Department of Economics and Finance

Chair of Empirical Finance

A new insight in the insurance sector: An Application of the ARCH-M and DCC-GARCH to European data

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1 Introduction

This dissertation has not only the aim of analyzing the impact of operating margin, that is the ratio of EBIT and revenues, on most of the European insurance companies' risk-return trade-off, but also of understanding the relationship, if any, of one of the major stock indexes for insurance companies, the EURO STOXX 600 Insurance, with their equity.

The reason why this topic has been chosen is that it has not been sufficiently covered by the literature and may be of interest to conduct such an analysis considering that the insurance sector is a key element to any country's economy in Europe, as confirmed in the last "European Insurance Overview" published by the European Insurance and Occupational Pensions Authority (EIOPA) at the end of 2021.

In this important document, it is also shown that the insurance companies of the countries that are under the direct supervision of EIOPA have registered, in 2020, an increase in total Gross Written Premiums (GWP) in the non-life business line, with casualty & property reinsurance being the branch with the highest increase.

When observing country distributions, median Solvency Capital Ratio (SCR) coverage values are above 150% and median Minimum Capital Requirement (MCR) coverage values are above 200% for all the observed countries.

This is a noticeable figure, considering that the 88.89% of the European insurance companies respect the imposed thresholds for the two above-mentioned capital requirements.

There is, however, a relevant fact to underline regarding the life insurance business line for the observed countries.

As a matter of fact, a general decrease in total gross written premiums has been observed in 2020.

Looking at the data, only the branch of health insurance saw an increase in gross written premiums, not enough to compensate the general decrease.

Finland and Portugal have been two of the most impacted countries, with a decrease in GWP of the sector of over 30%.

In this context, it is possible that all the negative market and regulatory shocks of recent times (e.g., provoked by COVID-19) have had a disruptive effect on both the performances and the revenues of insurance companies, raising the volatility of their business, a factor that would require a risk premium that should be incorporated in accounting performance indicators such as Return On Assets (ROA) and Return On Equity (ROE), according to DeYoung and Roland (2001), and that prices the volatility of revenues and, consequently, that of EBIT.

To provide an analysis of interest, in this dissertation it has been implemented a methodology that does not only exploit gross written premiums, but the whole financial statement's item of revenues, that also accounts for sources that do not come from traditional business. In general, the objective is to analyze the emergence of a risk premium accounting for the riskiness of the operating margin (the financial ratio of EBIT and revenues) with a model of insurance returns estimated by an ARCH-M procedure, that will be described in the sections below.

The ARCH-M model is proficient at estimating the risk premium because it considers the conditional volatility, the measure of risk, in the return equation, instead of running a regression on a risk adjusted basis.

To better understand the effect of the conditional volatility of the dependent variable, a general form of the model (that does not take into account σ_t) has been developed, also to show the differences in the parameters.

This has also allowed to study the effect of operating margin on ROA and ROE (the dependent variables), that have also been scaled down by a four semester moving average of their standard deviation and by their conditional volatility calculated through the use of a GARCH(1,1) model.

The data-set is composed of semi-annual (or annual, in case the latter frequency was not available on Refinitiv) observations from the beginning of 2001 to the end of the second semester of 2021 for revenues, EBIT, ROA, ROE and equity ratio belonging to 55 European insurance companies.

This dissertation is also aimed at investigating the relationship that links a stock market index to the financial performance of the equity of the insurance companies in the sample, in order to understand the dynamic correlation of the EURO STOXX 600 Insurance (i.e., the reference market index for European insurance companies) with the relative sector's stocks.

This is very uncommon, also considering that the estimation has been carried out asset by asset, in order to get a more significant number of results.

The contribution to the related literature is given by estimating the dynamic conditional betas for all the financial time series of stock returns issued on any European financial market from 01/01/2001 to 05/05/2022 using the DCC-GARCH model of Engle (2002), which employs a GARCH process to estimate the conditional co-movement between the above-mentioned assets and the considered stock market index, for which it has been considered a time series of returns of the same length as the paired stock.

The findings for the application of the ARCH-M process suggest that the parameter related to the conditional volatility has mostly been found significant in the model scaled by a four-semester moving average of the standard deviation of the dependent variable, together with the significance of the operating margin parameter, that is however more common in the non-scaled version.

Regarding the general form of the model, the results show that it captures the significance of the parameter associated to the operating margin (proving to be a good model for estimating the performance of the insurance companies), even though it is overestimated with respect to the ARCH-M process, considered that the conditional volatility is erased.

To resume, the surge of a risk premium associated to the volatility of revenues and EBIT (summarized in the operating margin ratio) seems supported by the empirical evidence, given the strong significance of the parameter related to the conditional volatility (mainly in the scaled versions of the ARCH-M).

The findings related to the application of the DCC-GARCH model instead show that the GARCH parameters are generally significant, suggesting a good specification.

This is also supported by the strong significance of the DCC's persistence parameter, namely β_{DCC}, even though α_{DCC} is significant only for some of the reported companies.

The empirical evidence suggests that the correlation between the analyzed stocks and the EURO STOXX 600 is found to be moderately positive, ranging from negative peaks of -20% to positive ones of maximum 30%, excluding the extremely rare outliers in the sample.

2 Literature Review and Hypotheses

2.1 Literature Review

The first sub-section reports, and briefly explains, the literature that has inspired this research, while the second introduces the hypotheses.

In the paper from Calmès and Théoret (2010), the aim is to analyze the impact of the share of commissions and fees, an income statement item that represents the revenue generated by non-traditional activities of insurance companies, on their risk-return trade-off, measured by financial statement variables as Return on Asset (ROA) and Return on Equity (ROE), of the entire Canadian Banking System, as an aggregate.

The authors take their inspiration from the related literature, such as Acharya et al. (2002), Stiroh (2004), Stiroh (2006b) and Lepetit et al. (2008), but they give a significant contribution by applying their methodology to a new data-set.

This is achieved through the application of an empirical model developed by the authors, based on the results of the previous works of Stiroh (2004) for the United States and by Calmès and Liu (2009) and Calmès and Théoret (2009) for Canada.

The general form of this model is:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Snonin_t + \beta_3 X_t + \epsilon_t \tag{2.1}$$

Where:

- Y_t is an accounting measure of bank performance – i.e., the return on equity (ROE) and the return on assets (ROA);
- $Snonin_t$ is the share of non-interest income in net operating revenue;
- X_t is the control variable;
- ϵ_t is the innovation or error term.

X_t controls for factors that impact banks' performances, for example bank size (that is often measured as the natural logarithm of total assets).

In order to improve the results and have a deeper understanding of how alternative sources of income are impacting on insurance companies' performances, Eq.(2.1) has also been estimated on a risk-adjusted basis.

In this equation, Y_t is thus divided by a fourth-quarter moving average of its standard deviation.

Another measure that has been considered was to scale down Y_t by dividing it by its conditional volatility, estimated by the means of a simple GARCH (1,1) model, that was introduced by Bollerslev (1986).

The authors extend the general form of the model by introducing a variable that accounts for risk in the equation by applying an ARCH-M model, developed by Engle et al. (1987). Eq.(2.1) thus becomes:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Snonin_t + \beta_3 X_t + \beta_4 \sigma_{c,t} + \epsilon_t \tag{2.2}$$

Also in this specification Y_t is scaled with the same methodology as in the general form of the model.

The main objective of the authors is to understand and capture the relationship between off-balance-sheet (OBS) activities, represented by the commissions and fees, on banks' risk-return trade-off.

They seem to go against the tide with respect to the literature, represented for example by Stiroh and Rumble (2006), De Jonghe (2009) and Stiroh (2006a), by supporting the thesis by which OBS activities do not imply diversification benefits for banks when they undergo an increase, since introducing a risk premium in the returns' models and resorting to an ARCH-M procedure, the results display that banks' risk-return trade-off underwent a structural break around 1997 (the reference period is 1997-2007).

While during the first period (1988–1996) the volatility variable is not significant in any of the return's equations, a risk premium eventually emerges, pricing the risk associated to OBS activities, similarly to DeYoung and Roland (2001) and Baele et al. (2007).

In summary, the authors find that the non-interest income generated by OBS activities no longer negatively impacts banks' returns.

Another paper that has influenced this dissertation, in examining the co-movement between assets and market, is Naeem et al. (2020).

The authors have tried to provide an insight of the impact of energy commodity uncertainties, measured by the indices developed by Balli et al. (2019), on the systematic risk of twelve industries in the US, on the basis of the evidence gathered by Narayan and Sharma (2011) and Phan et al. (2015).

