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SECTOR DIVERSIFICATION DURING CRISES: A EUROPEAN PERSPECTIVE

Michel BEINE,
Pierre-Yves PREUMONT
Ariane SZAFARZ

DULBEA I Université Libre de Bruxelles
Avenue F.D. Roosevelt, 50 - CP-140 I B-1050 Brussels I Belgium

Sector diversification during crises: A European perspective

Michel BEINE, Pierre-Yves PREUMONT and Ariane SZAFARZ

Université Libre de Bruxelles
DULBEA and CEB (Solvay Business School)

Abstract

The dynamics of the cross-correlations between the 10 Dow Jones European sector financial indices are analyzed through to the Dynamic Conditional Correlations (DCC) model during the period 1987-2003. First, the paper confirms that, on the whole, the correlations are highly volatile. Second, it brings insights on the behavior of the sector correlations during the IT bubble. The comparison of the pre- and post-bubble periods leads to the conclusion that the sector indices do not suffer from the contagion effects (a correlation increase damaging the portfolio diversification) observed by several authors on country indices. Therefore, it is argued that the benefits from sector diversification during crises must be taken into account by portfolio managers.

1. Introduction

The progressive integration of the European financial markets has pushed portfolio managers towards sector diversification rather than - or in top of - country diversification. While the returns of regional or national indices (Freimann (1998), Beckers (1999)) tend to be more and more correlated, inducing a reduction of diversification opportunities, sector correlations do not exhibit such a trend (Cavaglia, Brightman and Aked (2000), Hamelink, Harasty and Hillion (2001)).

In an international perspective, Goetzmann, Li and Rouwenhorst (2001), Ratanapakorn and Sharma (2002), and Das and Uppal (2004) have observed that geographical financial indices show a bothering characteristic: they are highly correlated during market crises[1]. This is bad news for investors since troubled times are precisely the ones during which they most need the benefits from diversification.

[1] However, within a Markov switching framework, Bialkowski *et al.* (2004) reject from the contagion from the US market to the other ones.

This paper analyses the dynamics of the cross-correlations between the Dow Jones European sector financial indices. In order to capture this dynamics in a precise way, we rely on the DCC (Dynamic Conditional Correlations) model suggested by Engle (2000) and further developed by Engle and Sheppard (2001). This approach sheds interesting light on the behavior of correlations. First, it confirms that, in general, the variability of correlations is quite high. Second, since the data period includes the so-called "internet bubble", our results bring insights on the behavior of the sector correlations during a crisis, a currently hot topic for portfolio managers.

On the methodological side, empirical investigations are very sensitive to the underlying specification for the correlation matrices. Earlier studies relied mostly upon rolling correlations which suffer from unsatisfactory statistical properties. Generating slow correlation updating, this method is not well designed to reproduce the effects of important perturbations. Indeed, it underestimates the impact of shocks on the return cross-moments and overestimates their persistence. Like volatilities, covariances and correlations may vary very rapidly. Their movements often result from the emergence of major news. In this case, the impact is nearly instantaneous and requires a model capable of reproducing sudden and potentially large variations in correlations.

While GARCH (Generalized AutoRegressive Conditional Heteroskedasticity) models have become common for representing the evolving volatility of financial returns, the dynamic approach of covariances and correlations is only very recent and absent from the models used by most practitioners. The reason for this limitation lays probably more in the model complexity than in theoretical considerations. Several attempts to take into account time-varying correlations have nevertheless been proposed in the recent econometric literature.

Multivariate (G)ARCH models (Bollerslev *et al*., 1988) may be viewed as unconstraint approaches since the variances and covariances are estimated without imposing restrictions on the structural parameters[2]. The drawback of these models follows from their high degree of freedom: without heavy assumptions, such as constant correlations (Bollerslev, 1990), they are hardly manageable for systems involving more than three variables[3]. To circumvent this problem, authors have recently proposed models which are more restrictive than the multivariate GARCH ones, but designed for dealing with time-varying variances and covariances. Along these lines, the DCC (Dynamic Conditional Correlations) specification suggested by Engle (2000) has been further studied by Engle and Sheppard (2001).

Medium to large size system estimation is crucial for financial analysis and decision making. Even aggregated by sectors, the markets include many assets. Thus, unconstraint GARCH models are obviously inapplicable. This paper is based on DCC models for modeling European sector indices cross-sectional dynamics. Moreover, it pays a special attention to the technological sector which has been much scrutinized recently, after the so-called "internet bubble" episode. It investigates the evolving links between this special sector and the other ones.

