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Market Risk Assessment on Packaged Retail and Insurance-based Investment Products

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I hereby declare that the work submitted is mine and that where I have made use of another's work I have attributed the source(s) according to the Regulations set in the Student's Handbook.

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Abstract

This dissertation was written as part of the MSc in Banking & Finance at the International Hellenic University.

The purpose of this research is to clarify whether the methodology proposed by the European Supervisory Authorities (ESAs) within Delegated Regulation (EU) 2017/653 for the calculation of market risk of certain Packaged Retail and Insurance-based Investment Products (PRIIPs) is a valid one. More specifically, ESAs have announced that the Unit-Linked products which are labeled as Category II PRIIPs, will be subject to the Cornish-Fisher Value-at-Risk (CFVaR) methodology for their market risk assessment. Since the regulations drafted by ESAs regarding PRIIPs are relatively new, the difficulty of this thesis lies in the fact that there is scant literature on the subject under investigation. Five risk models are put into test in order to validate the appropriateness of the methodology announced by ESAs. Initially, Historical Value-at-Risk and Expected Shortfall are employed as the most simplistic methods. However, these methods cannot incorporate the possibility of financial instability. In order to tackle this barrier, the Cornish-Fisher expansion is introduced. Both CFVaR as proposed by ESAs and the classic CFVaR as described in certain academic papers show that Cornish-Fischer is a more robust model than the simpler ones. However, when Cornish-Fischer Expected Shortfall (CFES) is applied, two strong points are formed. Firstly, it is observed that only in half of the cases Cornish-Fischer can be considered a reliable method and secondly the CFES is a more coherent risk measure than CFVaR. According to the results, it is assumed that the Cornish-Fischer expansion is unable to accurately estimate the market risk of Unit-Linked products when excessive fat-tailed or non-symmetrical distributions are present. Finally, it is proposed that a different methodology could be also looked into by the regulatory bodies which will capture the excessive values of products in financial distress.

Keywords: Value-at-Risk, Expected Shortfall, Cornish-Fischer, PRIIPs

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Chapter 1. Introduction

Market risk has bothered a great number of academics, researchers and analysts over the years. As globalization becomes more intense and markets tend to integrate with each other, it is not surprising that an earthquake in Japan can trigger a downside in the price of U.S. dollar.

Every financial product independently of its characteristics or the market being traded carries a combination of three main risks: credit risk, liquidity risk and market risk. It is widely accepted that the market risk cannot be eliminated or diversified since it is a systematic risk. In this manner, risk managers are deeply concerned with the proper assessment of the market risk and the calculation of possible losses.

Among the countries of the European Union (EU), there is a category of financial assets called Packaged Retail and Insurance-based Investment Products (PRIIPs). The main characteristic of these products is that the benefit the retail investor is entitled to is dependent upon market fluctuations. These types of products are offered by banks, financial institutions and insurance companies. For example, a Unit-Linked life insurance product which invests in mutual funds is considered a PRIIP. A Unit-Linked is considered a special life product which is separated into two parts. One part of the premium payment is allocated to life insurance and the other part is allocated to savings and investments. To be more precise, the buyer of a Unit-Linked invests in the units of a mutual fund or internal variable fund of the financial institution that issues the Unit-Linked.

It is not a rare phenomenon for risk managers and investors to undertake huge risks in order to gain abnormal returns either for their own sake or the shareholders'. However, high risks can result in high losses as well and even trigger a financial contagion. The European Supervisory Authorities (ESAs) have issued a number of regulations in order to measure and control the risks associated with PRIIPs. These regulations will come into force on 1st of January, 2018 and every PRIIP traded in the market must comply with the regulations in order to be legit.

ESAs are going to implement a number of methodologies in order to compute the market risk of various kinds of PRIIPs. The PRIIPs are separated into four different categories depending on their components. This thesis will analyze Unit-Linked products which are labeled as Category II PRIIPS. More specifically, the authorities have announced that the methodology for measuring market risk in Category II PRIIPs will be the Cornish-Fisher Value-at-Risk (CFVaR) at 97.5% confidence level. Analysts, academics and financial institutions have expressed their concerns regarding the coherence of this methodology. This thesis will try to measure the market risk of certain Unit-Linked products both with the methodology decided by ESAs and the counter methodologies proposed by opposing parties. Such methodologies include the Expected Shortfall (ES) instead of Value-at-Risk (VaR) and Cornish-Fischer Expected Shortfall (CFES) instead of CFVaR. In this manner, it is attempted to shed light on whether the authorities are applying the most effective risk models or generating more uncertainty in the broader market.

In order to provide well-grounded results, there are used real-time data. We pick every Unit-Linked product traded in the Greek market and download its historical closing prices from www.naftemporiki.com. There are two criteria for incorporating a Unit-Linked in our research. The Unit-Linked must be traded in the market for five years at least and the daily closing prices (observations) for the last five years must count for more than 1100. We pick only the ones with five-year daily closing prices because ESAs deem this size of observations as the most optimum one. Moreover, we conclude at the limit of at least 1100 observations in order to form a large database and for the results of our Unit-Linked products to be comparable as well.

Five different risk models are implemented in order to evaluate the results of market risk values from various perspectives. Initially, the simplistic Historical Value-at-Risk and Historical Expected Shortfall are used. However, these modes do not incorporate the variables of excess kurtosis and skewness and hence they are not able to properly estimate the market risk in periods of financial distress. Following on, the Cornish-Fischer expansion is put into action. Cornish-Fisher expansion is supposed to compute market risk more efficiently when financial instability is present. Both CFVaR as proposed by ESAs and the classic CFVaR as presented in the papers of Sjostrand and Aktas

(2011), Maillard (2012) and Cavenaile and Lejeune (2012) are put into effect. At this point, some important realizations come into force regarding the validity of CFVaR as the most appropriate risk model. Reaching the final stage of this research, CFES is employed in order to help us form a robust opinion. By applying all these models, we are able to gradually add more criterions and categorize the Unit-Linked products according to their compatibility with the methodology proposed by ESAs.

This thesis bears a major drawback but offers a great benefit. Since this is a newly researched topic, there is scant literature review on PRIIPs or previous relative research conducted. In the meantime, the financial institutions trading PRIIPs are in turmoil in order to get themselves ready before the 1st of January, 2018. This thesis will contribute both to the academic and business community by enriching the existing literature and aiding risk managers in assessing the market risk. Moreover, the real impact of the new regulations on retail investors' preferences and financial institutions' revenues will become known sometime in the mid of 2018. That being said, it would not be bold to claim that the findings of this research may result in delivering predictive accuracy.

CHAPTER 2 describes the literature review on PRIIPs and the methodologies applied. There are analytically presented different views of well-known researchers and the originality of this thesis. CHAPTER 3 discloses details of the risk methodologies used and the rationale for applying certain models. CHAPTER 4 includes the empirical analysis of the data and the results derived from it. Finally, in CHAPTER 5 the conclusions of this research are stated.

Chapter 2. Literature Review

This chapter presents the literature review related to the PRIIPs and the steps taken by ESAs and the EU in order to vote the final Regulation Technical Standards (RTS). RTS is a series of regulations that define the way that the technical aspects of the PRIIPs will be approached. Moreover, a discussion is conducted regarding the various methodologies implemented in this thesis from the perspective of acknowledged researchers and academics.

2.1 Packaged Retail and Insurance-based Investment Products (PRIIPs)

The first introduction of PRIIPs was administered by the European Parliament and the European Commission on 9th of December, 2014. Following that, the ESAs had to construct the RTS of the Key Information Documents (KIDS). A KID is a document that must accompany each PRIIP traded in the European Economic Area (EEA) and demonstrate the relevant information, risks, costs and possible returns. These new RTS were originally dated to come into force on 1st of January, 2017. However, a series of consultation papers from financial institutions all over the EU which were posted by 26th of January, 2016, raised a number of controversial issues regarding the RTS. To name a few, Robeco which is an international asset management company, states in its consultation paper that the methodologies should be described in greater detail and the formulas reviewed for errors. Moreover, German Insurance Association (GDV) and BNP Paribas among others note that the time allocated for implementing the new RTS on the PRIIPs is too narrow. On September 2016, just three months before the new RTS' implementation, the European Parliament and the Commission of the EU members voted to delay their application by one year. Mortimer T. (2016) states in his article that the main reason that the approval of PRRIPs RTS was delayed, was due to the very complex methodologies regarding the calculation of costs and risks. More specifically, he notes that the decision of authorities to change the calculations based on historical performances to future simulations was executed in a rushed way without allocating enough time for investors and companies to prepare themselves. Finally, on 8th of March, 2017, the final RTS were announced by ESAs. The RTS were approved by the European Commission and the European Parliament on 3rd of April 2017 with their implementation date being the 1st of January, 2018. It is worth mentioning though, that even up to this date there are some parts in the RTS with quite a vagueness. A wide complaint has been that of companies being unable to efficiently assess which kind of products belong to each PRIIPs' category. The rationale of this accusation lies on the notion that the RTS lack of detailed explanations when it comes to either categorization of financial products or description of the methodologies applied.

2.2 Value-at-Risk

Risk managers and investors all over the world use VaR in order to measure for expected losses and perform a long-term capital management strategy. Cheung and Powell (2012) define VaR as the calculated amount of a financial product that can be lost under a particular confidence level and time horizon. More specifically, VaR can be approached in three different ways: the parametric, the nonparametric and the semi-parametric method. The parametric method is used when the distribution that the data follows is known. Amedee-Manesme and Barthelemy (2015) describe the parametric method as the most used and simple one. However, they argue that this method may prove inefficient when asymmetric distributions are formed. The nonparametric method is used when there is not necessary to make an assumption for the distribution of the data's returns. Taylor (2008) states that the most used nonparametric method is the historical simulation and raises some concerns regarding the number of past periods that should be included. Finally, the semi-parametric method is a combination of a parametric and nonparametric approach.