The dynamic betas obtained by using the dynamic conditional correlation-generalized autoregressive conditional heteroskedasticity (DCC-GARCH) model, developed by Engle (2002), display notably good results that seem to support the thesis that real estate, financials, and basic materials are high-risk industries.

The authors' results also show that energy uncertainties have a significant positive impact on basic material, basic resources, financials, oil and gas and real estate.

Conversely, they identify the negative impact on consumer goods, consumer services, health care, industrials, and technology industries.

Although the field of research is quite different from the one that has been chosen for this dissertation, the authors have provided a significant help in the understanding of the DCC-GARCH model, specifically when it comes to its practical application.

Thanks to their analysis, it has been easier to study the dynamic correlation of the time series of financial returns of the stocks issued by the analyzed companies in the sample.

Cappiello et al. (2006) have instead proposed a slight modification of the DCC-GARCH model, that accounts for the asymmetry related to the variance of the returns, regarding which there is vast literature, like the leverage effect studied by Black (1976) and Christie (1982) or the volatility feedback effect rate discussed by Campbell and Hentschel (1992).

The data analyzed by the authors come from international equity and bonds, represented by the FTSE All-World Indices for 21 countries and the DataStream Benchmark Bond Indices with 5 years average maturity for 13 of them.

The application of the ADCC-GARCH has led the authors to interesting results that tend to confirm their initial hypothesis that the data analyzed display a strong asymmetry in correlation, while, regarding conditional volatility, this effect is found to be significant mostly for equity.

It is also worth mentioning that, in this paper, a structural break was evidenced in 1999, the year in which the Euro was introduced, with the correlation related to the equity data that only increases after that year.

2.2 Hypotheses

Following what has been stated in the section above, this paper intends to verify two main hypotheses:

1. *H1*: Given that the performance of an insurance company directly depends on its volume of revenues and on EBIT, it is expected that a risk premium factor should emerge, and thus be linked to the volatility of both this variables (that are put together in the financial ratio of operating margin), similarly to what has been reported by DeYoung and Roland (2001), who claimed that the increasing volatility of banks' revenues generates a risk premium in accounting measures of performance, that in this paper are represented by ROA and ROE. For example, an increase in the volatility of revenues should require the emergence of a positive risk premium that prices it.

This would require a strong significance of the parameter associated to the conditional volatility in the ARCH-M model;

2. *H2*: Given that it is difficult to find a company that does not show a direct relation with its reference stock market, it is expected that the DCC-GARCH model displays a sufficient significance of its parameters, that capture the relative above-mentioned dynamic correlation.

The estimated correlation is also expected to be moderate in absolute value, since insurance companies are very keen on mitigating any kind of risk, thus including market risk, that surges in light of a significant correlation with the market and the events that characterize it.

3 Data and Methodology

3.1 Data

The analysis proposed in this dissertation has been performed on financial data available for several insurance companies that are listed on the European stock market.

In order to perform more accurate research, also insurance companies that have been recently de-listed have been considered.

The data-set of this dissertation contains observations from 01/01/2001 to 05/05/2022 about:

1. Time series of stock returns (daily);

2. Income statements (annual, semi–annual);

3. Balance sheets (annual, semi–annual).

The stock returns' time series have been downloaded from Bloomberg, also using the Excel add-on.

The data in the income statements and balance sheets have instead been downloaded from Refinitiv, since it is much more versatile and complete when it comes to financial analysis' items with respect to Bloomberg.

The data-set also contains stocks issued by absorbed or acquired companies, for the sake of completeness of the analysis.

In order to avoid distortions caused by different values of the currencies, all the data have been reported in euro, with the value of the exchange being the average foreign exchange rate for the semester/year considered.

The data available via income statement and balance sheet have generally been considered in their semi–annual form, since it allowed the data-set to contain more observations, smoothing the analysis.

In total there are 55 insurance companies in the sample.

Table 1: Representation of the sample

Country	**Insurance Company**
Austria	Uniqa
Austria	Vienna Insurance Group
Belgium	Ageas
Bosnia	Sarajevo Osiguranje
Croatia	Croatia Osiguranje
Croatia	Jadransko (Adriatic)

Cyprus	Atlantic Insurance
Cyprus	Cosmos Insurance
Cyprus	Minerva Insurance
Denmark	Almbrand
Denmark	Topdanmark
Denmark	Tryg
Finland	Sampo
France	AXA
France	CNP Assurance
France	SCOR SE
Germany	Allianz
Germany	Hannover Rueck
Germany	MLP
Germany	Nuerenberger
Germany	Rheinland
Germany	WUW
Holland	Aegon
Holland	NN Group
Holland	ING Group
Italy	Cattolica Assicurazioni
Italy	Generali Assicurazioni
Italy	Milano Assicurazioni
Italy	Unipolsai
Italy	Vittoria Assicurazioni
Norway	Gjensidige
Norway	Protector
Norway	Storebrand

Serbia	Dunav
Slovenia	Sava Re
Slovenia	Zavarovalnica Triglav
Spain	Grupo Catalana
Spain	Mapfre
Switzerland	Baloise
Switzerland	Helvetia
Switzerland	Swiss Life
Switzerland	Swiss Re
Switzerland	Vaudoise
Switzerland	Zurich
UK	Admiral
UK	Aviva
UK	Beazley
UK	Hansard
UK	Hargreaves
UK	Hiscox
UK	Lancashire
UK	Legal & General
UK	Phoenix Group
UK	Prudential
UK	RSA Insurance
UK	St James's Place

In the case in which the semi–annual form was missing (as for Refinitiv), the annual form has been considered.

The following is a list of cases in which this has happened:

1. **Belgium**:

- Ageas;

2. **Croatia**:

- Adriatic;
- Croatia;

3. **Danmark**:

- Alm Brand;
- TopDanmark;
- Tryg;

4. **Germany**:

- Allianz;
- Hannover Rueck;
- MLP;
- Rheinland;
- Wuestenrot Wuertembergische;

5. **Italy**:

- Compagnia di Assicurazione di Milano;

6. **Norway**:

- Gjensidige;
- Protector;
- Storebrand;

7. **Holland**:

- Aegon;
- NN group;
- Ing Groep;

8. **Slovenia**;

- Sava Re;

- Zavarovalnica Triglav.

In addition, in order to carry out the analysis through the application of the DCC-GARCH, the latest version of the MFE Econometric Toolbox (developed by Kevin Sheppard) has been used.

However, the DCC-GARCH analysis has not been conducted for Milano Assicurazioni S.p.A., JLT Group, RSA Insurance and St James's place Insurance since their stock returns' time series could not fit the *dcc* function.

3.2 Methodology: Application of the ARCH-M model

A brief reminder of the ARCH-M is necessary to introduce this section.

The ARCH-M model is:

$$Y_t = c + \theta\sqrt{h_t} + \epsilon_t, where : \epsilon_t|I_{t-1} \sim N(0, h_t); \tag{3.1}$$

The innovation term ϵ_t is ARCH(q) and I_{t-1} is the available information set.

The model assumes heteroskedastic disturbances and standard deviations that directly impact the mean.

The parameters of the ARCH-M can be estimated through maximum likelihood.

First, we need to define the following:

$$\begin{aligned} Y_t|X_t, \Pi \sim N(\beta' X_t + \delta h_t, h_t^2) \\ h_t^2 = \alpha' W_{\eta t} + \gamma' Z_t \end{aligned} \tag{3.2}$$

X_t and Z_t are respectively k x 1 and j x 1 vectors exogenous variables.

Z_t also incorporates a constant, whose coefficient stands for a fixed and constant variance component of h_t.