Crises are defined ambiguously in the literature. While some authors view a crisis as a period during which the market drops sharply (“bear market”), others associate it to a high volatility episode (“turmoil”). Therefore, this paper will consider both possibilities.

A large body of the financial literature is dealing with the so-called "contagion and interdependence" question (see, e.g., Forbes and Rigobon, 2002; Billio and Pelizzon, 2003). These papers are concerned with the propagation of shocks during financial crises. However, as stated by Dungey *et al.* (2003) in an extensive survey on this topic, "contagion is both difficult to define and difficult to measure" (p. 64). In particular, the periods of crises are hard to define and to econometrically identify independently of the sample characteristics.

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[2] See Bauwens *et al.* (2004) for a recent extensive survey on multivariate GARCH models.
[3] In bivariate systems, mGARCH models, like the VECH and BEKK models, have nevertheless been applied. See Beine (2004) for an exemple.

Globally, empirical papers tend to detect contagion among currencies (Fukura and Saruwatari, 2003), and equity markets (Edwards and Susmel, 2001; Caporale *et al.*, 2005). The literature on contagion is mostly concentrated on geographic interactions, as stated by Karolyi (2003, p. 184): "*Contagion, in general, is used to refer to the spread of market shocks - mostly, on the downside - from one country to another* (…)". To our knowledge, there exists no published study on sector contagion. Therefore, our paper provides a first step in this direction.

Raddatz and Rigobon (2003) show that monetary policy explains differences in sector reactions to shocks. In particular, they exhibit that the FED's response to the high-tech crisis created induced asymmetric effects across sectors, favoring the ones that are more interest rate sensitive, like durable consumption and residential investment. Our paper is based on European sector indices and does not discuss the origin of sector correlations. Nevertheless, Raddatz and Rigobon's (2003) results offer an interesting view on the potential mechanisms at work in sector contagion. Another view on inter-sector relationship sends back to sector concentration. Indeed, as industry concentration leads to more volatile markets (Xing, 2004), it should play a role on cross-correlations. However, the effect of a crisis on concentration still remains an open question.

Besides the econometrical aspects of this work, the results themselves turn out to be very useful for portfolio managers, market makers as well as regulators in charge of measuring market risks. Indeed, most covariance matrices estimated during relatively quiet financial times are not applicable for evaluating global risks during crises. On the opposite, data drawn from turbulent periods cannot give an appropriate picture of the way the markets work. Therefore, only dynamic models are suited to account for both situations.

The paper is built as follows. Section 2 presents the ARCH-DCC setting considered in the empirics. Section 3 sheds a first light on the European sector financial database while Section 4 estimates conditional volatility and correlations. A special attention to the impact of the internet bubble is paid in Section 5 while Section 6 infers practical consequences for portfolio managers. Section 6 concludes.

2. *The model*

We follow the general specification developed by Engle and Sheppard (2001) assuming that the $k \times 1$ vector of filtered[4] sector returns r_t is conditionally normal with mean zero:

$$r_t / \Im_{t-1} \sim N\left(0, H_t\right), \qquad (1)$$

where the information set $\Im_{t-1}$ includes all past returns:

$$\Im_{t-1} = \left\{ r_{t-1}, r_{t-2}, \ldots \right\}. \qquad (2)$$

The conditional covariance matrix $H_t = \left(h_{ij,t}\right)$ is decomposed in the following way:

$$H_t = D_t R_t D_t \,, \qquad (3)$$

where $R_t = \left(\rho_{ij,t}\right)$ is the time varying correlation matrix and D_t is the diagonal matrix of time varying standard deviations whose i[th] diagonal element is equal to $\sqrt{h_{ii,t}}$.

The DCC model is estimated in two steps. First, univariate GARCH-type models are fitted for each series, leading to estimates of $h_{ii,t}$. In this paper, we use the most standard specification, that is, a GARCH (1,1) for all sector returns:

$$h_{ii,t} = w_i + \alpha . r_{i,t-1}^2 + \beta . h_{ii,t-1} \,, \qquad (4)$$

where $\alpha + \beta < 1$.

Second, standardized residuals are used to obtain the correlations dynamics. The i[th] standardized residual, denoted by $\varepsilon_{i,t}$, is given by :

$$\varepsilon_{it} = \frac{r_{it}}{\sqrt{h_{ii,t}}} \,. \qquad (5)$$

The dynamics of the correlations is provided by the DCC (1,1) model :

$$Q_t = \left(1 - a - b\right)\overline{Q} + a\varepsilon_{t-1}\varepsilon_{t-1}^{'} + bQ_{t-1} \qquad (6)$$

$$R_t = Q_t^{*} Q_t Q_t^{*-1} \;\;, \qquad (7)$$

[4] An AR (5) filter with a constant is used here.