Acerbi and Tasche (2002) mention in their paper that for a risk measure to be considered a valid one it should be labeled as coherent. They also state that for a risk measure to be coherent it must fulfill four axioms: monotonicity, sub-additivity, positive homogeneity and translation invariance. They prove in their paper that VaR method is not a coherent one since it is not sub-additive. Moreover, they conclude that Expected Shortfall (ES) should be used instead since it is a coherent and better risk measure than VaR. Yamai and Yoshiba (2005) mention two drawbacks in relation to VaR techniques. The first one is that investors who wish to raise their expected returns may be misguided by false outcomes derived by VaR. The second one is that VaR is not easy to use when investors seek to make the best out of their holdings.

Many companies and specialists have expressed their opposing opinions on using the VaR method for assessing the market risk on category II PRIIPS. Stuff. D (2016) mentions in his article that Expected Shortfall should be used instead of VaR. Cube Investing (2017) also criticizes the adoption of VaR since it does not take into account the left tail of the distribution where a big amount of possible losses can be hidden. Adding, Basel Committee on Banking Supervision (BCBS) (2013) decided to shift its methodology of market risk assessment from the VaR at 99% confidence level to ES at 97.5% confidence level. On its consultative document which was released in October of 2013 it is stated that ES at a confidence level of 97.5% is more appropriate for determining the market risk in stress conditions. Danielsson, James, Valenzuela and Zer (2016) implemented the propositions of BCBS by constructing many different risk models. They concluded that in periods of financial distress there is not a unique robust reliable model.

2.3 Expected Shortfall

Artzner et al. (1999) were the ones who introduced Expected Shortfall. Expected Shortfall is a method that can deal with the problem of the quantile risk measure. Hull (2015) mentions in his book that ES ultimately tries to measure the expected returns of a fund in the worst possible scenario. In a recent paper, Barrailler & Dufour (2015) show that ES is taking into account the whole distribution of the value of a portfolio and is a more rational risk metric. Zhao and Shi (2010) use the ES method to count for mutual find risk in their paper. They demonstrate that when an asymmetric Laplace distribution exists, ES is an effective risk measure. Liang and Park (2010) concluded that risk measures such as ES and Tail Risk are more effective to standard deviation when dealing with hedge fund failure calculations. Oh and Moon (2006) realize that VaR values are not so great as ES values which means that VaR techniques may result in misjudging risks related to the tail of a distribution. Chen (2007) demonstrates that the best nonparametric estimation of Expected Shortfall is the one that calculates the average of the worst losses exceeding VaR. On the other hand, Jadhav, Ramanathan and Naik-Nimbalkar (2009) suggested two new models for the Expected Shortfall. They found that there is not necessary to take into account all the worst prices exceeding VaR in order to count for ES.

Liu and Kuntjoro (2015) constructed nine different models in order to measure VaR and ES. They mention in their paper that ES in contrast to VaR limits the chance for a risk manager to make false risk estimations. Righi and Ceretta (2015) tried to determine the ES models that best fit every kind of financial asset. They conclude that characteristics such as fat tails, big skewness or normality assumptions generate controversial results. Tolikas (2014) argues that both ES and VaR which make assumptions of normal distributions can lead to wrong results in case of turbulent economic periods. Emmer, Kratz and Tasche (2015) tried to counter ES with a new methodology called Expectiles. However, they did not find enough evidence to support their hypothesis.

Researchers and analysts are striving to find a model that will effectively assess the market risk in periods of financial crisis. Righi and Ceretta (2016) proposed the Shortfall Deviation Risk (SDR) as an appropriate risk measure to include such scenarios. The SDR merges two risk notions, the possibility of poor results (ES) and the volatility of a potential outcome (SD). Thus, SDR takes into consideration the tails of a distribution which stand for the worst values. They concluded in SDR being a more fitting risk measure than VaR and ES when scenarios of increased riskiness are present. Moreover, Sjostrand and Aktas (2011) showed in their master's thesis that when dealing with a stock of extreme volatility, methods of VaR and ES are not effective in producing the right results. However, Cornish-Fischer VaR could successfully measure the risk in case of extreme events.

2.4 Cornish-Fischer Value-at-Risk

ESAs have proposed the Cornish-Fischer VaR (CFVFaR) at 97.5% confidence level for market risk measurement in Category II PRIIPs. The Cornish-Fisher expansion was initially developed by Cornish and Fisher (1937) and later generalized by Hill and Davis (1968). Zangari (1996) applied both the CFVaR and simple VaR methodology on a portfolio consisting of government bonds and exchange options. He concluded that CFVaR delivers more reliable results than simple VaR. Maillard (2012) mentions in his paper that CFVaR ultimately tries to calculate the third and fourth moment of a distribution. In simple words, CFVaR takes into consideration the skewness and kurtosis of the data's distribution and thus can deal with non-normal distributions as well. However, CFVaR has two pitfalls: (i) violating the field of the formula's application and (ii) mixing up the kurtosis and skewness of the distribution with the ones of the formula's.

Jaschke (2001) tests in his paper the application of Cornish-Fischer (CF) method with delta-gamma-normal approximations. Ultimately, he tries to sort out if it is wise to use the CF method instead of the Fourier inversion, saddle point methods or Monte Carlo. He concludes that the CF method is an effective one when the data's returns are normally distributed. Favre and Galeano (2002) discovered that CFVaR can be effectively used in case of negative skewness or positive excessive kurtosis. Bali, Gokcan and Liang (2007) discovered a significant positive connection between CFVaR and the expected returns of hedge funds. In their paper, they used the CF expansion in such a way that it included the skewness and kurtosis of the distribution and attempted to estimate the tails of the Skewed Generalized T-distribution. Following, Grau-Carles, Sainz, Otamendi and Doncel (2010) show in their paper that Cornish-Fisher expansion allows individuals to use profits or losses in an asymmetric way and thus if kurtosis and skewness are present, CFVaR is more accurate than simple VaR. Cavenaile and Lejeune (2012) noticed that CFVaR should never be used for confidence levels below 95.84%. Moreover, they demonstrate that when high confidence levels are applied, more restrictions should be enforced on the relevant skewness levels for the CFVaR to be valid.

2.5 Cornish-Fischer Expected Shortfall

Cornish-Fischer Expected Shortfall (CFES) or else Modified Expected Shortfall (MES) is a relatively new risk measure. As expected, the literature review on this methodology is quite limited. The CFES was firstly introduced by Boudt, Peterson and Croux (2008). They found that for larger than normal skewness and kurtosis, CFVaR and CFES are superior estimators of VaR and ES than simple VaR and ES. Recently, Martin and Arora (2015) published a paper about the inefficiency of CFVaR and CFES. A part of their research was the application of CFVaR, CFES, simple VaR and simple ES at 97.5% confidence levels as proposed by Basel Committee. They concluded that CFVaR and CFES are inefficient when applied in returns with normal distribution and especially in returns with t-distributions.

Chapter 3. Methodology

In this chapter, there are described the methodologies that are implemented on the Unit-Linked products. It is also presented the rationale for choosing the relevant methodologies and their contribution to this research. Initially, the Historical VaR is presented which is a nonparametric method of VaR estimation. Following on, the Historical ES is analyzed as a counter methodology to Historical VaR. Since both of these measures are not able to correctly assess the market risk in periods of financial crisis, the Cornish-Fischer expansion is applied to the Unit-Linked products. Two different risk models of CFVaR are used in this research as a counter methodology for Historical VaR and the newly presented CFES as a counter methodology for Historical ES and CFVaR.

3.1 Historical Value-at-Risk

The dominant feature of a nonparametric method such as Historical VaR is that there is no need to make an assumption for the data's distribution. It is also considered as the most simplistic method of calculating risk and it is implemented by many organizations. Its simplicity lies in the rationale that the observations of the past can predict the future returns. The processing of the data starts with calculating the natural logarithmic (ln) returns of the closing prices of a Unit-Linked product or any other financial instrument.

$$R_{i,t} = \frac{\ln(P_t)}{\ln(P_{t-1})}, \text{ for i = 1, 2, . . . , N}$$

Where:

$R_{i,t}$ = the natural logarithmic return on Unit-Linked i in time t.

P_t = the closing price of the Unit-Linked in day t.

N = number of observations.

Following on, the returns are sorted from the smallest to the largest one creating a new return ascending sorting list $R_{i'}$, for i' = 1, 2, . . . , N. We find the number j that corresponds to the confidence level α by the following formula:

$$j = (100\% - a)N$$

We round up j to the nearest unit and the return $R_{i'}$ from the ascending sorting list that matches the rounded up j' is our Historical VaR on one day.

$$VaR_a = R_{i'}$$

The strong point of this methodology is that it takes into account all the historical prices of our Unit-Linked products. However, its major drawback is that it gives the same weight to every return regardless of its chronological order. We implement this methodology to our data set in order to use it as a benchmark for Cornish-Fischer VaR methodology and check whether the belief that CFVaR is a more appropriate risk model than Historic VaR in periods of high volatility is consistent.

3.2 Historical Expected Shortfall

From 2013 and up to date, Expected Shortfall is regarded to be the new best model to measure market risk. Even Basel Committee (2013) approved ES at 97.5% confidence level to be a more coherent risk measure than VaR. In this thesis, we implement a simplistic method of calculating the nonparametric Historical ES. The computation of Historical VaR in advance is essential in order to count for Historical ES and the formula is given by:

$$ES_a = \frac{1}{j'} \sum_{i'=1}^{i'=j'} R_{i'}$$

The advantage of ES lies in the rationale that it counts for the losses exceeding VaR. Thus, ES should always produce equal or larger losses than VaR. However, the disadvantage of VaR and hence ES is that they do not account for skewness or excess kurtosis and ultimately underestimate future possible losses when non-normal distributions are present. We perform Historical ES on our Unit-Linked products in order to verify the credibility of past papers that ES is always larger than VaR. Moreover, Historical ES will be used as a benchmark for CFES.

