P 500 return (respectively the HY bond return) and a oscillation of the correlation between the S&P 500 return and the HY bond return around 0.38 in the period from October 2007 to January 2008 (Figures 1 and 2). This finding is in agreement with the results obtained by several authors such as Gulko (2002), Connolly et al., (2005), Andersson et al., (2008) and Aslanidis and Christiansen (2010), who found that the correlation between government bond returns (riskless assets) and stock index returns (risky asset) decreased sharply during a crisis period. These findings illustrated the "flight-to-quality".

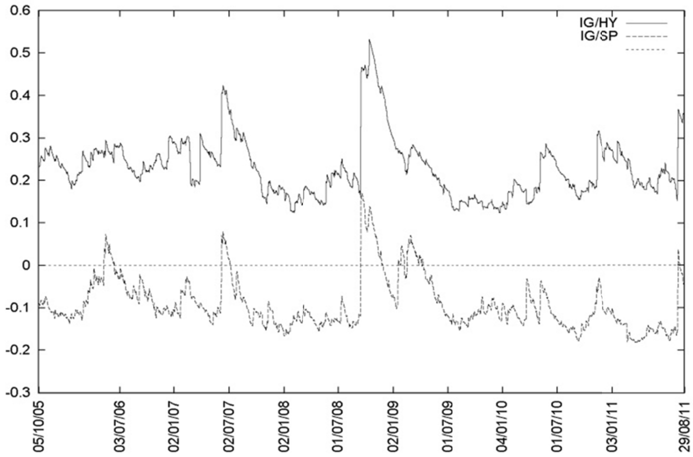

Figure 1. Conditional correlations between IG/HY and IG/SP500

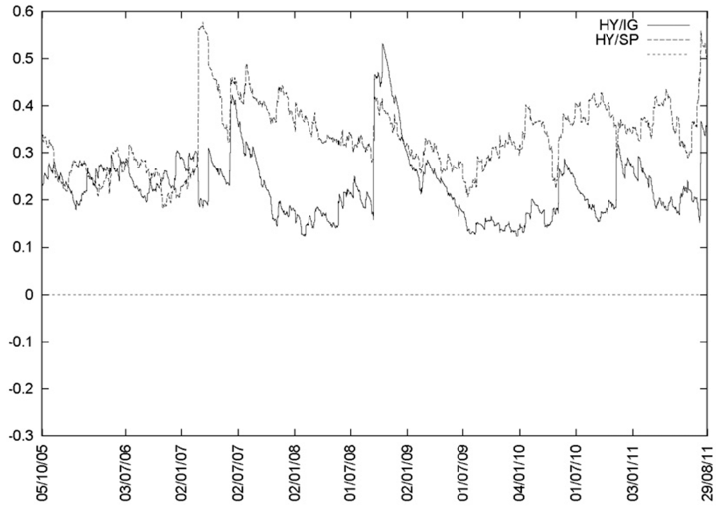

Figure 2. Conditional correlations between HY/IG; HY/SP500

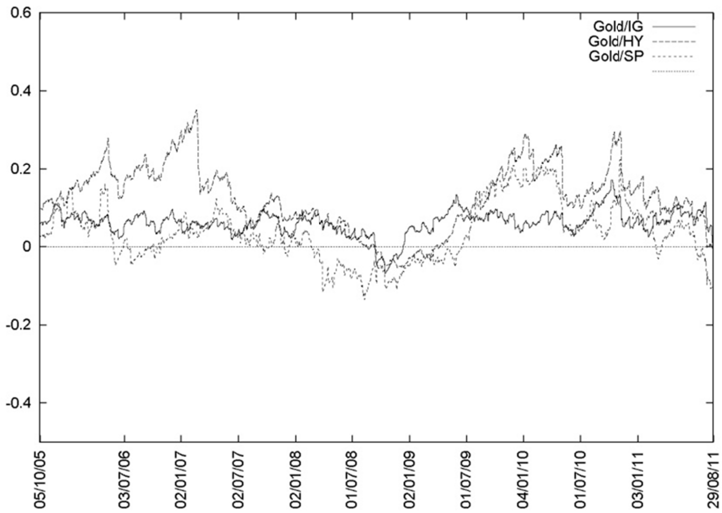

Figure 3. Conditional correlations between Gold/IG; Gold/HY and Gold/SP500

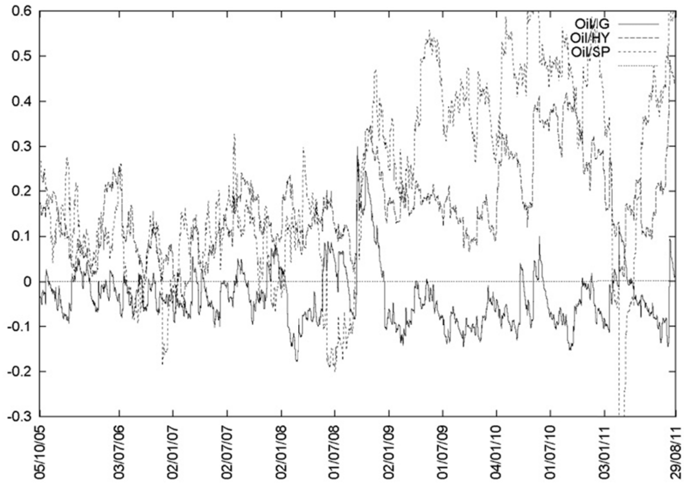

Figure 4. Conditional correlations between Oil/IG; Oil/HY and Oil/SP500

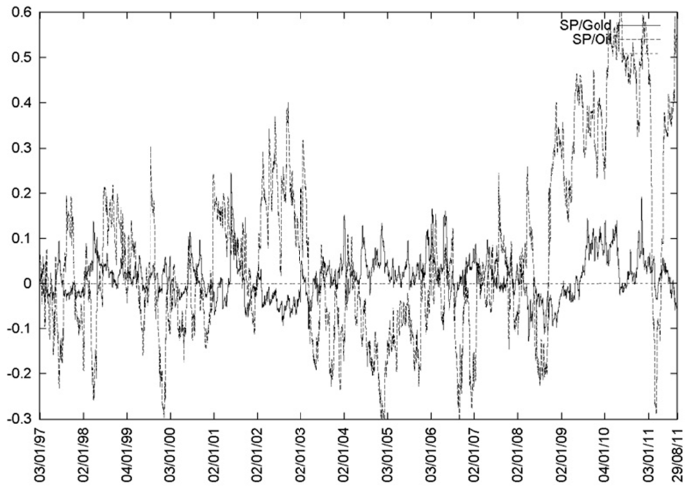