Where $\bar{Q}$ is the unconditional covariance and Q_t^* is the diagonal matrix whose i^th^ diagonal element is equal to $\sqrt{q_{ii,t}}$, where $q_{ij,t}$ is the typical element of matrix Q_t.

3. Data and descriptive statistics

The data sets comprise daily returns observed from January 1, 1987 to May 6, 2003, of the ten Dow Jones European sector indices (DJSTOXX600). The return of the i^{th} indice, denoted r_{it}, is obtained from the corresponding price level P_{it}:

$$r_{it} = 100 \times (\ln(P_{it}) - \ln(P_{i,t-1})) . \qquad (8)$$

Closing days are omitted.

The classification of firms in sectors is explained by the indices producer as follows (Stoxx, 2001): “Companies are uniquely classified in only one of the 18 Dow Jones STOXX market sectors, based on their primary revenue source. Primary revenue sources are reviewed quarterly and any resulting change to a company’s sector classification is implemented at the quarterly reviews in March, June, September and December. Corporate actions – e.g. mergers, takeovers and spin-offs – are continually reviewed and any resulting change to a company’s sector classification is implemented immediately, i.e. simultaneously with the corporate actions”. The firms' classification and the relative weights of the different sectors as of April, 30, 2003 are given in Table 1.

Table 1: The composition of the sectoral indices

	Dow Jones STOXX 600	Total
1	**Basic Materials**	4.49%
	Basic Resources	2.25%
	Chemicals	2.24%
2	**Consumer, Cyclical**	10.27%
	Automobiles	1.82%
	Cyclical Goods & Services	3.21%
	Media	2.91%
	Retail	2.32%
3	**Consumer, Non-Cyclical**	10.42%
	Food & Beverage	6.38%
	Non-cyclical Goods & Services	4.04%
4	**Energy**	10.96%
	Energy	10.96%
5	**Financial**	28.27%
	Banks	20.41%
	Financial Services	2.23%
	Insurance	5.63%
6	**Healthcare**	10.89%
	Healthcare	10.89%
7	**Industrial**	5.93%
	Construction	1.78%
	Industrial Goods & Services	4.16%
8	**Technology**	5.14%
	Technology	5.14%
9	**Telecommunications**	8.99%
	Telecommunications	8.99%
10	**Utilities**	4.64%
	Utilities	4.64%
	Total	**100.00%**

Source: Stoxx, Statistical Monthly Report April 2003: data as of April, 30,2003.

Table 2 provides descriptive statistics of the two first unconditional moments of the sector returns. The full period is considered, as well as the sub-periods before and after the "internet bubble" occurrence. The break date is taken as the day the highest level of the technology index was reached, i.e., the 6th of March, 2000.

Table 2. Descriptive statistics of the sectorial indices (January 1, 1987- May 6, 2003)

	Returns (annualized)			Risk (annualized standard deviation)		
	Average	1st period	2nd period	Average	1st period	2nd period
Basic	7.67	11.89	-8.29	19.23	17.41	25.55
Cyclical	1.72	8.97	-23.72	20.88	17.90	30.42
Non Cyclical	9.24	14.58	-10.61	16.82	16.09	19.59
Energy	12.08	16.11	-3.17	20.25	17.71	28.63
Financial	5.57	10.41	-12.72	19.69	16.49	29.65
Health	9.69	13.54	-4.78	23.11	21.41	29.29
Industrial	7.26	14.52	-18.63	17.34	16.03	21.99
Technology	6.26	19.85	-36.01	30.30	21.92	52.65
Telecom	11.46	28.29	-38.77	27.20	23.54	38.91
Utilities	9.68	16.49	-15.19	17.10	20.49	22.65
Total	8.05	15.43	-18.40	16.07	14.73	24.23

Not surprisingly, the crash of the internet bubble resulted in a sharp drop in the technology index and in a strong increase of volatility of this sector. While the technology sector obviously experienced the largest movements, all the other indices followed a similar pattern, i.e., low returns associated to a huge volatility increase. Therefore, the two pregnant features of a financial crisis were at work: Bad returns and turbulent markets.

With varying amplitudes, all sector average returns shared the same features: positive over the whole period and over the first subperiod, negative after the burst of the internet bubble. More strikingly, all sectors also share a rise in variance after the crash. This observation points in favour of a common GARCH-type representation for the conditional variances.