3.3 Cornish-Fischer Expansion

The Cornish-Fischer expansion offers a better approximation than the most used risk measures of Historical VaR and ES since it calculates for moments of order higher than two. In this thesis, the moments of the CF expansion are estimated from historical returns. Moreover, in order to calculate the third and fourth moments of the CF expansion which represent the skewness and excess kurtosis accordingly, the formulas of the population skewness and population excess kurtosis are used. The population approximation is implemented instead of the sample one in order to care for the entire cluster of our data. Before presenting the models introduced by ESAs and various researchers like Cavenaile and Lejeune (2012), Maillard (2012) and Martin and Arora (2015) we will present the way that the model is built step by step.

Initially, the four moments (μ) of the CF expansion are estimated[1]:

$$\mu_1 = \text{average return } (R_{\bar{i}})$$

$$\text{Where } R_{\bar{i}} = \frac{1}{N}\sum_{i=1}^{i=N} R_i$$

$$\mu_2 = \text{variance } (s^2)$$

$$\text{Where } s^2 = \frac{1}{N}\sum_{i=1}^{i=N}(R_i - R_{\bar{i}})^2$$

$$\mu_3 = \frac{1}{N}\sum_{i=1}^{i=N}(R_i - R_{\bar{i}})^3$$

$$\mu_4 = \frac{1}{N}\sum_{i=1}^{i=N}(R_i - R_{\bar{i}})^4$$

As soon as the moments of the CF expansion are calculated, the population volatility (σ), population skewness (S) and population excess kurtosis (K) are computed. We account for the excess kurtosis instead of kurtosis since 66 out of 70 Unit-Linked products that are used in our research have an excess kurtosis larger than three. Since a distribution with zero skewness and kurtosis of three is considered a normal one, we use the formula of excess kurtosis in order for our model to care for leptokurtic distributions with fat tails as well.

Getting into more detail, the population volatility (σ) is given by the simple formula of:

[1] A detailed and accurate description of the moments' calculation is presented in Maillard's (2012) paper.

$$\sigma = \sqrt{s^2}$$

The population skewness (S) derives from:

$$S = \frac{\mu_3}{\sigma^3}$$

And the population excess kurtosis (K) is the yield of:

$$K = \frac{\mu_4}{\sigma^4} - 3$$

Moreover, in order to proceed with the calculation of CFVaR and CFES, we need to estimate the quantile ($z_{a'}$) of our historical returns' distribution where $z_{a'} = \varphi(a')$ with $\varphi(a')$ being the normal distribution function for α'~ N (0, 1), where α' = 1 - α.

Though, $z_{a'}$ is a quantile fitting more to a Gaussian (normal) distribution. Since we have to deal with non-Gaussian distributions, we need to transform $z_{a'}$ with a Cornish-Fischer formula in order to incorporate the skewness (S) and excess kurtosis (K) as well. Thus, the adjusted $z_{cf,a'}$ with the Cornish-Fischer expansion is given by:

$$z_{cf,a'} = z_{\alpha'} + \frac{1}{6}\left(z_{\alpha'}^2 - 1\right) S + \frac{1}{24}\left(z_{\alpha'}^3 - 3z_{\alpha}\right) K - \frac{1}{36}\left(2z_{\alpha'}^3 - 5z_{\alpha'}\right) S^2 \qquad (1)$$

The random variable $z_{cf,a'}$ is the only component of a Cornish-Fischer expansion that incorporates the possibility of non-normality in the returns' distribution. In this manner, it bears the largest weight when it comes to affecting the outcome of the models described in the following subsections. According to Cavenaile and Lejeune (2012), we expect $z_{cf,a'}$ to increase as skewness increases and to decrease as excess kurtosis increases. Since, CFVaR and CFES are demonstrated in negative prices, any decrease of $z_{cf,a'}$ would trigger an increase of CFVaR and CFES and hence an increase of risk.

Sjostrand and Aktas (2011) present in their master's thesis that when the returns' distribution is normal, CFVaR and VaR should produce the same result, whereas if there are slight deviations from normality, CFVaR is a more effective model than VaR. However, they conclude that if large deviations from normality take place then an entirely different method should be used.

3.3.1 Cornish-Fischer Value-at-Risk

Initially, we estimate the market risk of the Unit-Linked products with the classic model of CFVaR as proposed by most academics throughout the years. The formula is given by:

$$CFVaR_a = R_{\bar{\imath}} + \sigma\, z_{cf,a'} \qquad (2)$$

As evidenced by Cavenaile and Lejeune (2012), when extreme negative values of skewness are not present, it is expected for $z_{cf,a'}$ to always produce a negative value. In this manner, we anticipate that the higher the volatility of a Unit-Linked the more negative the value of the second part of the $CFVaR_a$ formula and hence the total market risk.

3.3.2 Cornish-Fischer Value-at-Risk by European Supervisory Authorities

ESAs announced the formula for the calculation of CFVaR in March of 2017. A large number of financial organizations rushed to express their opinions and worries on the validity of the formula used. For example, Aegon UK, Aegon Ireland and the Bank & Insurance Division of the Austrian Federal Economic Chamber mention that the formula is not explained in detail and therefore makes the application of it quite difficult. Moreover, Robeco published its response to the methodologies used and asked for more technical details and the background of the formulas presented. Robeco also noticed that the notations used in the RTS should be presented in such a way that will be readable by quant minded people. On the other hand, Arfima Financial Solutions has proposed the application of sample estimators when estimating the CFVaR in order to reduce bias.

We try to decompose the formula of CFVaR as proposed by ESAs in order to clarify its components and realize whether there is a difference with the classic formula of CFVaR. The formula given by ESAs is:

$$CFVaR_{a,ESAs} = \sigma\sqrt{T}\left(-1.96 + 0.474\, S\, \frac{1}{\sqrt{T}} - 0.0687\, K\, \frac{1}{T} + 0.146\, S^2\, \frac{1}{T}\right) - \frac{1}{2}\,\sigma^2\, T$$

Where T stands for the number of trading days in the recommended holding period. Since we are measuring the worst possible losses that may occur in one trading day, T will be equal to one and therefore the previous formula can be rewritten as:

$$CFVaR_{a,ESAs} = \sigma\,(-1.96 + 0.474\,S - 0.0687\,K + 0.146\,S^2) - \tfrac{1}{2}\,\sigma^2 \qquad (3)$$

ESAs are considering this formula for the confidence level α at 97.5%. We will demonstrate that the part of the formula which is inside the parenthesis equals to $z_{cf,a'}$ for α = 97.5%.

Initially, the first component of -1.96 equals to $z_{\alpha'}$. The number of $(0.474)\,S$ equals to $\frac{1}{6}\left(z_{\alpha'}^2 - 1\right)S$. The third component of $z_{cf,a'}$ which is $\frac{1}{24}\left(z_{\alpha'}^3 - 3z_{\alpha}\right)K$ equals to –(0.0687)K. Finally (0.146) S^2 equals to $\frac{1}{36}\left(2z_{\alpha'}^3 - 5z_{\alpha'}\right)S^2$. By substituting the numbers in the parenthesis of equation (3) with the ones of (1) we conclude that the formula of CFVaR proposed by ESAs at the confidence level 97.5% for one trading day is:

$$CFVaR_{a,ESAs} = \sigma\, z_{cf,a'} - \tfrac{1}{2}\,\sigma^2 \qquad (4)$$

We notice that there is a slight difference between the model (4) proposed by ESAs and the usual model (2). Therefore, these models also produce slightly different outcomes but we will elaborate on their differences in the following chapter. It should be noted though that both models which are used in our data are incorporating the population estimators of the four moments and strictly follow the rules of the Cornish-Fischer expansion.

The rationale for implementing two different models of CFVaR is to find out whether the one proposed by ESAs or the classic one produces the most appropriate results. Moreover, by implementing the CFVaR, we will try to validate the assumption of CFVaR being a superior model to historical VaR when periods of extreme financial distress are present.

3.3.3 Cornish-Fischer Expected Shortfall

Generally, VaR and hence Cornish-Fischer VaR have been accused by many academics and organizations that they are not suitable methodologies for assessing the market risk of any kind of financial products. The weakest point of the methodologies associated with VaR lies on the fact that VaR counts only for the worst possible losses at an applied confidence level. So, someone would wonder what happens when that level is exceeded.

In order to answer the query above, we are implementing the methodology of Expected Shortfall in such a way that it will care for the higher order moments of skewness and excess kurtosis. Initially, we followed the same rationale as that of Historical ES and the average of losses exceeding CFVaR was computed. However, we judged that this methodology is way too simplistic and so we decided to implement the model proposed by Boudt et al. (2008). Moreover, Martin and Arora (2015) modified the model of Boudt et al. in a less complex one. Dr. Kris Boudt ensured us through a brief email discussion that the proposed model of Martin and Arora is a valid one and we could advance with it when calculating the market risk of our products. The formula is given by[2]:

$$CFES_a = R_{\bar{\iota}} - \frac{\sigma}{a'}\, \varphi(z_{cf,a'})[\, 1 + \frac{1}{6}\, z_{cf,\alpha'}^3\, S + \frac{1}{72}\left(z_{cf,\alpha'}^6 - 9\, z_{cf,\alpha'}^4 + 9 z_{cf,\alpha'}^2 + 3\right) S^2 + \frac{1}{24}\left(z_{cf,\alpha'}^4 - 2\, z_{cf,\alpha'}^2 - 1\right) K\,] \qquad (5)$$

Where $\varphi(z_{cf,a'})$ is the standard normal density function of $z_{cf,a'}$.

By implementing CFES, we provide additional literature on the already limited literature of this rather new methodology. Additionally, we demonstrate if CFES is able to calculate market risk in case of extreme events and whether it is a more rational downside risk measurement than Historical ES and CFVaR.

[2] A detailed description the complex formula's transformation into the simpler one can be found in Appendix A of Martin and Arora's (2015) paper.

Chapter 4. Data & Empirical Analysis

This chapter demonstrates the processing of the data and the results that are generated. We describe how the various models that are employed for calculating the market risk of Unit-Linked products affect the possible outcome. Moreover, an empirical analysis of the results is conducted in order to realize the limitations and possibilities of every model.