The component η is just a p x 1 vector of disturbances $\epsilon_{t-k}^2, k = (1, 2, \ldots, p)$ and given by the following equation:

$$\epsilon_t = y_t - (\beta' X_t + \delta h_t) \tag{3.3}$$

The model can contain restricted parametrizations of conditional variances to ϵ_{t-k}^2 thanks to W_t, a q x p array of fixed constants.
It is possible to group all the coefficients in a vector $\phi' = (\alpha', \gamma', \beta', \delta')$.
The log–likelihood function takes this form:

$$\sum_{t=1}^{T} L_t(\phi); L_t(\phi) = -log|h_t| - \epsilon_t^2/2h_t^2 \tag{3.4}$$

The first order conditions can be computed and take the form:

$$(\partial L_t)/(\partial \phi) = \sum([\epsilon_t^2 - h_t^2 - h_t\delta\epsilon_t]\partial h_t^{-4})(\partial h_t^2/\partial\phi)/2 - \sum[\epsilon_t/h_t^2][(\partial\beta')/(\partial\phi)] \tag{3.5}$$

Notice that this form, when $\delta = 0$, just reduces to an ARCH model, developed by Engle (1982).
Regarding the estimation, it is possible to make use of numerical derivatives, given that they are very flexible and simply to compute.
If $[S]_{ti} = (\partial L_t/\partial\phi), \partial L/\partial\phi = S'i$, with i being a T x 1 unit vector such that the FOC gives $S\text{'}i = 0$.
It is pacific that the Hessian of the log–likelihood is the sum of t conditional log–likelihoods.
If it is assumed that the log–likelihood is correctly specified, then:

$$F_t = E[(\partial L_t/\partial\phi)(\partial L_t'/\partial\phi)] = -E[\partial^2 L_t/\partial\phi\partial\phi'] \tag{3.6}$$

With F_t being the information matrix of the *t-th* observation.
F_t is also defined as the average of the information over each observation, so F_t=$E[(S\text{'}S)/T]$, while $S\text{'}S/T$ is assumed to be consistent for F.
To maximize the likelihood, it is suggested to make use of the method developed by Berndt et al. (1974), that use the following iteration:

$$\phi^{i+1} = \phi^i + \lambda(SS')^{-1}S'i \tag{3.7}$$

With λ being a length that has a unity value at the origin but that gets adjusted with a line search and S a matrix of derivatives evaluated at each value of ϕ^i.

According to Crowder (1976), a solution to the previous iteration would have a property such that $(SS')^{-1/2}(\phi^* - \phi^0) \sim N(0, I)$.

ϕ^* is the MLE retrieved from the iteration and ϕ^0 is a vector containing the real values of the parameters.

The inference procedures can be developed from the previous equations.

The first part of this dissertation intends to take a cue from Calmès and Théoret (2010) in order to apply an ARCH-M model to the data collected from the financial statements of all the reported insurance companies.

Obviously, it must be considered that the mentioned authors' data come from banks and not from insurance companies, and as such, they have very different business models and also have dissimilar sources of income, the former having a large portion of their revenues constituted by interests on loans and on deposits and the latter by the premiums earned from underwriting of assurances.

This consideration has led to a change in the original model, since, after having applied it to all the companies, the variable *snonin* (i.e., the portion of income derived from commissions and fees divided by net income) has been found to be not sufficiently explanatory of the performances of the considered insurance companies.

After long research, it has been found that the operating margin has a sufficient explanatory power, since it indeed considers two very important financial statement items, such as Earning Before Interests and Taxes (EBIT), and revenues.

The operating margin may be an interesting independent variable to implement in an ARCH-M model of this kind, since it describes how efficient a company is in making profits from its sales.

It is common to interpret the operating margin also as a measure of business risk, considering that a low capability of generating profits from business activities may indicate a badly managed and risky company to invest in.

So, the higher this ratio is, the better for the company.

EBIT, instead, is calculated as:

$$EBIT = NetIncome + Taxes + Interests. \tag{3.8}$$

EBIT is generally used to analyze how successful the operations of a company are, without taking into account the tax treatments or the cost of the capital structure, that may be company/country-specific.

The main advantage in using EBIT and revenues is that these are very simple and easy figures to understand and calculate, giving rise to a simple ratio that, on the contrary, can provide very interesting insights on the performance analysis of the insurance companies.

To complete the model, it has also been considered a control variable.

In this case, it has been chosen the equity ratio, deemed very significant for an insurance company, since it measures the relative proportion of equity used to finance the company's assets, taking into account both the total assets and the total shareholders' equity, i.e., measures of the company's size.

The general form of the considered model (that allows to understand the effect of operating margin on the dependent variable) is:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 OpertaingMargin_t + \beta_3 X_t + \epsilon_t \tag{3.9}$$

Where:

- Y_t is an accounting measure of bank performance – i.e. the return on equity (ROE) and the return on assets (ROA);
- $OperatingMargin_t$ is EBIT divided by revenues;
- X_t is the equity ratio;
- ϵ_t is the innovation or error term.

X_t controls for factors that impact banks performance.

Classical finance states that:

$$R_t = \theta_0 + \theta_1 risk_t + \mu_t \tag{3.10}$$

Where:

- R_t is the return;

- $Risk_t$ is a risk measure;
- μ_t is the innovation term.

The variable risk is introduced in Eq. (3.9) through the application of an ARCH-M model, such that the equation becomes of the following form:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 OpertaingMargin_t + \beta_3 X_t + \beta_4 \sigma_{c,t} + \epsilon_t \tag{3.11}$$

Where σ_c, t, the conditional volatility of the dependent variable, is computed using the following equation:

$$\sigma_t^2 = \theta_0 + \sigma_{t-1}^2 + \epsilon_{t-1}^2 \tag{3.12}$$

Eq.(3.9) and (3.11) are also estimated on a risk-adjusted basis.
Y_t has indeed been divided by a four-semester moving average of its standard deviation, in order to get a sufficient number of observations.
To scale down y_t, it has also been considered a different risk measure introduced by Calmès and Théoret (2009), relying on the ratio of y_t and its conditional volatility as measured by a classic GARCH(1, 1) model.
As mentioned before, the ARCH-M method may be an appropriate way of estimating the risk premium since it considers the conditional volatility (i.e., the aforementioned measure of risk) in the return equation.
The analysis has been conducted, and the model applied, to each of the considered insurance companies.

3.3 Methodology: Application of the DCC-GARCH model

In order to provide a deeper and different analysis of the financial performance of the insurance companies contained in the sample, it is given another point of view, which considers the main traditional financial instrument that an insurance company can issue on the market, i.e., equity.
In particular, the DCC-GARCH(1,1) model is applied to the data in order to understand the effect that the volatility of a major financial index such as the EURO STOXX 600 Insurance

has on the performance of the above-mentioned financial instrument, and consequently on that of the related insurance companies in the sample.

The DCC-GARCH(1,1) indeed allows to take into account the dynamics of the volatility and the correlation between the variables considered and, as generally stated in the literature, suits very well any financial time series.

This is a dynamic correlation model that allows the conditional correlation matrix R to be time-varying (i.e., R_t).

In this way, it is possible to retrieve a time-varying variance-covariance matrix such that:

$$H_t = D_t R_t D_t. \tag{3.13}$$

With respect to the parametrization of the time-varying conditional correlation matrix, it is important to underline that the conditional variances must be unity.

One of the most natural specifications of the correlation matrix is consequently given by a simple GARCH(1,1) model.

$$q_{i,j,t} = \bar{\rho_{i,j}} + \alpha(\epsilon_{i,t-1}\epsilon_{j,t-1} - \bar{\rho_{i,j}}) + \beta(q_{i,j,t-1} - \bar{\rho_{i,j}}) \tag{3.14}$$

If rewritten, it is possible to reduce the former equation to:

$$q_{i,j,t} = \bar{\rho_{i,j}}((1-\alpha-\beta)/(1-\alpha) + \alpha \sum_{s=1}^{\infty} \beta^s \epsilon_{i,t-s}\epsilon_{j,t-s} \tag{3.15}$$

In this context, the expectation of the cross product would be $\bar{\rho_{i,j}}$, but if the variances are considered, then: $\bar{\rho_{i,j}} = \mathrm{I}$.

The estimator for

$$\bar{\rho_{i,j,t}} = \bar{q_{i,j}}/\sqrt{\bar{q_{j,j,t}}\bar{q_{i,i,t}}} \tag{3.16}$$

is by design positive since $Q_t = [\bar{q_{i,j,t}}]$ is the covariance matrix, given by the weighted average of two matrices, one positive definite and the other positive semi-definite.

The persistence of the model is $\alpha + \beta < 1$.

In order to describe the methodology for the estimation, it is important to report the proper statistical specification of the model:

$$\begin{aligned} R_t|F_t &\sim N(0, D_t R_t D_t) \\ D_t^2 &= diag(\omega_i) + diag(k_i) \circ r_{t-1} r_{t-1}' + diag(\lambda_i) \circ D_t^2 \\ \epsilon_t &= D_t^{-1} r_t \\ Q_t &= S \circ (ii' - A - B) + A \circ \epsilon_{t-1}\epsilon_{t-1}' + B \circ Q_{t-1} \\ R_t &= diag(Q_t)^{-1} Q_t diag(Q_t)^{-1} \end{aligned} \tag{3.17}$$

Where i is a vector of ones and $\circ$ is the Hadamard product of two identically sized matrices which is computed through an element by element multiplication, with A and B that can be positive definite matrices.