Viewing the general tendencies in Table 2, one is tempted to conclude in favour of a contagion effect from the technological sector to the other ones during the period.

Another interpretation could be that the crash was mainly a global one[5] and that the spectacular drop in high tech sectors was only a part of it to be attributed to the high sensitivity of this sector. Also, the chosen break date adopted in Table 2 is questionable since other important events, like the terrible 911 episode (Hon et al., 2003), happened in the period under investigation. Only a fully dynamic analysis including correlations and causalities can allow for identifying the dominant effects.

Still, some sectors exhibit specific features. For instance, the "cyclical goods" index has the lowest average return over the first subperiod and the whole period and even over the second one if one takes out the two "high tech" sectors (techno and telecom). However, its variance is relatively high whatever the period. Non-cyclical goods and utilities exhibit similar patterns for the two first unconditional moments.

The highest average return is reached by the energy and telecom sectors while the largest global variance corresponds to the technological index. While the two "high-tech" sectors have the highest average returns during the pre-bubble period and the highest variance over each sample subperiod, there is an important difference between them regarding the post-bubble variances. The technological index return has experienced almost twice the variance of the telecom one. Moreover, while the drop in both average returns is dramatic, the telecom sector which was the most profitable one before the crash became the worst afterwards.

4. The dynamics of conditional variances and correlations: Results

In order to characterize the pattern of the volatility of each sector, we have estimated a univariate GARCH(1,1) model for each index. The estimations rely on a AR(1)-GARCH(1,1) model with a constant included both in the conditional mean and variance equations. A Student-t distribution has been assumed in order to account for the excess leptokurtosis identified in the empirical distributions. The estimates are not provided here in order to save space. Nevertheless, Figure 2 displays the evolution of the conditional variances obtained through the GARCH estimations.

Figure 2 exhibits the growth in volatility that was experienced by all sectors, a fact already observed from Table 2. However, the evolution patterns show that a typical succession of quiet and volatile periods. Visual comparisons must nevertheless be carried with care due to the different generated scales.

The observation period starts in January 1987. Therefore, the October '87 crash (analysed by, e.g., Malliaris and Urrutia, 1992; Wigmore 1998) appears on the volatility figures at the beginning of the series (Fig. 2). It is present in all graphs. In some sectors, like energy, utilities, cyclical and non-cyclical goods, the volatility impact of this crash even dominates the internet bubble one.

The typical GARCH dynamics alternates turbulent and relatively quiet periods. As a matter of fact, the period stretching from more or less 1993 to 1997 looks calm for almost all sectors. Actually, these four years might be seen as an exceptionally unperturbed time separating two turbulent periods. While the explanation of this phenomenon lies beyond the scope of this paper, note that, for most sectors, about three fourths of the observation period were agitated, meaning that the 911 event and the internet crash could have simply restored the volatility at the level already existing in earlier times. However, for the telecom and technology securities, the shock was much stronger.