4.1 Data

In order to gather a decent amount of observations, we pick 70 Unit-Linked products traded in the Greek market. We deem necessary to follow the guidelines of ESAs to the fullest. Thus, we pick daily closing prices for the dates from 01/10/2012 up to 30/09/2017. We use Microsoft Excel in order to work with our data and produce results. Since we implement a number of different methodologies we need to establish a general rule of how we are going to treat our Unit-Linked products. We decide that when a Unit-Linked follows the basic rules of the applied methodology it will be labeled as “Healthy” and when it produces abnormal results it will be characterized as “Problematic”. However, if there is lack of certainty for the category that it belongs to, it will be classified as “Controversial”. This rationale will help us realize which Unit-Linked products do not generate coherent results and thus should be approached in a different way. Moreover, we will be able to create groups of Healthy, Problematic and Controversial Unit-Linked products and look for any common characteristics or extraordinary values. A detailed list of the Unit-Linked products that are used in this research can be found in the Appendix.

Table 1 – Unit Linked & Four Moments

Unit-Linked	Mean Return	Volatility	Skewness	Kurtosis
ADBMFV	0.013%	0.606%	0.169	7.423
AGROZ1	0.029%	32.086%	-0.001	327.230
AGROZ2	0.024%	0.513%	0.173	117.766
AL	0.026%	1.380%	-2.084	39.911
ALCINV1	0.010%	0.285%	-0.387	3.280
ALCINV2	0.015%	0.350%	-0.665	5.569

ALCINV3	0.022%	0.526%	-0.619	5.344
ALCPR1	0.019%	0.340%	-0.637	4.106
ALCPR2	0.023%	0.508%	-0.697	4.240
AMI	0.004%	0.190%	-0.162	2.925
AMIERTGB	0.043%	0.826%	-0.567	4.697
AMIGHUK	-0.021%	2.594%	-0.598	5.469
AMII	0.003%	0.260%	-0.102	2.166
AMM	0.000%	0.024%	9.437	471.710
AMVV	-0.040%	0.890%	0.126	2.538
AMV	-0.002%	1.058%	-0.258	3.106
APFI	0.023%	0.729%	-0.849	6.129
CITI_1	0.009%	0.490%	-0.380	5.193
CITI_2	0.012%	0.575%	-0.622	7.878
CITI_3	0.013%	0.614%	-0.678	7.725
CITI_FU	0.022%	0.602%	-0.444	4.179
EEI3E	0.001%	0.265%	1.822	375.966
EEP2EI	-0.025%	2.628%	1.462	36.234
EEPL2E	0.008%	0.297%	2.260	226.042
EES	0.016%	1.020%	-0.955	25.404
EESE1	0.001%	3.245%	0.465	199.836
EESE2	0.004%	2.929%	-2.898	133.238
EESE3	0.005%	3.471%	0.006	193.087
EESE4	-0.001%	3.448%	-2.286	117.713
EESE6	0.002%	2.965%	1.020	221.441
EESE7	0.005%	2.830%	1.390	269.668
EESE8	0.004%	3.053%	2.388	235.481
EESE9	0.000%	3.176%	0.767	206.969
ETHBO	0.018%	0.159%	-0.574	10.557
ETHCH	0.013%	0.264%	-0.932	12.352
ETHSYN	0.011%	5.647%	-0.006	594.103
GFO	0.023%	0.418%	0.043	11.141
GFZ	0.026%	0.271%	0.758	23.901
GROPFA	0.000%	0.001%	0.201	32.493
GROU	0.038%	0.670%	-0.311	2.443
GROUP	0.029%	0.396%	-0.528	3.149
GROUPA	0.010%	0.153%	-0.641	6.175
GROUPF	-0.033%	2.624%	-0.762	7.005
HELF1	0.009%	0.270%	-0.332	3.621
HELF2	0.012%	0.567%	-0.709	5.188
HELF3	0.013%	0.927%	-0.828	6.387
HEZEE	0.006%	1.052%	-0.020	505.191
HEZMA	0.010%	0.416%	-0.420	4.043
HEZY	0.012%	1.575%	0.187	426.994

INE26	-0.006%	0.203%	-0.064	234.017
INE31	-0.006%	0.276%	0.435	329.527
INKZ21	-0.004%	0.321%	-0.742	11.385
INKZBO	-0.002%	0.058%	-1.810	25.279
IP103	0.000%	0.159%	-7.373	93.111
JGABAE	0.000%	0.496%	0.084	5.666
MDE5U	0.010%	0.496%	0.426	333.864
METR_LIIIIEU	0.025%	0.712%	-0.444	3.538
METR_LIIIIVEU	0.013%	0.307%	-0.463	3.272
METR_LIVEU	0.021%	0.532%	-0.490	3.942
METR_LIVIEU	0.009%	0.222%	-0.525	2.918
METR_LIVIEUII	0.007%	0.194%	-0.395	18.497
MEU1	-0.054%	2.794%	-32.437	1081.432
MEU2	-0.054%	2.784%	-32.464	1082.766
MI21	0.017%	0.610%	-0.314	6.570
MI2I	0.016%	0.585%	-1.212	87.926
MSCU	-0.065%	3.289%	-32.508	1084.324
MTRSEE	-0.003%	0.137%	-0.827	5.536
MTRVPL2	0.032%	1.125%	-1.829	28.206
MWU	0.008%	0.374%	0.259	16.214
TES	-0.004%	3.335%	-1.629	166.064

Before proceeding with applying the models of CHAPTER 3 to our data, we initially compute the four moments for every Unit-Linked. Table 1 presents the population mean return, population volatility, population skewness and population excess kurtosis. At this point, we notice that the mean return for all Unit-Linked fluctuates between -0.065% and 0.045%. Volatility is on average at 1.56%. When it comes to skewness we notice that not many values are near to zero of the normal distribution. At the same time, there are some products with significant deviations from normality. Finally, excess kurtosis is the most disturbing moment of all. Very few Unit-Linked have a normalized excess kurtosis of 3. That means that most of our distributions are not normal ones and we probably have to deal with a period of extreme financial distress. The following subchapters display the results generated by applying the models of CHAPTER 3 and an empirical explanation of them.

4.2 Historical Value-at-Risk

Initially, it is calculated the market risk of the Unit-Linked with the Historical VaR at 97.5% confidence level. In this way, we are able to form a primary opinion of the worst possible losses that might occur at the given confidence level and simultaneously create a benchmark to compare with other models.

Table 2 – Unit-Linked & Historical Value-at-Risk

Unit-Linked	**Historical VaR**
GROUPF	-5.675%
EEP2EI	-5.264%
AMIGHUK	-5.043%
EESE4	-4.000%
TES	-3.955%
EESE3	-3.929%
EESE1	-3.842%
EESE2	-3.842%
EESE9	-3.644%
EESE8	-3.546%
EESE6	-3.435%
EESE7	-2.893%
AL	-2.876%
MTRVPL2	-2.326%
AMV	-2.169%
HELF3	-1.942%
AMVV	-1.835%
EES	-1.788%
AMIERTGB	-1.661%
METR_LIIIIEU	-1.546%
GROU	-1.540%
APFI	-1.504%
AGROZ1	-1.454%
MI21	-1.306%
CITI_FU	-1.290%
CITI_3	-1.222%
HEZY	-1.190%
MI2I	-1.171%
HELF2	-1.163%
ADBMFV	-1.140%
METR_LIVEU	-1.132%
ALCINV3	-1.120%

CITI_2	-1.117%
ALCPR2	-1.039%
CITI_1	-1.036%
JGABAE	-0.970%
GFO	-0.949%
MWU	-0.874%
GROUP	-0.845%
AGROZ2	-0.780%
ALCINV2	-0.780%
ETHSYN	-0.770%
HEZEE	-0.707%
HEZMA	-0.707%
ALCPR1	-0.698%
METR_LIIIIVEU	-0.676%
AMII	-0.604%
INKZ21	-0.603%
ALCINV1	-0.601%
HELF1	-0.544%
METR_LIVIEU	-0.479%
ETHCH	-0.472%
GFZ	-0.434%
EEPL2E	-0.403%
METR_LIVIEUII	-0.346%
ETHBO	-0.334%
MDE5U	-0.312%
GROUPA	-0.308%
MTRSEE	-0.302%
AMI	-0.296%
MSCU	-0.274%
EEI3E	-0.272%
INE31	-0.249%
MEU2	-0.238%
MEU1	-0.234%
INE26	-0.226%
IP103	-0.206%
INKZBO	-0.097%
GROPFA	-0.004%
AMM	0.000%

Table 2 is sorted from the riskiest Unit-Linked to the less risky one. We notice that the products fluctuate on a scale of approximately -5.50% up to almost 0%. The deviation in these values could lie on the kind of financial assets that every Unit-Linked invests in. Someone would expect that a product which invests heavily in equity or in a market in distress like the Greek one would generate higher negative values. It is also worth mentioning that values of higher than -0.1% are out of the ordinary and should be treated with suspicion.

4.3 Historical Expected Shortfall

It has already been mentioned that Expected Shortfall is, in general, a more coherent risk measure than Value-at-Risk. We should, therefore, expect Historical ES generating bigger losses that Historical VaR for the same Unit-Linked products.