The normality assumption in the first equation in (10) generates the log-likelihood function. It can be written in the following form:

$$\begin{aligned} \mathbf{r}_t|F_t &\sim N(0, D_t R_t D_t), \\ L &= -1/2 \sum_{t=1}^{T} (\mathbf{n} log(2\pi) + log|H_t| + r_t' H_t^{-1} r_t) \\ &= -1/2 \sum_{t=1}^{T} (\mathbf{n} log(2\pi) + log|D_t R_t D_t| + r_t' D_t^{-1} R_t D_t^{-1} r_t) \\ &= -1/2 \sum_{t=1}^{T} (\mathbf{n} log(2\pi) + 2log|D_t| + log|R_t| + \epsilon_t' R_t^{-1} \epsilon_t) \\ &= -1/2 \sum_{t=1}^{T} (\mathbf{n} log(2\pi) + 2log|D_t| + r_t' D_t^{-1} D_t^{-1} r_t - \epsilon_t' \epsilon_t + log|R_t| + \epsilon_t' R_t^{-1} \epsilon_t) \end{aligned} \tag{3.18}$$

The maximization can be performed over the parameters.

It is also interesting to report that Engle (2002) has proved that other estimation methods provided for example by Newey and McFadden (1994) give back consistent but inefficient estimates of the parameters.

4 Results

In this section, the results and the findings that have been achieved during the analysis proposed in the dissertation will be reported and discussed.

Given the great number of insurance companies analyzed and the various models that have been applied, this section reports only some significant and exemplary results in terms of tables containing the betas of the used variables in the equations developed in section 3.2, that are however completely explanatory of the general results.
The figures related to section 3.3 are also exemplary, but equally explanatory of the related results, for which instead are integrally reported the tables with the parameters.
Additional materials can be found in the Appendix.

4.1 Results and discussion for the ARCH-M

Table 2

	General Model 1	General Model 2	General Model 3
alfa	0.0008	0.9537	0.2532
beta	0.0019	0.7037***	0.8326***
gamma	0.0362***	0.8007	1.0000
delta	0.0000	0.8295	0.0000
theta	/	/	/

Legenda

Betas of the general form of the model applied to ROA for AXA

**Significant at 0,1 level.

***Significant at 0.05 level.

****Significant at 0.01 level.

Table 3

	ARCH-M Model 1	ARCH-M Model 2	ARCH-M Model 3
β_0	0.0004	0.9137	0.0000
β_1	0.0020	0.0000	0.0000
β_2	0.0362***	1.0000	1.0000
β_3	0.0000	1.0000	0.0000
β_4	0.0915***	0.2017	0.9334***

Legenda

Betas of the ARCH-M model applied to ROA for AXA

*Significant at 0,1 level.

**Significant at 0.05 level.

***Significant at 0.01 level.

Table 4

	ARCH-M Model 1	ARCH-M Model 2	ARCH-M Model 3
β_0	0.0034	1.0000	1.0000
β_1	0.0588	0.5849	0.0000
β_2	0.0044***	0.5837	1.0000
β_3	0.0151**	0.2397	1.0000
β_4	0.0006	0.1826	1.0000***

Legenda

Betas of the ARCH-M model applied to ROA for Vaudoise

*Significant at 0,1 level.

**Significant at 0.05 level.

***Significant at 0.01 level.

Table 5

	General Model 1	General Model 2	General Model 3
β_0	0.0034	0.9333	1.0000
β_1	0.0588	0.6730***	0.8505***
β_2	0.0044***	0.8310	0.1073
β_3	0.0151	0.8623	1.0000
β_4	/	/	/

Legenda

Betas of the general form of the model applied to ROA for Vaudoise

*Significant at 0,1 level.

**Significant at 0.05 level.

***Significant at 0.01 level.

Table 6

	ARCH-M Model 1	ARCH-M Model 2	ARCH-M Model 3
β_0	0.0612	0.0000	0.0000
β_1	0.2762*	0.0000	0.0000
β_2	0.2205***	1.0000	0.0000
β_3	0.0000	0.0000	0.0000
β_4	0.0000	0.7379	0.9318***

Legenda

Betas of the ARCH-M applied to ROE for Storebrand

*Significant at 0,1 level.

**Significant at 0.05 level.

***Significant at 0.01 level.

Table 7

	General Model 1	General Model 2	General Model 3
β_0	0.0630	1.0000	0.8391
β_1	0.2984**	0.1557	0.0000
β_2	0.2331***	1.0000	0.0000
β_3	0.0000	1.0000	0.0000
β_4	/	/	/

Legenda

Betas of the general form of the model applied to ROE for Storebrand

*Significant at 0,1 level.

**Significant at 0.05 level.

***Significant at 0.01 level.

Table 8

	ARCH-M Model 1	ARCH-M Model 2	ARCH-M Model 3
β_0	0.0511	0.0000	0.0000
β_1	0.0000	0.0000	0.0000
β_2	0.0146*	0.0573	0.0367
β_3	0.1356	1.0000	1.0000
β_4	0.2481	0.8004	0.9309***

Legenda

Betas of the ARCH-M applied to ROE for Sampo

*Significant at 0,1 level.

**Significant at 0.05 level.

***Significant at 0.01 level.

Table 9

	General Model 1	General Model 2	General Model 3
β_0	0.1204*	0.2637	1.0000***
β_1	0.0000	0.9353***	0.2720
β_2	0.0160***	0.0000	0.0000
β_3	0.0322	1.0000	0.4431
β_4	/	/	/

Legenda

Betas of the general form of the model applied to ROE for Sampo

*Significant at 0,1 level.

**Significant at 0.05 level.

***Significant at 0.01 level.

Table 10

	General Model 1	General Model 2	General Model 3
β_0	0.0000	0.7990***	0.2099***
β_1	0.1386***	0.5457***	0.8897***
β_2	0.0914***	0.6668***	1.0000
β_3	0.0098	0.6916	1.0000
β_4	/	/	/

Legenda

Betas of the general form of the model applied to ROA for VIG

*Significant at 0,1 level.

**Significant at 0.05 level.

***Significant at 0.01 level.

Table 11

	ARCH-M Model 1	ARCH-M Model 2	ARCH-M Model 3
β_0	0.0000	0.0000	0.1092
β_1	0.1154	0.0749	0.0000
β_2	0.0853***	1.0000	1.0000
β_3	0.0117	1.0000	1.0000
β_4	0.0454	0.7877***	0.9132***

Legenda

Betas of the ARCH-M model applied to ROA for VIG

*Significant at 0,1 level.

**Significant at 0.05 level.

***Significant at 0.01 level.

Examining the results, it is possible to notice how the estimation of the models (considering the three proposed versions), both for Return on Assets and for Return on Equity, has provided significant results in terms of three main variables, that are the operating margin, the autoregressive component and the conditional volatility of the dependent variable.

The non-scaled version of the general form of the model has provided the best results in terms of significance of the parameters, except the one applied for example to Generali, that seems to be over-performed by the version scaled by the four-semester moving standard deviation.

It is also worth mentioning that the parameter corresponding to the operating margin is in general statistically more significant if compared to the results obtained by Calmès and Théoret (2010), when considering the non-scaled version of the general form of the model and the one that takes into account the four-semester moving standard deviation.

It is possible to observe that the autoregressive component, both when considering ROA or ROE, is strongly significant in the general form of the model, regardless of the version considered (i.e., scaled and non-scaled).

The control variable adopted (i.e., the equity ratio for company i) is instead significant only for some of the non-scaled versions of the ARCH-M process and of the general form of the model when considering the return on assets, meaning that the size of an insurance company may influence the operating results, as it might be thought, given that a bigger insurance company could have a larger portion of the market and consequently a much higher volume of business and a higher value of assets and equity.

The significance of this variable is mainly found in Switzerland's insurance companies (together with many huge insurance companies such as Sampo, Tryg, Allianz, Mapfre, Rheinland, Aegon and Hannover Rueck for example).

Regarding ROE, the significance of this parameter is somehow lost in general.

One of the main observations that is worth reporting is that all the parameters are generally positive, indicating for example that increasing/decreasing operating margin leads to a proportional increase/decrease in the dependent variables, enhancing/worsening the performance of the insurance companies.

In particular, the operating margin parameter is higher in the model applied to the Return on Equity, compared to the Return on Assets.

These results tend to show that the operating margin may be considered as one of the key variables that explain and influence the performance of the insurance companies contained in the sample.

Regarding the ARCH-M model, it is important to underline that it has been applied to the data in order to introduce a direct risk premium measure in the returns' equation, as commonly accepted in asset pricing theory.

The ARCH-M procedure is also useful for capturing the non-linearity created by the change in volatility of revenues since the ARCH-M model is non-linear by definition.

The incorporation of a risk premium measure leads to important changes in the parameters and their significance.

In general, it is possible to observe that the non-scaled version of the ARCH-M process, both for ROA and ROE, provides a good continuity with the results of the general form of the model since the parameter associated to the operating margin is commonly significant and positive.