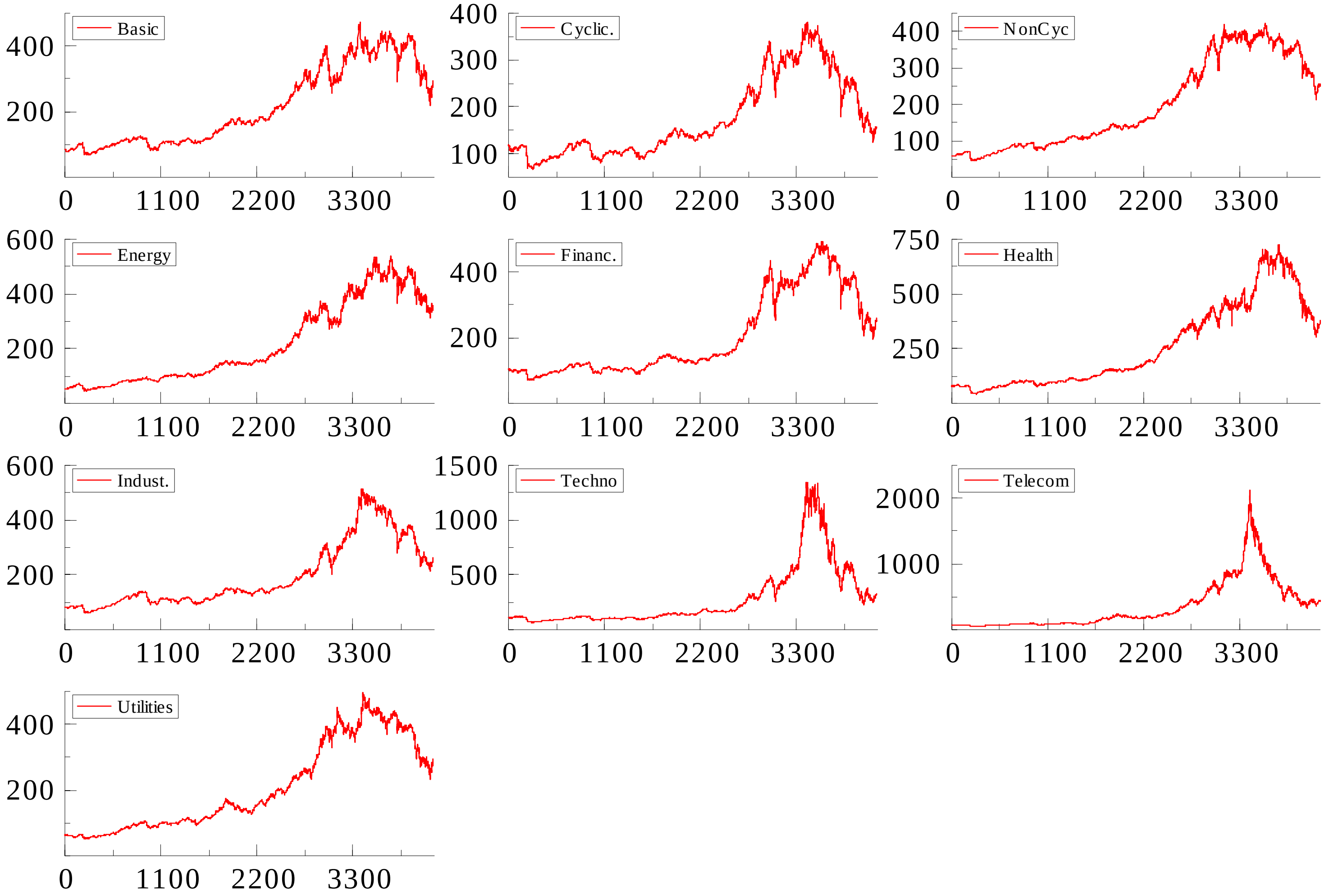

Figure 2: Dynamics of the ten DJ indexes, period: January 1, 1987- May 6, 2003.