Table 3 – Historical Value-at-Risk & Historical Expected Shortfall

Unit-Linked	Volatility	Historical VaR	Historical ES	Difference
AGROZ1	32.086%	-1.454%	-49.101%	-47.647%
EESE4	3.448%	-4.000%	-10.504%	-6.503%
EESE3	3.471%	-3.929%	-9.673%	-5.744%
TES	3.335%	-3.955%	-9.690%	-5.735%
ETHSYN	5.647%	-0.770%	-5.972%	-5.202%
EESE2	2.929%	-3.842%	-9.024%	-5.182%
EESE1	3.245%	-3.842%	-8.928%	-5.086%
EESE9	3.176%	-3.644%	-8.689%	-5.045%
MSCU	3.289%	-0.274%	-4.874%	-4.601%
EESE6	2.965%	-3.435%	-7.838%	-4.403%
EESE8	3.053%	-3.546%	-7.941%	-4.395%
EESE7	2.830%	-2.893%	-7.019%	-4.126%
MEU1	2.794%	-0.234%	-3.912%	-3.677%
MEU2	2.784%	-0.238%	-3.898%	-3.660%
EEP2EI	2.628%	-5.264%	-8.044%	-2.780%
AMIGHUK	2.594%	-5.043%	-7.815%	-2.772%
GROUPF	2.624%	-5.675%	-8.426%	-2.751%
AL	1.380%	-2.876%	-4.963%	-2.087%
HEZY	1.575%	-1.190%	-3.014%	-1.824%
EES	1.020%	-1.788%	-3.485%	-1.697%
MTRVPL2	1.125%	-2.326%	-3.620%	-1.295%
HEZEE	1.052%	-0.707%	-1.649%	-0.942%
HELF3	0.927%	-1.942%	-2.833%	-0.891%
AMV	1.058%	-2.169%	-2.977%	-0.808%
AMIERTGB	0.826%	-1.661%	-2.441%	-0.780%
APFI	0.729%	-1.504%	-2.256%	-0.752%

MDE5U	0.496%	-0.312%	-0.966%	-0.654%
MI21	0.610%	-1.306%	-1.937%	-0.631%
AGROZ2	0.513%	-0.780%	-1.370%	-0.591%
GFO	0.418%	-0.949%	-1.533%	-0.585%
CITI_3	0.614%	-1.222%	-1.791%	-0.568%
CITI_FU	0.602%	-1.290%	-1.856%	-0.565%
MI2I	0.585%	-1.171%	-1.730%	-0.560%
HELF2	0.567%	-1.163%	-1.721%	-0.558%
METR_LIIIIEU	0.712%	-1.546%	-2.092%	-0.546%
HEZMA	0.416%	-0.707%	-1.243%	-0.537%
AMVV	0.890%	-1.835%	-2.353%	-0.518%
CITI_2	0.575%	-1.117%	-1.621%	-0.504%
ALCPR2	0.508%	-1.039%	-1.529%	-0.490%
JGABAE	0.496%	-0.970%	-1.454%	-0.485%
GFZ	0.271%	-0.434%	-0.905%	-0.471%
ADBMFV	0.606%	-1.140%	-1.599%	-0.460%
METR_LIVEU	0.532%	-1.132%	-1.586%	-0.455%
ALCINV3	0.526%	-1.120%	-1.554%	-0.434%
GROU	0.670%	-1.540%	-1.967%	-0.426%
MWU	0.374%	-0.874%	-1.278%	-0.404%
EEPL2E	0.297%	-0.403%	-0.788%	-0.385%
ETHCH	0.264%	-0.472%	-0.853%	-0.382%
INKZ21	0.321%	-0.603%	-0.976%	-0.373%
INE31	0.276%	-0.249%	-0.620%	-0.371%
CITI_1	0.490%	-1.036%	-1.404%	-0.368%
IP103	0.159%	-0.206%	-0.572%	-0.366%
GROUP	0.396%	-0.845%	-1.201%	-0.356%
ALCPR1	0.340%	-0.698%	-1.039%	-0.340%
EEI3E	0.265%	-0.272%	-0.593%	-0.321%
INE26	0.203%	-0.226%	-0.503%	-0.277%
METR_LIVIEUII	0.194%	-0.346%	-0.619%	-0.273%
HELF1	0.270%	-0.544%	-0.816%	-0.272%
ALCINV2	0.350%	-0.780%	-1.044%	-0.265%
METR_LIIIIVEU	0.307%	-0.676%	-0.922%	-0.246%
ALCINV1	0.285%	-0.601%	-0.822%	-0.221%
METR_LIVIEU	0.222%	-0.479%	-0.673%	-0.194%
AMI	0.190%	-0.296%	-0.467%	-0.170%
GROUPA	0.153%	-0.308%	-0.475%	-0.167%
MTRSEE	0.137%	-0.302%	-0.465%	-0.163%
ETHBO	0.159%	-0.334%	-0.453%	-0.119%
INKZBO	0.058%	-0.097%	-0.215%	-0.118%
AMII	0.260%	-0.604%	-0.710%	-0.106%
AMM	0.024%	0.000%	-0.001%	-0.001%

GROPFA	0.001%	-0.004%	-0.004%	-0.001%

Table 3 depicts the Volatility, Historical VaR, Historical ES and the Difference between Historical ES and VaR. It is noticed that the basic rule of ES generating higher losses than VaR is a valid one since for all Unit-Linked products Historical ES is more negative that Historical VaR. It is worth mentioning though, that since Historical ES is calculated as the average of the worst losses exceeding Historical VaR, Table 3 produces reasonable and expected results. However, we notice that as Volatility increases so does the difference between the two risk measures. Table 3 is presented in ascending order according to the column of Difference. This helps us realize that for values of Volatility higher than 2.5%, the Difference in the two risk measures is higher than 2.5% as well. We deem that any Unit-Linked that falls in that level of difference or higher should be treated with higher consideration. The first Unit-Linked which is AGROZ1 has an extremely high volatility and therefore an abnormal difference in its market risk measurement. In this manner, it is proposed that none of the two risk measures are able to efficiently estimate its market risk. It is also realized that the two bottom Unit-Linked products generate almost zero market risk values with both methodologies. This is a rare phenomenon and such values should be treated with greater attention.

4.4 Cornish-Fischer Value-at-Risk

This subchapter presents the most significant results of this research. Initially, we calculate the z-quantile for all Unit-Linked products since it is the major component for the evaluation of both CFVaR and CFES which are described in the next subchapters.

Table 4 – Unit-Linked & z-quantile

Unit-Linked	**Skewness**	**Kurtosis**	z_{cf}
ETHSYN	-0.006	594.103	-42.789
HEZEE	-0.020	505.191	-36.685
HEZY	0.187	426.994	-31.208
EEI3E	1.822	375.966	-26.448
MDE5U	0.426	333.864	-24.674
AGROZ1	-0.001	327.230	-24.447
INE31	0.435	329.527	-24.371

EESE7	1.390	269.668	-19.551
INE26	-0.064	234.017	-18.071
AMM	9.437	471.710	-16.897
EESE6	1.020	221.441	-16.542
EESE8	2.388	235.481	-16.178
EESE9	0.767	206.969	-15.733
EEPL2E	2.260	226.042	-15.677
EESE1	0.465	199.836	-15.440
EESE3	0.006	193.087	-15.226
TES	-1.629	166.064	-13.755
EESE2	-2.898	133.238	-11.262
EESE4	-2.286	117.713	-10.368
AGROZ2	0.173	117.766	-9.966
MI2I	-1.212	87.926	-8.361
AL	-2.084	39.911	-5.055
MTRVPL2	-1.829	28.206	-4.276
GROPFA	0.201	32.493	-4.092
INKZBO	-1.810	25.279	-4.076
EES	-0.955	25.404	-4.025
IP103	-7.373	93.111	-3.910
EEP2EI	1.462	36.234	-3.445
METR_LIVIEUII	-0.395	18.497	-3.395
GFZ	0.758	23.901	-3.160
ETHCH	-0.932	12.352	-3.123
INKZ21	-0.742	11.385	-3.013
MWU	0.259	16.214	-2.942
ETHBO	-0.574	10.557	-2.909
CITI_3	-0.678	7.725	-2.745
CITI_2	-0.622	7.878	-2.739
GROUPF	-0.762	7.005	-2.717
GFO	0.043	11.141	-2.705
HELF3	-0.828	6.387	-2.691
APFI	-0.849	6.129	-2.678
MTRSEE	-0.827	5.536	-2.632
GROUPA	-0.641	6.175	-2.628
ALCINV2	-0.665	5.569	-2.593
HELF2	-0.709	5.188	-2.579
AMIGHUK	-0.598	5.469	-2.567
ALCINV3	-0.619	5.344	-2.564
MI21	-0.314	6.570	-2.546
ALCPR2	-0.697	4.240	-2.510
AMIERTGB	-0.567	4.697	-2.504
ALCPR1	-0.637	4.106	-2.485

CITI_1	-0.380	5.193	-2.476
CITI_FU	-0.444	4.179	-2.429
METR_LIVEU	-0.490	3.942	-2.428
HEZMA	-0.420	4.043	-2.411
ADBMFV	0.169	7.423	-2.386
GROUP	-0.528	3.149	-2.386
METR_LIIIIEU	-0.444	3.538	-2.385
METR_LIIIIVEU	-0.463	3.272	-2.373
METR_LIVIEU	-0.525	2.918	-2.369
HELF1	-0.332	3.621	-2.350
ALCINV1	-0.387	3.280	-2.347
JGABAE	0.084	5.666	-2.309
AMV	-0.258	3.106	-2.286
GROU	-0.311	2.443	-2.261
AMI	-0.162	2.925	-2.234
AMII	-0.102	2.166	-2.155
AMVV	0.126	2.538	-2.072
MEU1	-32.437	1081.432	62.051
MEU2	-32.464	1082.766	62.206
MSCU	-32.508	1084.324	62.494

In Table 4, the Unit-Linked products are presented in an ascending order according to the column of z_{cf}. By observing the results of the table above someone can arrive in certain conclusions. Initially, it is noticed that the higher the excess kurtosis the more negative the z-quantile. However, there is a discontinuity in the ascending order of z_{cf} and descending order of excess kurtosis. We notice that some higher values of excess kurtosis produce less negative z_{cf} than it would be anticipated. The reason for this disorder lies in the values of skewness. If someone takes a closer look, he can realize that as skewness gets more positive it causes z_{cf} to get less negative and thus operates as a counterweight for increased values of excess kurtosis. However, at the same time, it is worth mentioning that large negative values of skewness can mistakenly drive the z-quantile even to positive values. In the subchapter 4.6 we will attempt to demonstrate how the values of z-quantile and excess kurtosis help us differentiate between a Healthy, a Problematic or a Controversial Unit-Linked product.