Figure 5. Conditional correlations between SP500/Gold and SP500/Oil

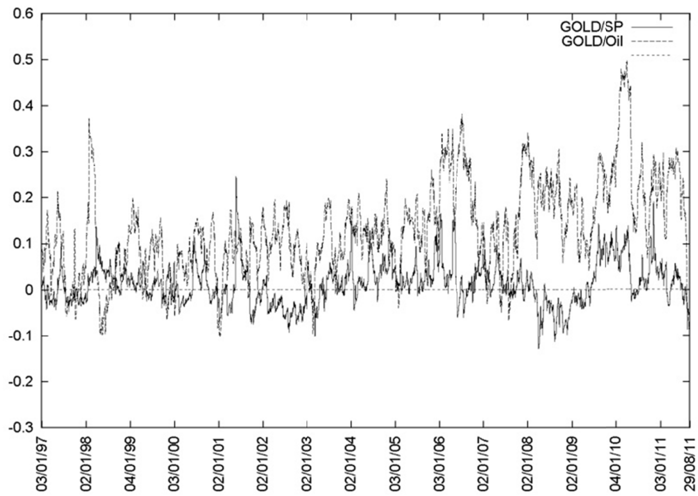

Figure 6. Conditional correlations between Gold/SP500 and Gold/Oil

During the first phase of the subprime crisis, the commodity prices examined presented similar patterns to the IG bond price and different patterns from the S&P 500 return and the HY bond return. Both these commodity prices rose, by 52 per cent (gold) and 57 per cent (crude oil) from June 2007 to March 2008. This observation is in agreement with the hike in the conditional correlation between these two commodities' returns on this period (Figure 6). Similarly, the conditional correlations between these commodity prices returns and the IG bond return were also slightly up, except during a few short periods (Figures 3 and 4). By contrast, the conditional correlations between the S&P 500 return and the returns of these both commodities decreased in the first phase of the subprime crisis (Figure 5). Similarly, the correlations between the HY bond return and both the commodities' returns also declined (Figures 3 and 4).