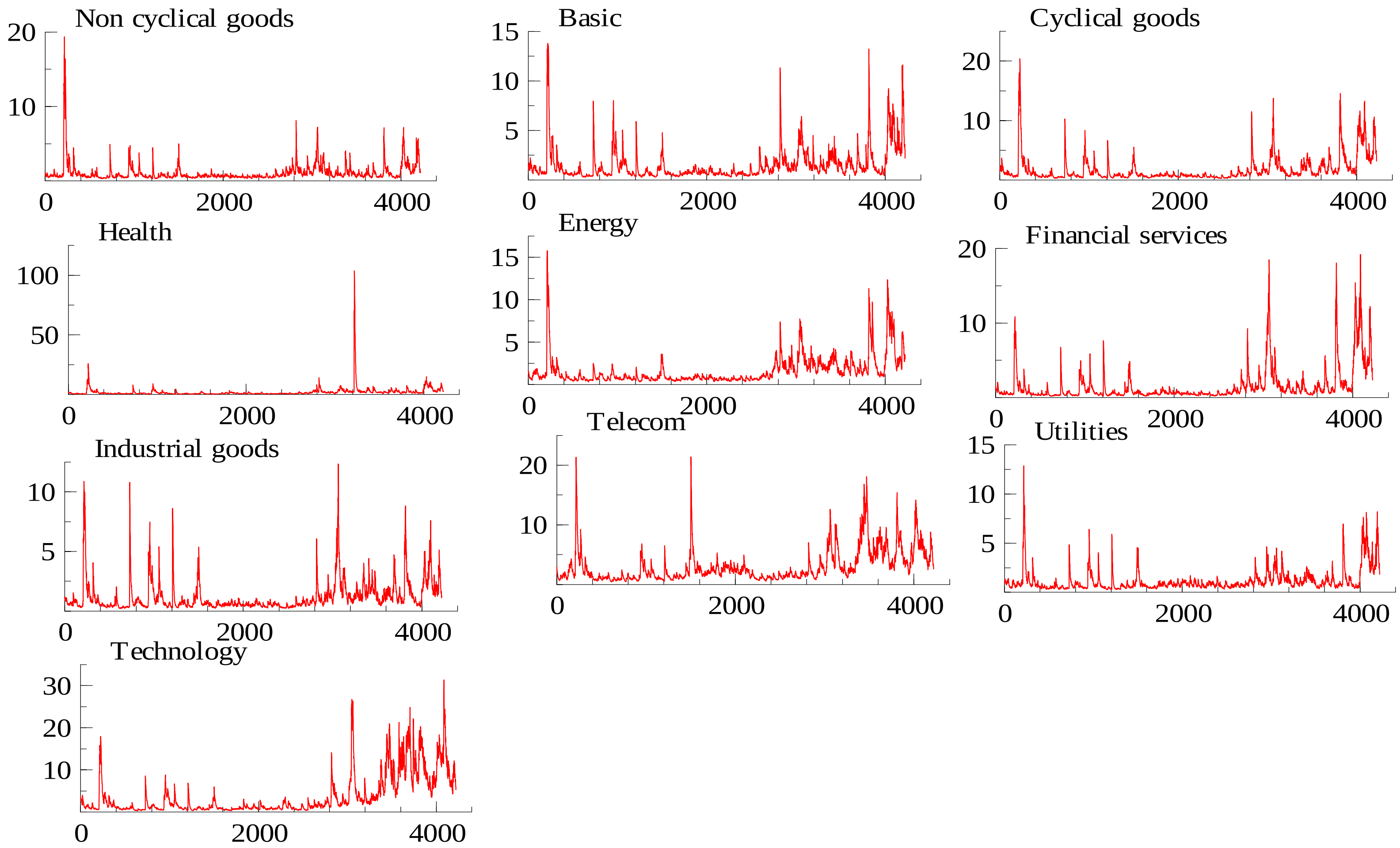

Figure 3: Conditional variances of the ten DJ indexes drawn from univariate GARCH(1,1)

5. The technological sector: Characteristics and links with the other sectors

The technology sector has experienced a huge growth in the conditional volatility during the early 2000's. However, as may be seen from Fig. 2., this movement already started at the end of 1997, thus before the beginning of the price decline.

Another important feature for portfolio managers lies in the evolution of cross-correlations among sectors. According to some authors, like Chesnay and Jondeau (2000), troubled periods are likely to exhibit higher correlations. If this were indeed the case, then the diversification would become the less efficient when it is the most wanted.

Our results point in the opposite direction. Figure 3 displays the conditional correlations of returns estimated from the DCC(1,1) model for the nine indexes against the technology index returns. The estimated conditional correlations between the technology sectors and the other ones (see Figure 3) either remained stable or dropped, sometimes sharply during the so-called technology bubble (2000-2002). Only the utilities sector might be seen as an exception to this global picture.

In a sense, it is not surprising that a single sector crisis implies a reduction of its correlation with the other sectors. Indeed, if one believes that the fundamentals of the other sectors remained unchanged, then there should be no reason, except contagion, for observing impacts on any market which is not directly linked to technology. Furthermore, the disconnection of the technological stock price evolution from the global stock market should mechanically lead to a drop in correlations.

However, things are not so simple. Indeed, as already shown, all sectors have experienced a volatility increase during and after the crisis, which indicates that some degree of contagion was at stake. Thus, we are facing a paradoxical situation where, on the one hand, conditional variances are increasing and, on the other hand, correlations are mostly decreasing. At first sight, returns behave as if the turmoil was affecting all sectors but separately. This conclusion contrasts with the main findings of papers on geographic contagion. Therefore, it brings a strong argument in favor of sector diversification as opposed to country diversification, especially during markets' hard times.

Geographic crises are usually associated not only with a global rise of volatility but also with a downward movement on markets all around the globe. Thus, as a matter of fact, the contagion is to be measured by both volatility and correlation. Furthermore, the behavior of sector indices indicates that these correlation and volatility may evolve very differently.

Our observation period allows for a comparison of the impacts of the IT bubble (sector crisis) and the October 1987 crash (global crisis) on the correlation series. Only a slight drop in correlations was observable in 1987, with the exception of three sectors: Industrial goods, utilities, and to some extent cyclical goods. Interestingly, two out of these three sectors (namely, industrial goods and utilities) are precisely the ones for which the correlation with the technology sector was the less influenced during the IT bubble. Moreover, the drop in correlation in 1987 was shorter lasting than in 2000-2001. Globally, none of the crises resulted in a rise of the correlations with the technological sector.