Table 5 – Unit-Linked & Cornish-Fischer Value-at-Risk by ESAs

Unit-Linked	**Volatility**	z_{cf}	**CFVaR by ESAs**
AGROZ1	32.086%	-24.447	-789.542%
ETHSYN	5.647%	-42.789	-241.776%
EESE7	2.830%	-19.551	-55.367%
EESE3	3.471%	-15.226	-52.905%
EESE1	3.245%	-15.440	-50.157%
EESE9	3.176%	-15.733	-50.022%
EESE8	3.053%	-16.178	-49.436%
HEZY	1.575%	-31.208	-49.156%
EESE6	2.965%	-16.542	-49.094%
TES	3.335%	-13.755	-45.928%
HEZEE	1.052%	-36.685	-38.607%
EESE4	3.448%	-10.368	-35.807%
EESE2	2.929%	-11.262	-33.028%
MDE5U	0.496%	-24.674	-12.239%
EEP2EI	2.628%	-3.445	-9.088%
GROUPF	2.624%	-2.717	-7.165%
EEI3E	0.265%	-26.448	-7.019%
AL	1.380%	-5.055	-6.983%
INE31	0.276%	-24.371	-6.715%
AMIGHUK	2.594%	-2.567	-6.691%
AGROZ2	0.513%	-9.966	-5.116%
MI2I	0.585%	-8.361	-4.897%
MTRVPL2	1.125%	-4.276	-4.818%
EEPL2E	0.297%	-15.677	-4.656%
EES	1.020%	-4.025	-4.111%
INE26	0.203%	-18.071	-3.663%
HELF3	0.927%	-2.691	-2.499%
AMV	1.058%	-2.286	-2.425%
AMIERTGB	0.826%	-2.504	-2.072%
APFI	0.729%	-2.678	-1.954%
AMVV	0.890%	-2.072	-1.848%
METR_LIIIIEU	0.712%	-2.385	-1.700%
CITI_3	0.614%	-2.745	-1.688%
CITI_2	0.575%	-2.739	-1.576%
MI21	0.610%	-2.546	-1.554%
GROU	0.670%	-2.261	-1.517%
HELF2	0.567%	-2.579	-1.465%
CITI_FU	0.602%	-2.429	-1.464%
ADBMFV	0.606%	-2.386	-1.447%
ALCINV3	0.526%	-2.564	-1.351%

METR_LIVEU	0.532%	-2.428	-1.293%
ALCPR2	0.508%	-2.510	-1.277%
CITI_1	0.490%	-2.476	-1.214%
JGABAE	0.496%	-2.309	-1.146%
GFO	0.418%	-2.705	-1.131%
MWU	0.374%	-2.942	-1.102%
HEZMA	0.416%	-2.411	-1.003%
INKZ21	0.321%	-3.013	-0.968%
GROUP	0.396%	-2.386	-0.946%
ALCINV2	0.350%	-2.593	-0.907%
GFZ	0.271%	-3.160	-0.857%
ALCPR1	0.340%	-2.485	-0.846%
ETHCH	0.264%	-3.123	-0.824%
METR_LIIIIVEU	0.307%	-2.373	-0.728%
ALCINV1	0.285%	-2.347	-0.670%
METR_LIVIEUII	0.194%	-3.395	-0.659%
HELF1	0.270%	-2.350	-0.636%
IP103	0.159%	-3.910	-0.622%
AMII	0.260%	-2.155	-0.560%
METR_LIVIEU	0.222%	-2.369	-0.526%
ETHBO	0.159%	-2.909	-0.463%
AMI	0.190%	-2.234	-0.425%
AMM	0.024%	-16.897	-0.402%
GROUPA	0.153%	-2.628	-0.401%
MTRSEE	0.137%	-2.632	-0.359%
INKZBO	0.058%	-4.076	-0.237%
GROPFA	0.001%	-4.092	-0.005%
MEU2	2.784%	62.206	173.147%
MEU1	2.794%	62.051	173.330%
MSCU	3.289%	62.494	205.505%

Table 5 presents the CFVaR for every Unit-Linked as proposed by the European Supervisory Authorities. These CFVaR values are of high importance since these are the market risk values that the financial institutions will have to be based upon in order to compute the overall risk of their products. We have chosen to present only the volatility and z-quantile of the Unit-Linked products along with their CFVaR values. Their mean return values are so low that they do not bear a significant weight in the outcome of the CFVaR. In this manner, volatility and z_{cf} are the components that materially affect the final outcome of CFVaR. It is observed that as volatility increases and z_{cf}

decreases, the CFVaR decreases as well. More specifically, there are noticed some large negative values of CFVaR in the first two rows of the table. We deem that possible losses of that size are out of the ordinary and we will try to decipher if CFVaR is the best methodology for measuring market risk in turbulent economic periods. On the other hand, it is worth mentioning that the CFVaR of the bottom three Unit-Linked is estimated as positive. It is widely accepted that a positive CFVaR cannot be a valid value and we strongly believe that the positive z-quantile is responsible for this abnormality. Moreover, it is observed that the Unit-Linked GROPFA produces a market risk of almost zero. We deem that such a small value could be unrealistic and the outcome of a possible misinterpretation. We expect that as our research further progress we will notice even more abnormalities and gradually we will be able to set some limits up to what level of distress is CFVaR able to efficiently operate.

Table 6 – Cornish-Fischer Value-at-Risk by ESAs & Historical Value-at-Risk

Unit-Linked	Skewness	Kurtosis	Historical VaR	CFVaR by ESAs	Difference
AGROZ1	-0.001	327.230	-1.454%	-789.542%	-788.089%
ETHSYN	-0.006	594.103	-0.770%	-241.776%	-241.006%
EESE7	1.390	269.668	-2.893%	-55.367%	-52.474%
EESE3	0.006	193.087	-3.929%	-52.905%	-48.977%
HEZY	0.187	426.994	-1.190%	-49.156%	-47.966%
EESE9	0.767	206.969	-3.644%	-50.022%	-46.378%
EESE1	0.465	199.836	-3.842%	-50.157%	-46.315%
EESE8	2.388	235.481	-3.546%	-49.436%	-45.890%
EESE6	1.020	221.441	-3.435%	-49.094%	-45.659%
TES	-1.629	166.064	-3.955%	-45.928%	-41.973%
HEZEE	-0.020	505.191	-0.707%	-38.607%	-37.900%
EESE4	-2.286	117.713	-4.000%	-35.807%	-31.807%
EESE2	-2.898	133.238	-3.842%	-33.028%	-29.187%
MDE5U	0.426	333.864	-0.312%	-12.239%	-11.927%
EEI3E	1.822	375.966	-0.272%	-7.019%	-6.747%
INE31	0.435	329.527	-0.249%	-6.715%	-6.466%
AGROZ2	0.173	117.766	-0.780%	-5.116%	-4.336%
EEPL2E	2.260	226.042	-0.403%	-4.656%	-4.253%
AL	-2.084	39.911	-2.876%	-6.983%	-4.107%
EEP2EI	1.462	36.234	-5.264%	-9.088%	-3.824%
MI2I	-1.212	87.926	-1.171%	-4.897%	-3.726%
INE26	-0.064	234.017	-0.226%	-3.663%	-3.437%
MTRVPL2	-1.829	28.206	-2.326%	-4.818%	-2.493%

EES	-0.955	25.404	-1.788%	-4.111%	-2.323%
AMIGHUK	-0.598	5.469	-5.043%	-6.691%	-1.647%
GROUPF	-0.762	7.005	-5.675%	-7.165%	-1.490%
HELF3	-0.828	6.387	-1.942%	-2.499%	-0.558%
CITI_3	-0.678	7.725	-1.222%	-1.688%	-0.466%
CITI_2	-0.622	7.878	-1.117%	-1.576%	-0.458%
APFI	-0.849	6.129	-1.504%	-1.954%	-0.450%
GFZ	0.758	23.901	-0.434%	-0.857%	-0.424%
IP103	-7.373	93.111	-0.206%	-0.622%	-0.416%
AMIERTGB	-0.567	4.697	-1.661%	-2.072%	-0.411%
AMM	9.437	471.710	0.000%	-0.402%	-0.402%
INKZ21	-0.742	11.385	-0.603%	-0.968%	-0.365%
ETHCH	-0.932	12.352	-0.472%	-0.824%	-0.353%
METR_LIVIEUII	-0.395	18.497	-0.346%	-0.659%	-0.313%
ADBMFV	0.169	7.423	-1.140%	-1.447%	-0.308%
HELF2	-0.709	5.188	-1.163%	-1.465%	-0.302%
HEZMA	-0.420	4.043	-0.707%	-1.003%	-0.296%
AMV	-0.258	3.106	-2.169%	-2.425%	-0.256%
MI21	-0.314	6.570	-1.306%	-1.554%	-0.248%
ALCPR2	-0.697	4.240	-1.039%	-1.277%	-0.238%
ALCINV3	-0.619	5.344	-1.120%	-1.351%	-0.231%
MWU	0.259	16.214	-0.874%	-1.102%	-0.227%
GFO	0.043	11.141	-0.949%	-1.131%	-0.182%
CITI_1	-0.380	5.193	-1.036%	-1.214%	-0.178%
JGABAE	0.084	5.666	-0.970%	-1.146%	-0.177%
CITI_FU	-0.444	4.179	-1.290%	-1.464%	-0.174%
METR_LIVEU	-0.490	3.942	-1.132%	-1.293%	-0.162%
METR_LIIIIEU	-0.444	3.538	-1.546%	-1.700%	-0.154%
ALCPR1	-0.637	4.106	-0.698%	-0.846%	-0.148%
INKZBO	-1.810	25.279	-0.097%	-0.237%	-0.141%
ETHBO	-0.574	10.557	-0.334%	-0.463%	-0.129%
AMI	-0.162	2.925	-0.296%	-0.425%	-0.128%
ALCINV2	-0.665	5.569	-0.780%	-0.907%	-0.128%
GROUP	-0.528	3.149	-0.845%	-0.946%	-0.101%
GROUPA	-0.641	6.175	-0.308%	-0.401%	-0.093%
HELF1	-0.332	3.621	-0.544%	-0.636%	-0.092%
ALCINV1	-0.387	3.280	-0.601%	-0.670%	-0.069%
MTRSEE	-0.827	5.536	-0.302%	-0.359%	-0.057%
METR_LIIIIVEU	-0.463	3.272	-0.676%	-0.728%	-0.052%
METR_LIVIEU	-0.525	2.918	-0.479%	-0.526%	-0.047%
AMVV	0.126	2.538	-1.835%	-1.848%	-0.014%
GROPFA	0.201	32.493	-0.004%	-0.005%	-0.002%
GROU	-0.311	2.443	-1.540%	-1.517%	0.023%