At the beginning of 2008 the crisis had become sufficiently severe to threaten the stability of the financial system; several institutions, such Bear Stearns, began going bankrupt or announced the reduced value of their assets. Thus, uncertainty on markets and risk premium associated with equities rose. Investors then sold more of their equities/stocks as well as corporate bonds (IG and HY bonds) in order to invest in gold and government bonds ("flight-to-quality"). All the assets examined here, except gold, lost value during the first months of 2008 and then their conditional correlations increased (Figures 1, 2 and 6). These observations illustrated the transmission of the negative effects of this crisis towards other assets (IG bonds) and then can be considered as a contagion. However, due to its higher quality, the IG bond lost only 1.90 per cent compared to the loss of the HY bond and the S&P 500, which went down by 8.60 per cent and 11 per cent, respectively, on the period from 2 January to 14 March 2008. By contrast, due to the "flightto- quality" gold price went up by 18.50 per cent, then the correlations between this commodity return and the returns of the other examined assets stayed stable or declined until the uncertainty alleviated in the middle of March 2008 (Figures 3 and 6). During the middle of March, the sale of Bear Stearns to JP Morgan Chase and the measures (Term Auction Facility, Term Securities Lending Facility and Primary Dealer Credit Facility) introduced by the Fed helped to alleviate uncertainty on the markets and then enabled assets' price levels to revive.

The financial markets plummeted again and more severely during summer 2008 as the financial crisis spread around the world and economic growth started to decline. The situation worsened more in September when uncertainty on the markets rose further due to the panic that resulted from the takeover by the US Federal of Fannie Mae and Freddie Mac on 7 September, the sale of Merrill Lynch to Bank of America on 14 September and the collapse of Lehman Brothers on 15 September. With the bankruptcy of Lehman Brothers, the financial crisis entered a new very severe phase marked by several failures of financial institutions and the plunge of stock markets around the world. Compared to the period summer 2007 - August 2008, this crisis affected more markets and the "flight-to-quality" was more pronounced during this deepest time of this crisis (September-November 2008) as nearly all investors fled into the safety of US Treasury bonds, gold, and the US dollar (perceived as the world's reserve currency). Thus, the S&P 500 index level, the crude oil price, the HY bond price and the IG bond price plummeted. For instance, on the period 15 September - 15 October 2008, the S&P 500, the HY bond, the IG bond and the crude oil lost 27.20 per cent, 22.70 per cent, 5.74 per cent and 18.70 per cent, respectively, of their values. The downward movements in these prices and in the S&P 500 level are in agreement with the sharp hike in the conditional correlations of these assets' returns in the period September Ű October 2008, as shown in Figures 1-6. By contrast, as the gold was considered safe assets, its price went up by 8.67 per cent on the period from 15 September to 15 October 2008 due to the "flight-to-quality", and then its correlation with the other assets went down (Figures 3 and 6). These latter correlations declined so deeply to attain a negative value; finding which is in line with the results obtained by Baur and Lucey (2010), Baur and McDermott (2010) and Coudert and Raymon-Feingold (2011).

The measures (Note 7) adopted by the Fed and other central banks during the deepest time (September - October 2008) of this crisis started to ease the pressure and to revive financial markets towards the end of 2008. However, a further shift towards riskless assets occurred again from the beginning of January until the middle of March 2009, when some problems, such as the agreement of the Danish parliament on a financial package, caused panic and uncertainty. During this period, equities/stock indexes around the world plunged again (Note 8). The S&P 500 index, the HY bond price, the IG bond price and the crude oil price dropped by 18.62 per cent, 15 per cent, 6 percent and 6 percent, respectively, over the period from 2 January to 15 March 2009. By contrast, due to the "flight-to-quality" the gold price appreciated more than 15 per cent in this period. In order to contain these collapses and reduce pressure on the markets, several central banks proposed measures. For instance, in March 2009 the Fed introduced the Quantitative Easing method to inject funds into the economy by creating new money and then using it to purchase assets (government bonds and mortgage-related assets) in order to lower borrowing costs and thereby stimulate the economy (Note 9). These measures enabled uncertainty to be reduced and restored confidence in the markets as well as reviving the stock markets. In sum, the "flight-to-quality" in the period January - March 2009 can explain our results (Figures 3 and 6) which reveal a decrease of the conditional correlation between the gold return and the four other assets' returns. These declines in correlations were less intense than the declines seen during the deepest period of the subprime crisis (September - October 2008).