Meeting the conclusions drawn by Ferreira and Gama (2003), this paper shows that the rise in sector volatility is, at least partially, compensated by a decline in sector correlations. This stylized fact offers a strong rationale in favor of wide portfolio diversification among sectors. Thus, even if country diversification may look fruitful and perhaps superior to sector diversification (a currently disputed assertion) under "normal" market conditions, the benefits from sector diversification during crises must be taken into account in portfolio management. Indeed, even if crises are usually short, their effects are long lasting for investors. The weighting of crisis-based arguments when managing portfolios remains an open question.

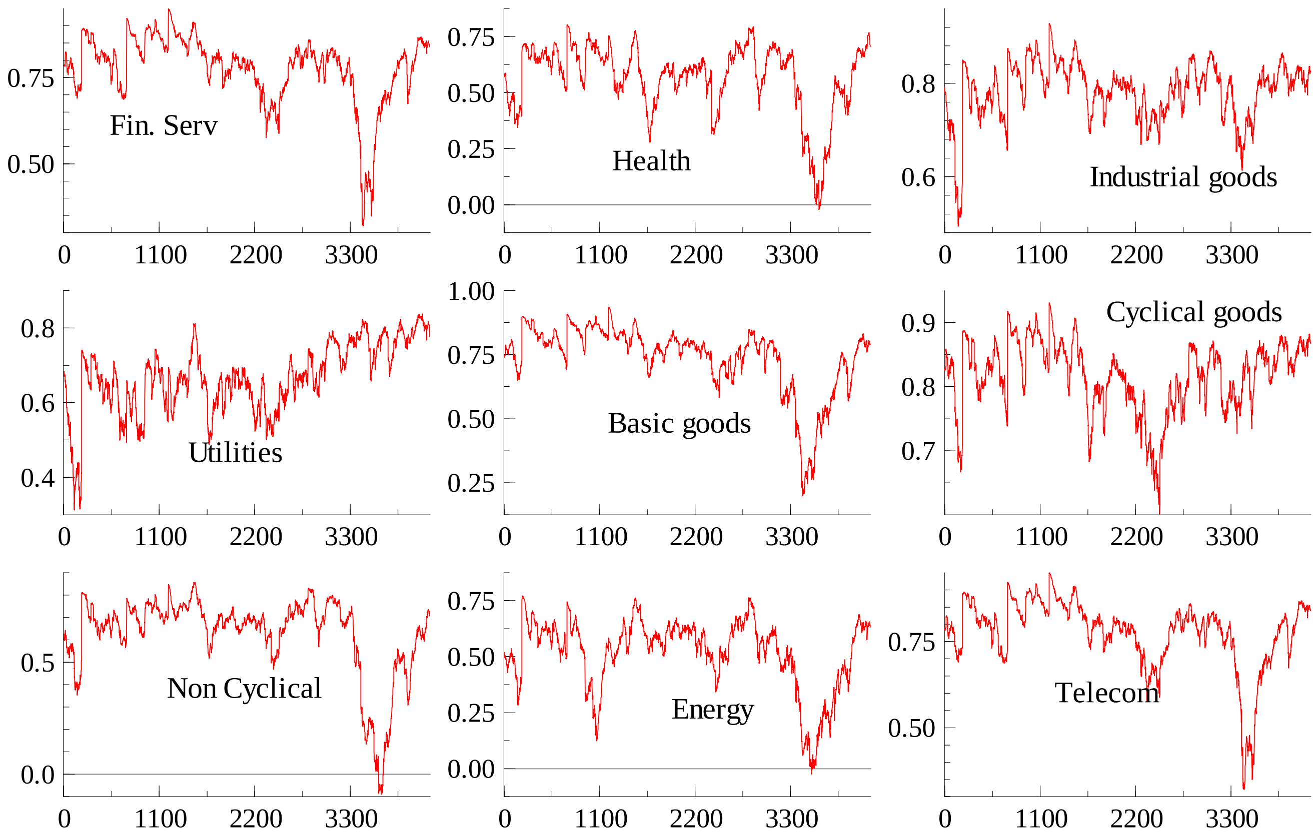

Figure 3: Conditional correlations of the sector returns against the technology returns.