AMII	-0.102	2.166	-0.604%	-0.560%	0.044%
MEU2	-32.464	1082.766	-0.238%	173.147%	173.385%
MEU1	-32.437	1081.432	-0.234%	173.330%	173.565%
MSCU	-32.508	1084.324	-0.274%	205.505%	205.779%

Table 6 demonstrates the difference between CFVaR as proposed by ESAs and Historical VaR. As already mentioned in a previous chapter, it was expected that CFVaR would generate higher losses than Historical VaR since the majority of the products deviate from normality. Moreover, the period which we are examining is a period of exaggerated financial distress and someone would anticipate that the Unit-Linked products available for trading in the Greek market would record extreme values as well.

Getting more into detail, at this stage of the research it is attempted to set some limits regarding the validity of the CFVaR methodology as proposed by ESAs. It is noticed that 5 out of the 70 Unit-Linked do not fulfill the rule of CFVaR generating higher loses than Historical VaR in turbulent economic periods and hence being a more coherent risk measure. More specifically, the Unit-Linked GROU and AMII generate lower losses with the CFVaR methodology. A common characteristic of both products is the value of excess kurtosis which is lower than 2.5. However, the difference in the outcome of these two methodologies is extremely small and it is regarded be of least importance. More importantly, MEU2, MEU1 and MSCU generate a positive outcome with CFVaR when Historical VaR generates a rather normal negative value. The excessive positive kurtosis and negative skewness most probably cause CFVaR to miscalculate the possible outcome.

Another point worth mentioning is that of excessive difference between the two methodologies. Since the table is presented in ascending order according to the column of difference someone can easily interpret that for excess kurtosis higher than 25 the difference is higher than 2%, which we deem a material variance for such products. However, three Unit-Linked, IP103, AMM and INKZBO seem to defy that rule. Although they have quite large excess kurtosis of 93.111, 471.710 and 25.279 accordingly, they generate rather normal values with both methodologies. Their common characteristic though is the excessive skewness in absolute values. Large positive or negative skewness could mean that we have got to deal with a non-symmetrical distribution. This could result in the conclusion that CFVaR may provide controversial outcomes when excessive non-symmetrical distributions are present. Unit-Linked GROPFA once more falls into the category of misinterpreted products as well. Although, it records an excess kurtosis of 32.493 its extremely small Historical VaR and CFVaR values along with the almost zero difference, identify it as a controversial finding.

Table 7 – Cornish-Fisher Value-at-Risk by ESAs & classic Cornish-Fischer Value-at-Risk

Unit-Linked	Mean Return	Volatility	CFVaR by ESAs	CFVaR	Difference
AGROZ1	0.0287%	32.086%	-789.542%	-784.366%	-5.1761%
ETHSYN	0.0111%	5.647%	-241.776%	-241.605%	-0.1706%
EESE3	0.0050%	3.471%	-52.905%	-52.840%	-0.0653%
EESE4	-0.0010%	3.448%	-35.807%	-35.749%	-0.0585%
EESE1	0.0006%	3.245%	-50.157%	-50.104%	-0.0533%
TES	-0.0039%	3.335%	-45.928%	-45.877%	-0.0517%
EESE8	0.0040%	3.053%	-49.436%	-49.386%	-0.0506%
EESE9	0.0001%	3.176%	-50.022%	-49.972%	-0.0505%
EESE2	0.0038%	2.929%	-33.028%	-32.982%	-0.0467%
AMIERTGB	0.0428%	0.826%	-2.072%	-2.026%	-0.0462%
EESE6	0.0017%	2.965%	-49.094%	-49.049%	-0.0456%
EESE7	0.0047%	2.830%	-55.367%	-55.322%	-0.0447%
GROU	0.0378%	0.670%	-1.517%	-1.477%	-0.0400%
MTRVPL2	0.0317%	1.125%	-4.818%	-4.780%	-0.0380%
AL	0.0258%	1.380%	-6.983%	-6.948%	-0.0353%
GROUP	0.0295%	0.396%	-0.946%	-0.916%	-0.0303%
METR_LIIIIEU	0.0250%	0.712%	-1.700%	-1.673%	-0.0276%
GFZ	0.0257%	0.271%	-0.857%	-0.831%	-0.0261%
APFI	0.0228%	0.729%	-1.954%	-1.929%	-0.0254%
AGROZ2	0.0241%	0.513%	-5.116%	-5.090%	-0.0254%
ALCPR2	0.0233%	0.508%	-1.277%	-1.252%	-0.0246%
HEZY	0.0121%	1.575%	-49.156%	-49.132%	-0.0245%
CITI_FU	0.0222%	0.602%	-1.464%	-1.440%	-0.0240%
GFO	0.0227%	0.418%	-1.131%	-1.107%	-0.0235%
ALCINV3	0.0216%	0.526%	-1.351%	-1.328%	-0.0230%
METR_LIVEU	0.0208%	0.532%	-1.293%	-1.271%	-0.0222%
EES	0.0159%	1.020%	-4.111%	-4.090%	-0.0211%
ALCPR1	0.0186%	0.340%	-0.846%	-0.827%	-0.0192%
MI21	0.0169%	0.610%	-1.554%	-1.535%	-0.0187%
MI2I	0.0162%	0.585%	-4.897%	-4.879%	-0.0179%
ETHBO	0.0176%	0.159%	-0.463%	-0.445%	-0.0177%

HELF3	0.0126%	0.927%	-2.499%	-2.482%	-0.0169%
ALCINV2	0.0147%	0.350%	-0.907%	-0.892%	-0.0154%
CITI_3	0.0134%	0.614%	-1.688%	-1.673%	-0.0153%
ADBMFV	0.0127%	0.606%	-1.447%	-1.433%	-0.0145%
HELF2	0.0123%	0.567%	-1.465%	-1.451%	-0.0139%
ETHCH	0.0135%	0.264%	-0.824%	-0.810%	-0.0138%
METR_LIIIIVEU	0.0133%	0.307%	-0.728%	-0.715%	-0.0138%
CITI_2	0.0120%	0.575%	-1.576%	-1.562%	-0.0137%
AMIGHUK	-0.0210%	2.594%	-6.691%	-6.678%	-0.0126%
MDE5U	0.0103%	0.496%	-12.239%	-12.228%	-0.0116%
HEZEE	0.0060%	1.052%	-38.607%	-38.595%	-0.0115%
HEZMA	0.0102%	0.416%	-1.003%	-0.992%	-0.0110%
ALCINV1	0.0102%	0.285%	-0.670%	-0.659%	-0.0106%
GROUPA	0.0103%	0.153%	-0.401%	-0.391%	-0.0104%
CITI_1	0.0092%	0.490%	-1.214%	-1.204%	-0.0104%
EEP2EI	-0.0249%	2.628%	-9.088%	-9.079%	-0.0097%
METR_LIVIEU	0.0094%	0.222%	-0.526%	-0.517%	-0.0096%
HELF1	0.0085%	0.270%	-0.636%	-0.627%	-0.0089%
MWU	0.0080%	0.374%	-1.102%	-1.093%	-0.0087%
EEPL2E	0.0076%	0.297%	-4.656%	-4.648%	-0.0081%
METR_LIVIEUII	0.0070%	0.194%	-0.659%	-0.652%	-0.0072%
AMI	0.0040%	0.190%	-0.425%	-0.421%	-0.0042%
AMV	-0.0019%	1.058%	-2.425%	-2.421%	-0.0037%
AMII	0.0028%	0.260%	-0.560%	-0.557%	-0.0031%
JGABAE	0.0001%	0.496%	-1.146%	-1.145%	-0.0013%
EEI3E	0.0008%	0.265%	-7.019%	-7.018%	-0.0012%
GROUPF	-0.0333%	2.624%	-7.165%	-7.164%	-0.0012%
IP103	0.0001%	0.159%	-0.622%	-0.622%	-0.0002%
GROPFA	-0.0001%	0.001%	-0.005%	-0.005%	0.0001%
AMM	-0.0003%	0.024%	-0.402%	-0.402%	0.0003%
INKZBO	-0.0024%	0.058%	-0.237%	-0.240%	0.0024%
MTRSEE	-0.0026%	0.137%	-0.359%	-0.362%	0.0025%
INKZ21	-0.0043%	0.321%	-0.968%	-0.972%	0.0038%
INE26	-0.0055%	0.203%	-3.663%	-3.668%	0.0053%
INE31	-0.0061%	0.276%	-6.715%	-6.721%	0.0057%
MSCU	-0.0648%	3.289%	205.505%	205.494%	0.0107%
MEU1	-0.0539%	2.794%	173.330%	173.315%	0.0149%
MEU2	-0.0540%	2.784%	173.147%	173.131%	0.0153%
AMVV	-0.0397%	0.890%	-1.848%	-1.884%	0.0357%

Table 7 is not of such high importance but it provides some rather interesting results. To begin with, the market risk of the Unit-Linked products is measured with both the

CFVaR methodology as proposed by ESAs and the classic CFVaR as presented in the academic papers of Sjostrand and Aktas (2011), Maillard (2012) and Cavenaile and Lejeune (2012). The last column of the table describes the difference in the outcomes of these two methodologies. Although, the difference in almost every Unit-Linked is of least significance there are some basic points to mention.