Finally, August 2011 was also characterized by a "flight-to-quality" as uncertainty rose sharply in August, caused by the US debt-ceiling crisis. Although the legislation to increase the debtceiling was signed on 2 August 2011, on 5 August, for the first time in the country's history, the US government bond was downgraded by the credit-rating agency Standard & Poor's due to the growing US budget deficit. This new provoked the plunge of the US stock market as well as markets around the world. Investors fearing the prospects of the US economic recovery and the ongoing Eurozone debt crisis sought safety mainly in US government bonds and gold. Thus, the S&P 500 and the crude oil lost 11.07 per cent and 9.60 per cent, respectively, of their values during the period from 3 August to 10 August 2011, whereas gold price went up by 6.16 per cent. As for the prices of HY bonds and IG bonds, they also decreased, but less than the S&P 500 index and the crude oil price. Indeed, the HY bond price went down by and 3.72 per cent and the IG bond price by 1.06 per cent. This "flight-to-quality" can then explain our finding revealing a hike in the conditional correlation between the S&P 500 return and the HY bond return (respectively the returns of the crude oil and the IG bond) at the beginning of August 2011 (Figures 1, 2, 4 and 5). By contrast, the conditional correlation between the return on gold and the four other retained assets' returns went down in this period (Figures 3 and 6).

In sum, our finding point out that gold was a safe haven during the subprime crisis. Portfolios containing gold during this crisis should have been more efficient than without. Furthermore, adding IG bonds in a portfolio during crisis period could improve the efficiency of this portfolio as the returns of IG bonds are feebly correlated with the returns of the S&P 500, the crude oil and the gold. Furthermore, the IG bond prices lost less value than the S&P 500, the HY bonds and the crude oil. These findings are valuable for the subprime crisis, it is important to check whether these assets were a safe haven during the past financial crises. In the next subsection, we will present and discuss only the case of the correlations amongst the gold, the S&P 500 and the crude oil during the past crises episodes.

4.4 Conditional Correlations and Other Financial Crises

The conditional correlation between the gold return and the S&P 500 return is not negative for every crisis episode (Coudert and Raymond-Feingold, 2011) and gold price does not increase for every crisis episode. Indeed, Figures 3 and 5 reveal that the correlation between the S&P 500 return and the gold return was slightly negative for a very short period during the Asian crisis. The decline of this correlation is due to the appreciation of the S&P 500 index and the very slight loss of the gold price. This crisis broke out on July 2nd 1997, when the Thai government was forced to float the Baht, and spread to some other Asian countries, such as Malaysia (August 1997), Indonesia (August 1997) and Hong-Kong (October 1997) due to the flight of speculators from Asian countries presenting similar weakness (financial crisis contagion). Investors reallocated their funds towards the USA, the European countries and some healthy emerging countries. Then, in these countries assets prices went up since investors preferred to reallocate their funds in the stock market instead of riskless assets, such gold, as the US economic growth was sustained and the inflation rate was close to the target fixed by the Fed in 1997. Indeed, it is mainly during periods marked by fears of recession, uncertainties regarding the credit markets, Fed rate cuts, a falling dollar, as well as inflationary concerns that gold is preferred.

Regarding the crude oil price, after a decline on the outbreak of the Asian crisis, it evolved in almost the same direction as the S&P index until the beginning of October 1997, but with lesser intensity. Thereafter, this commodity price was on a downward trend. The common trend of the S&P 500 index and the crude oil price, even with different intensity, is in agreement with our finding regarding the rise of the conditional correlation between this stock index return and this commodity return in the period from July to October 1997 (Figures 3 and 4). Thereafter, the crude oil price moved in the opposite direction to the S&P 500 index and then their correlation went down.

A similar scheme reappeared during the Russian crisis. During this crisis, the gold price and the crude oil price moved in almost the same direction. The prices of both these commodities declined very slightly until mid-August 1998 (crude oil) / the end of August 1998 (gold), increased strongly until the end of September 1998 and then went down slightly until March 1999. These observations explain our results revealing an increase of the conditional correlations between the returns of these both commodities in the period from June 1998 to March 1999 (Figures 4 and 5). Like these commodity prices, the S&P 500 level went down from 20 July 1998 to the end of August 1998. After a couple of days of hesitation, this stock index rose after 4 September 1998 until mid-1999. The evolution of these assets' returns from summer 1998 to the end of this year can explain our results (Figure 3) which reveal a downward trend of the conditional correlations between the S&P 500 return and the crude oil return as well as between this stock index return and the gold return in the period from early September 1998 to March 1999. In sum, similarly to the Asian crisis episode, the correlation between the S&P 500 return and the gold return declined slightly during the Russian crisis due mainly to the appreciation of the stock index and the slight loss of value of the gold price.