Table 3. Statistical features of correlations against technological sector

1st Januray 1987 – 6th May 2003

	Basic	Cycl.	NCycl	Energy	Finance	Health	Indust	Telecom	Utilit
Average	0.736	0.817	0.623	0.515	0.776	0.536	0.784	0.668	0.632
Standard error	0.135	0.055	0.180	0.160	0.101	0.156	0.063	0.098	0.115
Minimum	0.199	0.601	-0.090	-0.024	0.321	-0.022	0.494	0.313	0.240

Table 3 provides basic statistics on the correlations of all sectors against the technological one. Two comments are in order. First, correlations display a lot of heterogeneity with respect to their level and their variability. Some sectors like non cyclical goods, energy or health services have reached negative correlations against the technological sector, while others like industrial goods, cyclical goods, and telecommunications remain positively correlated over the whole period. Second, there seems to be a negative relationship between the average level of the correlations against the technological sector and its variability. Importantly, this stylized fact appears to go beyond the pure statistical effect due to the obvious restriction that correlations are comprised between -1 and 1. The uncertainty regarding the correlations of the industrial goods, cyclical goods, and telecommunication sectors are about two times smaller than the one relative to the other sectors. This is an important point for investors in search of diversification opportunities.

6. Practical consequences for the investors

A few crashes did affect the world stock markets during the 20th century. Investors are becoming aware of global risks. Two broad categories of such risks are identified by the researchers: the systemic risks induced by the international real linkages and the contagion risks which are often associated to some kind of overreaction and panic following sudden shocks.

As a matter of fact, the second class of risks is the most frightening one for the investors. as it materializes only infrequently and is thus difficult to forecast. Furthermore, earlier papers have shown that geographic contagion was observed under certain circumstances. leading to a reduction of diversification opportunities during crises.

A few years ago, European investors tended to consider assets from foreign European country on the same grounds as non-European assets. Since the creation of the single-currency area, things are slowly changing, at least in the Euroland where no more currency risk exists. Nevertheless, many portfolio managers still privilege country diversification, even within Europe, rather than sector diversification.

While several authors had already shown that this way of doing is becoming less and less relevant during quite times, our paper emphasizes that things are even more contrasted during crises. Indeed, while conditional volatility rise on almost all assets, correlations between sector indices exhibit a global downward tendency. In other words, contagion between sectors happens in volatility (no sector index is quiet during crises) but not in level (the sector indices move differently).

Another practical consequence of this empirical exercise on European sector indices stems from the methodology used. Indeed, most valuation models used by practitioners are based on a constant correlation hypothesis. We did not report here formal tests results but this hypothesis is obviously violated by the series. If one does not take into account the proper dynamics of correlations, then the optimal portfolio weights of the assets will be biased. For instance, during crises, since the mean sector correlation is going down, the potential benefits from diversification is becoming larger and, other things being equal, additional assets may lead to a substantial risk reduction (remember that variances are high during crises)[6].

One can argue that the technology crisis is a very special case and that during the period covered by this study, other dramatic events happened, like the 9/11 terrorist attack. However, each crisis is specific and crises are relatively rare events. In Europe, the

[6] Note, however, that with a different methodology based on a tail-beta approach, Straetmans *et al.* (2003) conclude that "*the potential for portfolio risk diversification during crisis periods, i.e. when diversification is most needed, has diminished after 9/11*" (p.16).

technology crisis is the first and only one that occurred since the creation of the single currency.

Anyhow, as far as investing decisions are concerned, the mechanism – still mysterious for most analysts – leading to market turmoil and contagion is not really at stake. Actually, the investors' wealth evolves in real time with the stock prices, not with the profound and refined explanations of the crisis that will be provided afterwards.

7. Concluding remarks

Crises are unpredictable but in the long run do happen. They can be viewed as bubbles or "fundamental" crashes associated to political, economical or purely financial events. Anyhow, market crises are hard to handle for stock holders, especially for those who did not earlier acknowledge their potential emergence.

However, the existence of such episodes might well be the reason for a high risk premium associated to stock markets (Jorion and Goetzmann (1999)). Together with the so-called "peso-problem" (a feared crisis which finally did not occur), these phenomena make it very hazardous to base portfolio management only on business-as-usual financial data. Two ways of tackling this problem are possible.

First, working with very long data series ensures that a few crises are incorporated in the sample period. However, this approach may lead to several problems including for instance, the survivorship and microstructure effects. Second, the direct assessment of the impact of crises on asset returns is followed by recent papers putting forward the existence of contagion. mainly between country indices. Thanks to the recent DCC methodology, our paper has shown that sector indices help mitigating this contagion.

On the methodological side, extensions of the DCC (Cappiello *et al.* 2002) to allow for asymmetric effects in the dynamics of the correlations and covariances could be considered. The relevance of these extensions should nevertheless be first assessed.

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