However, it is also fundamental to notice that the significance of the other components of the model become generally rarer.

On the other hand, it can be observed that at least one of the scaled versions of the ARCH-M model always capture the significance of β_4, the parameter associated to the conditional volatility of the dependent variable.

In contrast to Calmès and Théoret (2010), the constant introduced in the model is very rare, but this is not sufficient to invalidate the models.

In summary, introducing the risk premium in the returns' equation neutralizes the auto-regressivity of the returns' variables in all the versions of the ARCH-M, as in Calmès and Théoret (2010), but it also counteracts the significance of the operating margin in the scaled versions of the ARCH-M model of some insurance companies, transferring this impact to the conditional volatility variable, which becomes very important.

The hypothesis raised in this paper, regarding the surge of a risk premium associated to the volatility of revenues and EBIT (summarized in the operating margin ratio) seems supported by the empirical evidence, given the strong significance of β_4.

To conclude, it is worth mentioning that the ARCH-M procedure, scaled for the four-semester moving standard deviation of the returns, is generally better at capturing the ARCH-M effect (i.e., the significance of β_4).

This is for example, one of the main elements of difference with respect to the authors, since the authors provide empirical evidence of the fact that, despite the the ARCH-M procedure with the dependent variable scaled by the moving standard deviation provides good results in terms of significance of the parameters, the model that seems to better support their hypotheses is the one with the y_t scaled down by the conditional volatility obtained through the application of a GARCH(1,1) model.

4.2 Results and discussion for the DCC-GARCH

Insurance company	ω_i	α_i	β_i	ω_j	α_j	β_j
Uniqa	1.51e-05***	0.0844***	0.8606***	3.26e-06***	0.1253***	0.8650***
VIG	2.86e-06***	0.1180***	0.8818***	3.27e-06***	0.1254***	0.8649***
Ageas	5.95e-06***	0.1406***	0.8592***	3.24e-06***	0.1282***	0.8631***
Sarajevo Os.	5.71e-06	0.0693***	0.9305***	3.98e-06***	0.1402***	0.8419***
Cosmos	4.54e-06***	0.0414***	0.9565***	3.27e-06***	0.1254***	0.8649***
Minerva	1.58e-04***	0.0813***	0.8413***	3.27e-06***	0.1250***	0.8640***
Atlantic Insurance	4.00e-06***	0.0433***	0.9527***	3.26e-06***	0.1253***	0.8650***
Croatia Os.	6.81e-06***	0.0350***	0.9527***	3.26e-06***	0.1253***	0.8650***
Adriatic Insurance	1.69e-06***	0.0156***	0.9819***	3.09e-06***	0.1180***	0.8733***
Topdanmark	5.23e-05***	0.3917***	0.5493***	3.26e-06***	0.1254***	0.8649***
Tryg	9.46e-05***	0.4734***	0.3551***	3.28e-06***	0.1227***	0.8658***
Almbrand	1.16e-05	0.0896***	0.8840***	3.26e-06***	0.1253***	0.8650***
Sampo	5.64e-06***	0.0875***	0.8970***	3.34e-06***	0.1306***	0.8596***

Insurance company	ω_i	α_i	β_i	ω_j	α_j	β_j
CNP Assurance	1.15e-05***	0.1528***	0.8298***	3.27e-06***	0.1254***	0.8649***
Scor SE	2.40e-06	0.0563***	0.9422***	3.27e-06	0.1254***	0.8649**
AXA	7.34e-06***	0.1090***	0.8792***	3.26e-06***	0.1253***	0.8650***
Admiral Group	2.89e-06	0.0413***	0.9521***	3.37e-06***	0.1200***	0.8668***
Aviva	6.02e-06	0.0902***	0.9001***	3.27e-06***	0.1254***	0.8649***
Beazley	6.62e-06	0.0842***	0.8994***	2.93e-06***	0.1145***	0.8761***
Hansard	1.18e-04***	0.1398***	0.6637***	3.57e-06***	0.1276***	0.8615***
Heargraves	3.59e-05***	0.1230***	0.8125***	3.51e-06***	0.1270***	0.8625***
Hiscox	7.42e-06***	0.0665***	0.9132***	3.27e-06***	0.1254***	0.8649***
Lancaschire	5.05e-05***	0.0812***	0.7413***	3.30e-06***	0.1225***	0.8660***
Legal & General	5.61e-06***	0.0968***	0.8954***	3.27e-06***	0.1254***	0.8649***
Phoenix Group	1.52e-05***	0.1109***	0.8368***	3.36e-06***	0.1168***	0.8703***
Prudential	1.05e-05***	0.1063***	0.8780***	3.27e-06***	0.1254***	0.8649***
Allianz	5.84e-06***	0.1103***	0.8738***	3.26e-06***	0.1253***	0.8650***
Hannover Rueck	1.09e-05***	0.1360***	0.8371***	3.27e-06***	0.1254***	0.8649***
MLP	1.89e-05***	0.1460***	0.8332***	3.27e-06***	0.1254***	0.8649***
Nuerenberger	8.27e-06***	0.1648***	0.8115***	3.27e-06***	0.1254***	0.8649***
Rheinland	7.21e-06***	0.0715***	0.9273***	3.27e-06***	0.1254***	0.8649***
WUW	7.46e-06***	0.0950***	0.8866***	3.27e-06***	0.1254***	0.8649***

Insurance company	ω_i	α_i	β_i	ω_j	α_j	β_j
Generali	3.25e-06***	0.0871***	0.9040***	3.27e-06***	0.1254***	0.8649***
Cattolica Ass.	6.51e-06***	0.1228***	0.8740***	3.27e-06***	0.1254***	0.8649***
Unipolsai	7.95e-06***	0.1335***	0.8623***	3.27e-06***	0.1254***	0.8649***
Gjensidige	3.15e-05***	0.0610**	0.7633***	3.27e-06***	0.1177***	0.8662***
Protector	1.07e-04***	0.1200**	0.7085***	3.50e-06***	0.1254***	0.8632***
Storebrand	1.45e-05***	0.1088***	0.8717***	3.27e-06***	0.1254***	0.8649***
Aegon	6.87e-06***	0.0900***	0.9019***	3.27e-06***	0.1254***	0.8649***
NN Group	1.97e-05***	0.1483***	0.7727***	4.01e-06***	0.1342***	0.8457***
ING Group	5.29e-06***	0.1181***	0.8805***	3.27e-06***	0.1254***	0.8649***
Dunav	5.32e-05	0.0504*	0.9017***	3.28e-06***	0.1220***	0.8663***
Sava Re	3.75e-06***	0.0642***	0.9290***	3.51e-06***	0.1287***	0.8624***
Zavarovalnica Tr.	1.97e-05***	0.1282***	0.8030***	3.44e-06***	0.1274***	0.8637***
Grupo Catalana	2.72e-06***	0.0882***	0.9078***	3.26e-06***	0.1253***	0.8650***
Mapfre	4.60e-06***	0.0685***	0.9211***	3.27e-06***	0.1254***	0.8649***
Helvetia	3.70e-06***	0.0907***	0.9005***	3.27e-06***	0.1254***	0.8649***
Swiss Life	5.08e-06***	0.1040***	0.8854***	3.27e-06***	0.1254***	0.8649***
Swiss Re	8.90e-06***	0.1368***	0.8434***	3.27e-06***	0.1254***	0.8649***
Vaudoise	8.26e-06**	0.1286***	0.8471***	3.27e-06***	0.1254***	0.8649***
Zurich	3.80e-06***	0.0837***	0.9052***	3.27e-06***	0.1254***	0.8649***

Legenda

GARCH parameters of the DCC-GARCH model applied to equity

*Significant at 0.1 level.