In line with the results obtained during the Asian and the Russian crises, the conditional correlation between the S&P 500 index return and the gold price return was also on a downward trend during the dot-com crisis (2000-2002) (Figures 3 and 5). During the first months of this crisis, the downward trend of this correlation resulted from the slight increase of the stock index level and the slight decline of the gold price, whereas after August 2000 both these returns changed their direction. Indeed, at the outbreak of this crisis both the commodity prices and the S&P 500 index lost value from March to May 2000 and thereafter, they evolved on different paths. The S&P 500 index was on a slight upward trend until the end of August and then on a downward trend until October 2002, except that this index rose sharply during some very short periods, such as March-May 2001 and in September 2001. As for the gold price, it was on a slight downward trend from March 2000 to March 2001 and then was on an upward trend until the beginning of 2003. As expected, the gold price started to rise when fears of recession, concerns about the inflation rate and uncertainty in the financial markets were strong. Indeed, the US economy was on recession from March to November 2001 according to the National Bureau of Economic Research. Furthermore, In the USA, the inflation rate in 2000 and 2001 was above the target fixed by the Fed. Indeed, in 2000 the inflation rate reached 3.38 per cent, the highest level since 1992 and in 2001 this rate was 2.83 percent.

In sum, gold is a safe haven mainly during periods marketed by fears of recession, concerns about the inflation rate and strong uncertainty in the financial markets.

5. Conclusion

In this paper, we analyzed the conditional correlations across five U.S. assets' returns. These assets correspond to the high-yield bond, the investment-grade bond, the S&P 500, the crude oil and the gold. We used four Dynamic Conditional Correlation (DCC) models; the scalar DCC model (DCC), the asymmetric DCC (ADCC) model, the generalized DCC model (GDCC) and the generalized asymmetric DCC model (AGDCC). The results obtained with the AG-DCC model outperform the results obtained with the three other models. The results obtained with the AG-DCC lead to several substantial conclusions; which are described in what follow.

During stable periods, the HY bond return is correlated with the S&P 500 return as much as with the IG bond return; whereas during unstable periods, the former return is more correlated with the S&P 500 return than with the IG bond return. This finding is mainly explained by the credit risk component in the HY bond; a factor shared with equity returns and which is important during unstable periods. However, during crisis episodes, such during the subprime crisis, the HY bond losses less value than the S&P 500. Furthermore, during bull market, the HY bond price goes up as much as the stock index level. For instance, on the period from March 2009 to March 2010, the S&P 500 level increased by 55.12 per cent and the HY bond price by 42.85 per cent. Thus, by replacing some portion of stock index by HY bonds in a portfolio we can improve the efficiency of this portfolio.

The interdependence between the HY bond return and the crude oil return presents similar pattern than the interdependence between the S&P index return and this commodity return due to the common factor between the HY bond and the S&P 500. These interdependences are close to zero and sometimes slightly negative during stable periods. Similarly, the price of the IG bond is also slightly correlated negatively with the price of the crude oil in normal time, since a hike of the crude oil price influences positively the inflation rate, which has negative impact on the prices of the IG bonds and government bonds. During bear market and then uncertainty in the financial markets, the conditional correlations between the returns of the crude oil and the S&P 500 and between the returns of the crude oil price and the HY bond decrease due to the decline of the S&P 500 level and the HY bond price. If this latter financial situation is coupled with economic recession then the conditional correlation between the returns of the S&P 500 (respectively the HY bond) and the crude oil goes down since the price of the crude oil presents similar downward pattern than the S&P 500 level and the HY bond price. Thus, adding crude oil, stock index or HY bonds in a portfolio could benefit in stable and unstable periods, except during periods marketed by concerns about the economic growth.