**Significant at 0.05 level.

***Significant at 0.01 level.

Table 12

Insurance company	α_{DCC}	β_{DCC}
Uniqa	0.00742	0.8008***
VIG	8.64e-09	0.1946*
Ageas	0.0145	0.6652***
Sarajevo Os.	0.0023	0.9785***
Cosmos	1.88e-09	0.8746***
Minerva	4.20e-08	0.9426***
Atlantic Insurance	7.99e-04	0.9987***
Croatia Os.	0.0093	0.1364***
Adriatic Insurance	1.17e-10	0.9889***
Topdanmark	3.85e-08	0.6555***
Tryg	5.78e-09	0.9292***
Almbrand	5.62e-09	0.9335***
Sampo	0.0017	0.9313***
CNP Assurance	0.0045	0.2946
Scor SE	2.19e-08	0.7549**
AXA	7.87e-09	0.9097***
Admiral Group	2.62e-08	0.9034***

Insurance company	α_{DCC}	β_{DCC}
Aviva	1.47e-08	5.11e-09
Beazley	0.0045	0.6509***
Hansard	0.0022	0.9702***
Heargraves	0.0058	0.9351***
Hiscox	3.86e-09	9.78e-06***
Lancashire	1.00e-07	0.9947***
Legal & General	0.0182*	0.0152
Phoenix Group	6.25e-09	0.9927***
Prudential	2.021e-09	7.14e-09
Allianz	5.14e-08	9.17e-06
Hannover Rueck	1.34e-09	0.9434***
MLP	1.82e-09	0.8084*
Nuerenberger	5.41e-10	0.9854***
Rheinland	0.0084	0.6438***
WUW	0.0032	9.98e-06
Generali	8.263-05	0.41*
Cattolica Ass.	0.0094	0.3825
Unipolsai	0.0224	0.3210
Gjensidige	2.20e-09	0.9186***
Protector	0.0431	2.39e-06
Storebrand	1.35e-08	0.9208***

Insurance company	α_{DCC}	β_{DCC}
Aegon	4.653-09	1.00e-05
NN Group	0.0071	0.9755***
ING Group	0.0346*	0.1323
Dunav	0.091*	0.8786***
Sava Re	9.99e-09	4.56e-04
Zavarovalnica Tr.	3.027e-11	0.9909***
Grupo Catalana	0.0120**	0.0490*
Mapfre	2.11e-09	0.4909
Baloise	3.48e-08	0.0041
Helvetia	0.0038	0.1511
Swiss Life	0.0028	8.72e-05
Swiss Re	0.0098	0.2235
Vaudoise	3.93e-10	0.9948***
Zurich	0.0168**	2.48e-04

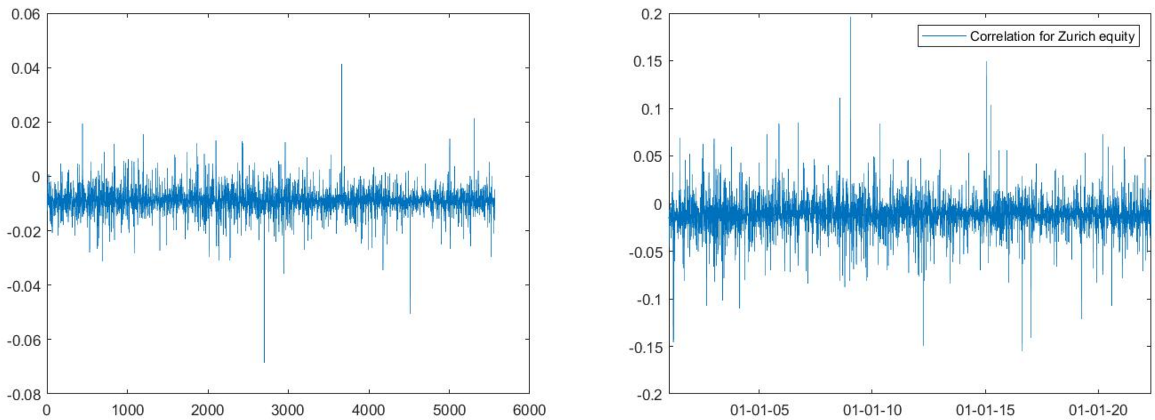
Legenda

α_{DCC} and β_{DCC} of the DCC-GARCH model applied to equity

*Significant at 0.1 level.

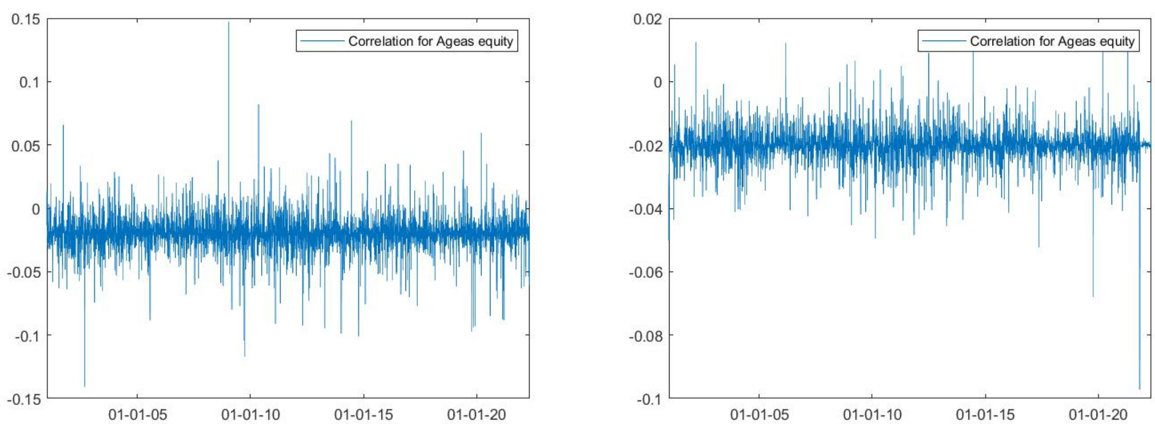
**Significant at 0.05 level.

***Significant at 0.01 level.



(a) *DCC-GARCH correlation for Helvetia equity* (b) *DCC-GARCH correlation for Zurich equity*

Figure 1



(a) *DCC-GARCH correlation for Grupo Catlana equity*

(b) *DCC-GARCH correlation for CNP Assurance equity*

Figure 2

The DCC-GARCH model is applied to the data in order to understand the relationship between the volatility of a major financial index such as the EURO STOXX 600 Insurance and the above-mentioned financial instruments, and with the proper financial performance of the related insurance companies in the sample.

The DCC-GARCH(1,1) indeed allows to take into account the dynamics of the volatility and of the correlation between the variables considered.

Following the procedure described in the data and methodology section, the estimation has been conducted asset by asset.

At the same time, this has allowed for a very detailed analysis for each insurance company and has given the possibility to describe the results in a general form with better detail and understanding.

The requirement of $\alpha_{DCC} + \beta_{DCC} < 1$ is always satisfied, so it is possible to assert that all the time series related to the analysed financial instruments display a mean reverting behaviour, which is in accordance with the vast literature that involves the model.

It can also be observed that both the parameters are always > 0, so that the general constraints are respected.

The results show the significance of the GARCH parameters.

It is important to underline that α_i indicates the sensitivity of the asset i after a volatility shock of the index (indicated with the j subscript), while β_i indicates its persistence.

Overall, the general significance of these parameters suggests a good specification.

It is worth considering that β_{DCC} is generally significant, while α_{DCC} is not, since it is rarer. The statistical significance of the DCC parameters suggests that the contribution of the correlation matrix in long run (always related to the concept of persistence), associated to β_{DCC}, is detected by the model, while the contribution of the realized immediate disturbance (represented by the residuals) to the correlation in the short run (i.e.,between t-1 and t), associated to α_{DCC} is infrequent, given that the significance of β_{DCC} is preeminent with respect to α_{DCC}.

The above-mentioned dynamic correlation to the disturbances is also very low (the parameter is almost every-time close to zero), while the persistence is generally high with the related parameter ranging mostly from 0.6438 (Rheinland) to 0.9987 (Atlantic Insurance), even though some parameters are very low but equally significant (0.1364 for Croatia Osiguranje).

More in detail, it is generally possible to note that the dynamic correlation ranges between -20% and +30%, but it is also possible to observe that it tends to stay positive, except for most of the stocks issued by Italian, Swiss, French insurance companies and Grupo Catalana (Spain).

In summary, the above-mentioned results lead to a partial validation of the second hypothesis, i.e., that there is a general positive dynamic correlation between the time series of the observed financial instruments and the EURO STOXX 600 Insurance index, mainly associated to a strong significance of the β_{DCC} parameter.

5 Conclusion

Following the results provided along the various sections and subsections of this dissertation, it is possible to proceed with its last part.

The aim has been to study the emergence of a risk premium accounting for the riskiness of the operating margin (the ratio between EBIT and revenues), taking a cue from the literature that has developed a model of returns estimated by an ARCH-M procedure, that has been reported in the data and methodology section above in three different versions (y_t scaled by a four-semester moving average of its standard deviation, y_t scaled by the conditional volatility of the dependent variable as calculated by a GARCH(1,1) and a non-scaled simple version of y_t).

The ARCH-M model has been selected since, if common asset pricing theory is considered, a simple risk-adjusted model may not be the optimal solution and not provide the best estimates, considering that instead the model directly incorporates volatility in the return equation, which should in fact figure on the right-hand side.

To make an example, in Calmès and Théoret (2010), the non-homogeneity in first degree of the time series of returns would be a main issue.

In general, it can be observed that the first hypothesis specified in section two has been confirmed since the significance of the parameter related to the conditional volatility in the ARCH-M process has been detected in the version scaled by a four-semester moving average of its standard deviation, together with the significance of the operating margin parameter (even though this beta is more common in the non-scaled version).

To provide a comparison, it has also been developed a general form of the model (also in the same three versions) that does not take into account the conditional volatility of the dependent variable.

It has been shown that it is also reliable in estimating the performance of insurance companies, but with the issue of an overestimated parameter related to the operating margin, given that the model does not take into account σ_t.

In summary, introducing the risk premium in the returns' equation neutralizes the autoregressivity of the returns variable (associated to β_1) in all the versions of the ARCH-M, as in Calmès and Théoret (2010), but it sometimes counteracts the significance of the operating margin parameter, even though only in the scaled versions of the ARCH-M model, transferring this impact to the conditional volatility variable, which becomes very influential, providing a good result of the applied process.

The general results indicate that the models, altogether, have been able to detect the statistical significance of the most important parameters, even though the progressive loss of the significance of the operating margin variable suggests that the reported ARCH-M models may not be the best possible, although they ensure that at least one (but also both in some cases, as for AXA, Baloise and Swiss RE) between β_2 and β_4 is always significant, that is of the main results that can be observed in Calmès and Théoret (2010).

The DCC-GARCH model has instead been applied to capture the dynamic correlation between the EURO STOXX 600 Insurance and the performance of the equity issued by the considered insurance companies.

The general results indicate that the model has been able to detect the statistical significance of the GARCH parameters, as well as of β_{DCC}, even though α_{DCC} is significant only for some of the reported companies.

This suggests that a partial (given that α_{DCC}'s significance is rare) contribution of the residuals to the correlation in the short run and a main contribution of the long run (related to the persistence) correlation matrix have been found in the data.

It is interesting to look at the plots of the dynamic correlation since they can tell that it is quite moderate and mean reverting in a range from -20% to +30%.

Apparently, however, there are some countries (Switzerland, France and Italy mainly), in which the dynamic correlation displayed by the DCC-GARCH is in contrast with the general results that have been previously discussed, since it tends to be negative most of the time.

This may be due to country-specific macro-economic factors.

In summary, the above-mentioned results lead to a partial validation of the second hypothesis, i.e., that there is a general positive dynamic correlation between the time series of the observed financial instruments and the EURO STOXX 600 Insurance index, with α_{DCC} that is, however, not commonly significant.

It may be interesting, in the future, to expand the model in section 3.2 in order to account for macroeconomic variables that may explain the differences in results detected between some countries.

Capturing the relation between macroeconomic variables and volatility is critical both to the pure finance environment and to the risk management field (in fact, this link may help in stress-testing studies or in computing VAR over significantly long time horizons.

As an alternative to the application of the DCC-GARCH, it could be equally interesting to account for asymmetric effects in the gathered data, given the appealing results obtained by the related literature.

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7 Appendix

In this section few more tables an figures, that may enhance the comprehension of the results, are reported.

Table 13

	ARCH-M Model 1	ARCH-M Model 2	ARCH-M Model 3
β_0	0.0000	1.0000	1.0000
β_1	0.0761	0.0000	0.0000
β_2	0.4133***	1.0000	1.0000
β_3	0.4854	1.0000	1.0000
β_4	0.0000	0.6728	0.5564

Legenda

Betas of the ARCH-M model applied to ROE for Allianz

*Significant at 0,1 level.

**Significant at 0.05 level.

***Significant at 0.01 level.

Table 14

	General Model 1	General Model 2	General Model 3
β_0	0.0000	0.2066	0.7113
β_1	0.0378	0.9548***	1.0000***
β_2	0.4217***	1.0000	0.9995
β_3	0.5140	1.0000	0.9994
β_4	/	/	/

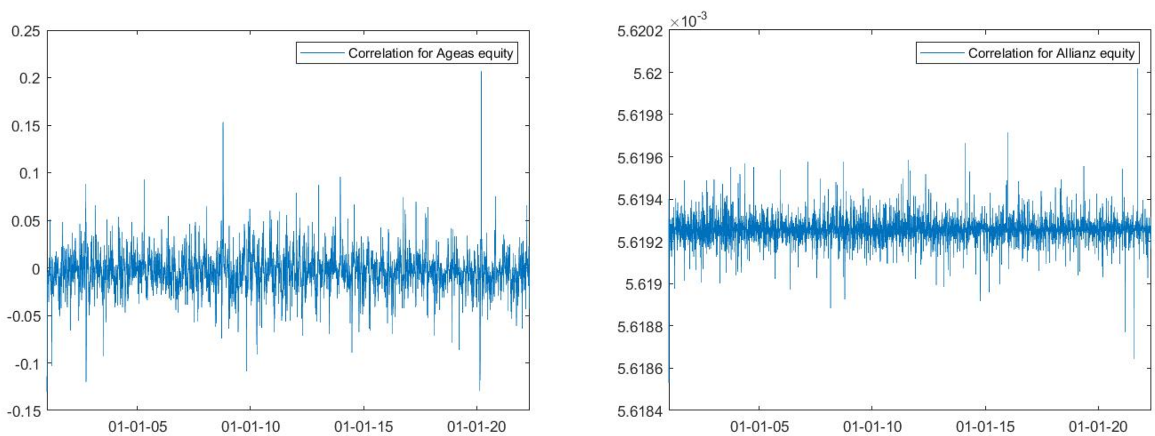
Legenda

Betas of the general form of the model applied to ROE for Allianz

*Significant at 0,1 level.

**Significant at 0.05 level.

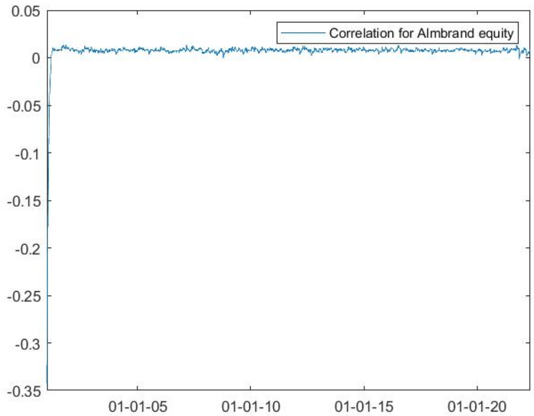
***Significant at 0.01 level.



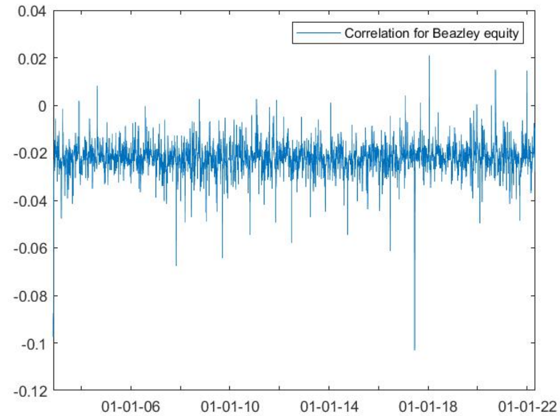
(a) *DCC-GARCH correlation for AGEAS equity*