Similarly to the crude oil, the gold return is feebly or negatively correlated with the returns of the both retained bonds and the S&P 500 in normal time since the former commodity does not depend on the same exogenous variables like the other assets. Furthermore, during financial crises the conditional correlation between the gold return and the return of the other retained assets is often negative. Precisely, the conditional correlation between risky assetsŠ returns (for example the S&P 500) and the gold return declined during the Asian crisis, the Russian crisis and during the first part of the Dot-com crisis due to the slight decline of the gold price and the appreciation of the S&P 500 index. By contrast, during the second part of the dot-com crisis and during the subprime crisis the conditional correlation between risky asset returns and gold return went also down, but due to the appreciation of the gold and the decline of the S&P 500 index level. Precisely, the gold price rose sharply during the subprime crisis, whereas during the second part of the Dot-com crisis, this price went up slightly. Furthermore, during these latter crises, the US economy was on a recession, inflation rates was high, concerns regarding the credit markets were important (during the subprime crisis). Thus, as stated by Coudert and Raymond-Feingold (2011) and confirmed by our results, gold is safe haven on average and not for every crisis episode or every country. During some crisis episode, this commodity is not used as safe haven, such during the Asian crisis, the Russian crisis and the first part of the dot-com crisis. During some crisis period, gold is a weak safe haven, such during the second part of the dot-com crisis and it can also be a strong safe haven during some crisis episode, such during the subprime crisis.

In sum, the statement that correlations across different asset classes decrease in times of crises, then creating potential for diversification through asset allocation (Smith, 2002; Hunter and Simon, 2004) is valuable for the correlation between riskless assets (such as government bonds or gold) and risky assets (such as equities, highyield bond).

Finally, the subprime crisis affected negatively first the stock market and the HY bonds and impacted negatively other assets (IG bonds and crude oil) when this crisis deepened and concerns about the economic growth appeared. This transmission of the negative effects of this crisis from one market to another market within the same country represents a contagion of this crisis. In sum, with the aggravation of the economic and financial situation the negative impacts of the subprime crisis have transmitted to other financial markets within the USA as well as to foreign markets (financial crisis "contagion"). Our results display in Figures 1-6 reveal also that the "flight-to-quality" from risky assets, such the S&P 500 and the HY bond, to riskless assets, such government bond, IG bond and gold, has accentuated when the subprime crisis has deepened.

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Notes

Note 1. See for example, Hartmann et al., (2001), Gulko, (2002), Stivers and Sun (2002), De Goeij and Marquering (2004), Connolly et al., (2005), Cappiello et al., (2006), Andersson et al., (2008), Baur and Lucey (2009), Baele et al., (2010) and Aslanidis and Christiansen (2010).

Note 2. A similar model was proposed by Tse and Tsui (2002), but the model proposed by Engle has been more popular.

Note 3. The ADCC model can be express as follow: $Q_t = (\overline{Q} - a^2\overline{Q} - b^2\overline{Q} - g^2\overline{Q}) + a^2\varepsilon_{t-1}\varepsilon'_{t-1} + b^2Q_{t-1} + g^2n_{t-1}n'_{t-1}$, where a, b and g are scalar parameters.

Note 4. In the DCC model, a sufficient condition for Q_t to be positive definite for all possible realizations is that the scalar parameters a and b are nonnegative and satisfy a + b < 1.

Note 5. See Bollerslev et al., (1992) for an excellent survey of the literature.

Note 6. The results obtained by Reilly et al., (2009) illustrated these relations. These authors found that the correlation between Treasury bonds and Baa bonds has been estimated at 0.68, as compared to correlations between Treasuries and HY bonds that fall to about 0.18 in the case of Ba bonds, 0.03 for Brated bonds, and -0.09 for Caa-rated bonds. By contrast, Reilly et al., found that the correlation between the S&P 500 and the high-quality bond is lower (0.206, and barely significant in a statistical sense) than the correlation between HY bonds and the S&P 500 (0.57 and statistically significant).

Note 7. In the USA, the Emergency Economic Stabilization Act of 2008 was introduced, which contained the Troubled Assets Relief Program, proposed by the Secretary of the Treasury, Henry Paulson, on 19 September, aiming to permit the US government to purchase illiquid assets (toxic assets) from financial institutions for $700 billion.

Note 8. For instance, in the UK British banking shares collapsed strongly, mainly on Monday 19 January 2009 (known as Blue Monday).

Note 9. In March the Bank of England announced the Asset Purchase Facility in order to purchase assets financed by issuing central bank reserves.

Appendix

Appendix I. BIC

	IG	HY	S&P 500	GOLD	OIL
10/2005-08/2011					
GARCH	-568.84	1132.62	4645.61	5033.68	6793.17
GJR	-541.86	1128.41	4628.8	5068.73	6789.45
EGARCH	-520.15	1134.11	4633.18	5072.21	6769.22
01/97-08/2011					
GARCH			11126.05	10345.89	16909.32
GJR			11011.43	10318.98	16904.55
EGARCH			10996.07	10366.02	16916.6