(b) *DCC-GARCH correlation for Allianz equity*

Figure 3

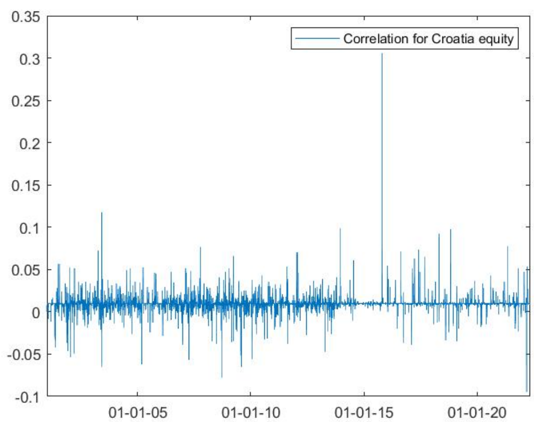


(a) *DCC-GARCH correlation for Almbrand equity*

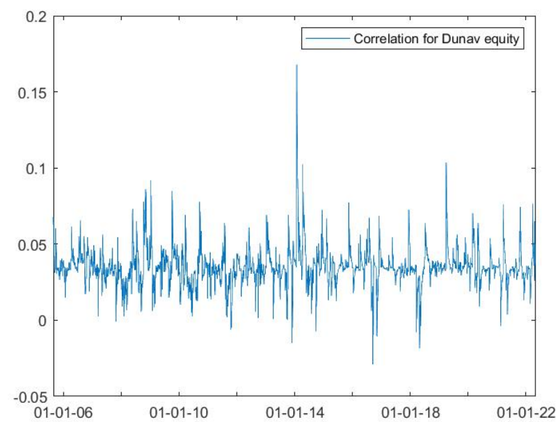


(b) *DCC-GARCH correlation for Beazley equity*

Figure 4

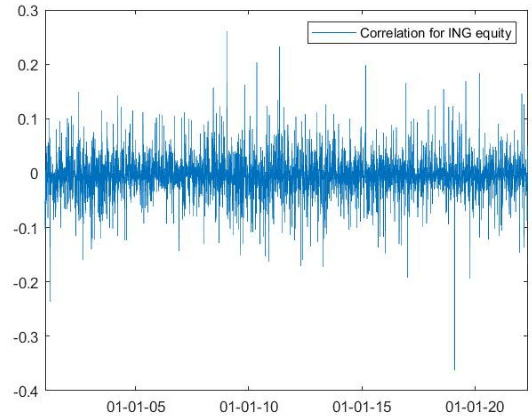


(a) *DCC-GARCH correlation for Croatia Os. equity*

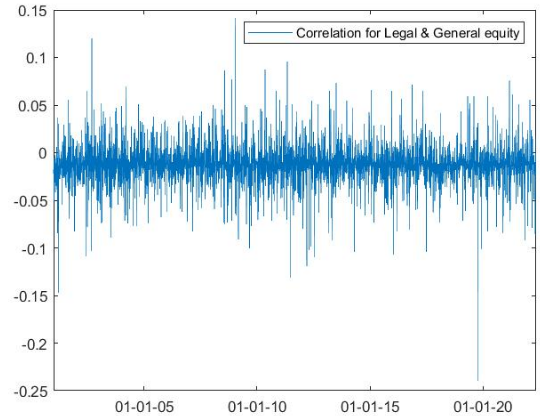


(b) *DCC-GARCH correlation for Dunav equity*

Figure 5

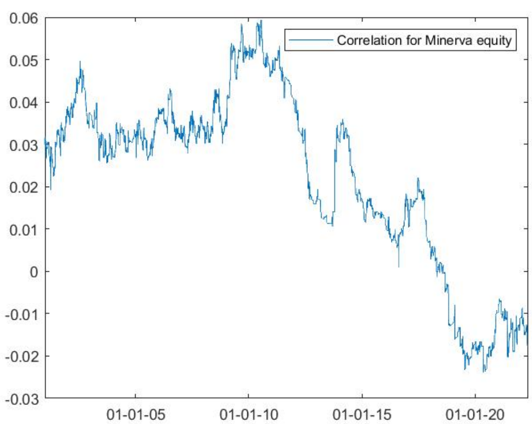


(a) *DCC-GARCH correlation for ING equity*

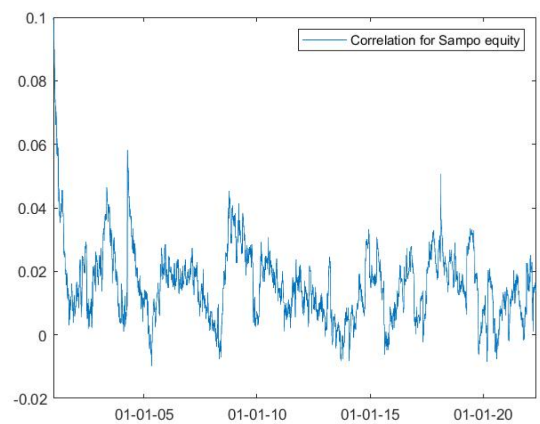


(b) *DCC-GARCH correlation for Legal & General equity*

Figure 6

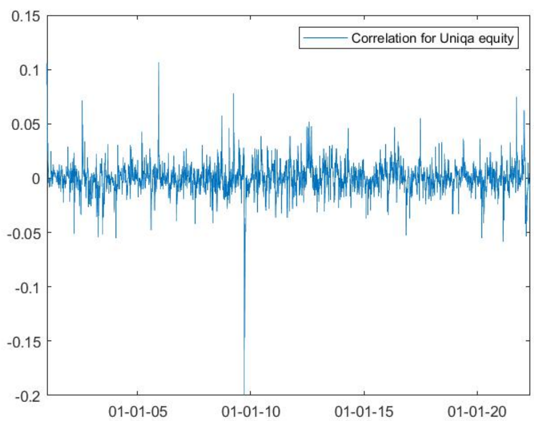


(a) *DCC-GARCH correlation for Minerva equity*

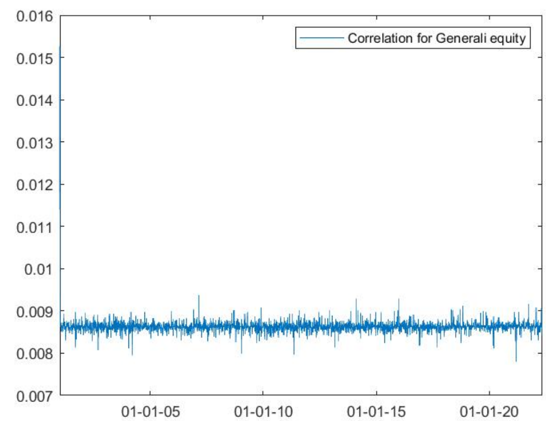


(b) *DCC-GARCH correlation for Sampo equity*

Figure 7



(a) *DCC-GARCH correlation for Uniqa equity*



(b) *DCC-GARCH correlation for Generali equity*

Figure 8

8 Summary

The main objectives of this dissertation are:

1. To analyze the impact of revenues and EBIT (put together in the operating margin ratio) on the risk-return trade-off of most of the insurance companies listed in the European stock markets;

2. To capture the relationship between the EURO STOXX 600 Insurance and the equity of the companies in the sample.

This topic has been chosen since it is not extensively covered by the literature, even though the importance of the insurance sector for the economy of the European countries has been rapidly growing in recent times, together with the related volume of business.

The preliminary phase of the dissertation has been to study a consistent part of the related literature, that has been reported in the second section, in order to acquire a sufficient knowledge about the topics and develop the ideas that led to the drafting of this paper.

Subsequently, all the necessary data for the proposed analysis have been gathered.

These include observations from 01/01/2001 to 05/05/2022 about:

1. Time series of stock returns (daily);
2. Income statements (annual, semi–annual);
3. Balance sheets (annual, semi–annual).

All the financial statement items have been downloaded from Refinitiv, while the time series of stock returns from Bloomberg (together with the Excel add-on).

The sample is composed of 55 insurance companies, with as many financial statements.

The time series of stock returns are instead 51.

To carry out the first analysis, an ARCH-M model has been applied to the financial statement data, in the wake of Calmès and Théoret (2010), with the difference that the operating margin has been considered, instead of the share of non-interest income, taking into account the different economic field to which the companies in the sample belong (i.e.,insurance instead of banking).

The ARCH-M process has not only been chosen since it directly incorporates volatility in the return's equation, but also because a simple risk-adjusted model may not be the optimal solution and may not provide the best estimates.

To conduct a more complete research, the dependent variables (ROA and ROE) have also been scaled down to provide a comparison with a non-scaled traditional version of the model, following the idea that a risk premium factor associated to the volatility of revenues and EBIT should be reflected in the accounting measures of performance.

In order to provide a better understanding of the effect of the conditional volatility of the dependent variable, a general form of the model (that does not take into account σ_t) has also been developed, which has also helped in capturing the effect of operating margin on ROA and ROE.

Regarding the second analysis, the DCC-GARCH has been applied both to the time series of stock returns of each insurance company and to the EURO STOXX 600 Insurance, that is the reference stock market index for the sector.

The hypotheses raised in this paper suggest that a risk premium related to the operating margin should emerge and that a moderate dynamic correlation between the equity of the insurance companies and the reference stock market should be found.

In general, it can be observed that the first hypothesis is confirmed since the significance of the parameter related to the conditional volatility in the ARCH-M process has been detected, mostly in the model scaled by a four-semester moving average of the standard deviation of the dependent variable, together with the significance of the operating margin parameter, that is however more significant in the non-scaled version.

The results for the DCC-GARCH, instead, tend to partially confirm the second hypothesis. The parameters related to the GARCH are indeed strongly significant, highlighting a high persistence and an elevated sensitivity of the assets to the shocks in the market.

The results for the DCC also tend to underline the high persistence in the model, although the contribution of the residuals to the dynamic correlation is generally not relevant.

To conclude, the dynamic correlation is found to be mainly positive and moderate, with peaks of maximum +30%, excluding the infrequent outliers.