First and foremost, it is realized that whenever the mean return is positive, the CFVaR by ESAs generates more negative values than the classic CFVaR. Moreover, higher volatility acts as an increasing factor in the difference between these two models. On the other hand, if the mean return is negative the classic CFVaR produces more negative values than the CFVaR by ESAs. It is observed though that if high volatility is present the rule of negative mean return does not apply and CFVaR once again produces the most negative values. Once more time, it is noticed that the three Unit-Linked products with excessive non-symmetrical distributions do not follow either of the rules described above.

4.5 Cornish-Fischer Expected Shortfall

In this subchapter, the CFES is examined. Since most of the returns' distributions do not follow the assumption of normality, CFES may prove to be a more credible risk measure than CFVaR. Moreover, by applying CFES it is attempted to include both the rule of Cornish-Fischer expansion being a more reliable method when financial distress is apparent and the general rule of Expected Shortfall being a more coherent risk measure than VaR. Finally, CFES is calculated in order to provide an alternative to the methodology proposed by ESAs.

Table 8 – Unit-Linked & Cornish-Fischer Expected Shortfall

Unit-Linked	**CFES**
EEP2EI	-20.1951%
GROUPF	-15.3847%
AMIGHUK	-14.0484%
HELF3	-5.2531%
AMV	-4.3576%
AMIERTGB	-4.1492%
APFI	-4.0607%

ADBMFV	-3.7977%
CITI_3	-3.6947%
MI21	-3.5927%
CITI_2	-3.4928%
METR_LIIIIEU	-3.1522%
GFO	-3.1479%
MWU	-3.0040%
HELF2	-2.9863%
AMVV	-2.9252%
CITI_FU	-2.8711%
ALCINV3	-2.7964%
JGABAE	-2.6317%
CITI_1	-2.5892%
IP103	-2.5190%
GROU	-2.4903%
METR_LIVEU	-2.4763%
ALCPR2	-2.4511%
GFZ	-2.2362%
HEZMA	-1.9543%
INKZ21	-1.9247%
ALCINV2	-1.8868%
GROUP	-1.6654%
ALCPR1	-1.6147%
ETHCH	-1.4652%
EES	-1.3664%
METR_LIIIIVEU	-1.3131%
ALCINV1	-1.2149%
HELF1	-1.1969%
ETHBO	-0.9843%
MTRVPL2	-0.9797%
METR_LIVIEU	-0.9121%
AMII	-0.8831%
GROUPA	-0.8537%
METR_LIVIEUII	-0.8519%
MTRSEE	-0.7413%
AMI	-0.7412%
INKZBO	-0.0894%
AL	-0.0806%
MSCU	-0.0648%
MEU2	-0.0540%
MEU1	-0.0539%
INE31	-0.0061%
INE26	-0.0055%

TES	-0.0039%
GROPFA	-0.0017%
EESE4	-0.0010%
AMM	-0.0003%
EESE9	0.0001%
EESE1	0.0006%
EEI3E	0.0008%
EESE6	0.0017%
EESE2	0.0038%
EESE8	0.0040%
EESE7	0.0047%
EESE3	0.0050%
HEZEE	0.0060%
EEPL2E	0.0076%
MDE5U	0.0103%
ETHSYN	0.0111%
HEZY	0.0121%
MI2I	0.0162%
AGROZ2	0.0241%
AGROZ1	0.0287%

Table 8 presents the market risk as calculated by the methodology of CFES in ascending order. It is noticed that the top three Unit-Linked products which record the worst possible losses produce an excess negative value and a large deviation from the rest of the Unit-Linked. On the other hand, it is observed that 16 Unit-Linked products generate a positive value. Such values are out of the ordinary since any VaR or ES model should always provide a negative value. Moreover, it is worth mentioning that 11 Unit-Linked products produce a negative value of higher than -0.1%. We deem that such values are extremely low and should be treated with higher consideration. It is expected that as soon as we compare CFES with CFVaR, we will be able to form a more robust opinion on the validity of these models.

Table 9 – Cornish-Fischer Expected Shortfall & Historical Expected Shortfall

Unit-Linked	Historical ES	CFES	Skewness	Kurtosis	z_{cf}
EEP2EI	-8.044%	-20.195%	1.462	36.234	-3.445
GROUPF	-8.426%	-15.385%	-0.762	7.005	-2.717
AMIGHUK	-7.815%	-14.048%	-0.598	5.469	-2.567
HELF3	-2.833%	-5.253%	-0.828	6.387	-2.691

AMV	-2.977%	-4.358%	-0.258	3.106	-2.286
AMIERTGB	-2.441%	-4.149%	-0.567	4.697	-2.504
APFI	-2.256%	-4.061%	-0.849	6.129	-2.678
ADBMFV	-1.599%	-3.798%	0.169	7.423	-2.386
CITI_3	-1.791%	-3.695%	-0.678	7.725	-2.745
MI21	-1.937%	-3.593%	-0.314	6.570	-2.546
CITI_2	-1.621%	-3.493%	-0.622	7.878	-2.739
METR_LIIIIEU	-2.092%	-3.152%	-0.444	3.538	-2.385
GFO	-1.533%	-3.148%	0.043	11.141	-2.705
MWU	-1.278%	-3.004%	0.259	16.214	-2.942
HELF2	-1.721%	-2.986%	-0.709	5.188	-2.579
AMVV	-2.353%	-2.925%	0.126	2.538	-2.072
CITI_FU	-1.856%	-2.871%	-0.444	4.179	-2.429
ALCINV3	-1.554%	-2.796%	-0.619	5.344	-2.564
JGABAE	-1.454%	-2.632%	0.084	5.666	-2.309
CITI_1	-1.404%	-2.589%	-0.380	5.193	-2.476
IP103	-0.572%	-2.519%	-7.373	93.111	-3.910
GROU	-1.967%	-2.490%	-0.311	2.443	-2.261
METR_LIVEU	-1.586%	-2.476%	-0.490	3.942	-2.428
ALCPR2	-1.529%	-2.451%	-0.697	4.240	-2.510
GFZ	-0.905%	-2.236%	0.758	23.901	-3.160
HEZMA	-1.243%	-1.954%	-0.420	4.043	-2.411
INKZ21	-0.976%	-1.925%	-0.742	11.385	-3.013
ALCINV2	-1.044%	-1.887%	-0.665	5.569	-2.593
GROUP	-1.201%	-1.665%	-0.528	3.149	-2.386
ALCPR1	-1.039%	-1.615%	-0.637	4.106	-2.485
ETHCH	-0.853%	-1.465%	-0.932	12.352	-3.123
METR_LIIIIVEU	-0.922%	-1.313%	-0.463	3.272	-2.373
ALCINV1	-0.822%	-1.215%	-0.387	3.280	-2.347
HELF1	-0.816%	-1.197%	-0.332	3.621	-2.350
ETHBO	-0.453%	-0.984%	-0.574	10.557	-2.909
METR_LIVIEU	-0.673%	-0.912%	-0.525	2.918	-2.369
AMII	-0.710%	-0.883%	-0.102	2.166	-2.155
GROUPA	-0.475%	-0.854%	-0.641	6.175	-2.628
METR_LIVIEUII	-0.619%	-0.852%	-0.395	18.497	-3.395
MTRSEE	-0.465%	-0.741%	-0.827	5.536	-2.632
AMI	-0.467%	-0.741%	-0.162	2.925	-2.234
EES	-3.485%	-1.366%	-0.955	25.404	-4.025
MTRVPL2	-3.620%	-0.980%	-1.829	28.206	-4.276
INKZBO	-0.215%	-0.089%	-1.810	25.279	-4.076
AL	-4.963%	-0.081%	-2.084	39.911	-5.055
MSCU	-4.874%	-0.065%	-32.508	1084.324	62.494
MEU2	-3.898%	-0.054%	-32.464	1082.766	62.206

MEU1	-3.912%	-0.054%	-32.437	1081.432	62.051
INE31	-0.620%	-0.006%	0.435	329.527	-24.371
INE26	-0.503%	-0.006%	-0.064	234.017	-18.071
TES	-9.690%	-0.004%	-1.629	166.064	-13.755
GROPFA	-0.004%	-0.002%	0.201	32.493	-4.092
EESE4	-10.504%	-0.001%	-2.286	117.713	-10.368
AMM	-0.001%	0.000%	9.437	471.710	-16.897
EESE9	-8.689%	0.000%	0.767	206.969	-15.733
EESE1	-8.928%	0.001%	0.465	199.836	-15.440
EEI3E	-0.593%	0.001%	1.822	375.966	-26.448
EESE6	-7.838%	0.002%	1.020	221.441	-16.542
EESE2	-9.024%	0.004%	-2.898	133.238	-11.262
EESE8	-7.941%	0.004%	2.388	235.481	-16.178
EESE7	-7.019%	0.005%	1.390	269.668	-19.551
EESE3	-9.673%	0.005%	0.006	193.087	-15.226
HEZEE	-1.649%	0.006%	-0.020	505.191	-36.685
EEPL2E	-0.788%	0.008%	2.260	226.042	-15.677
MDE5U	-0.966%	0.010%	0.426	333.864	-24.674
ETHSYN	-5.972%	0.011%	-0.006	594.103	-42.789
HEZY	-3.014%	0.012%	0.187	426.994	-31.208
MI2I	-1.730%	0.016%	-1.212	87.926	-8.361
AGROZ2	-1.370%	0.024%	0.173	117.766	-9.966
AGROZ1	-49.101%	0.029%	-0.001	327.230	-24.447

Table 9 offers a comparison between CFES and Historical ES. This table offers a variety of results which validate some assumptions made in the previous subchapters and are consistent with some of the restrictions mentioned in previous tables as well. For convenient reasons, the table is modified to show in the top 41 rows the Unit-Linked products that behave normally and in the following rows the rather problematic products. To start with, someone can notice that the bottom 29 Unit-Linked products, that is from Unit-Linked EES and thereafter, the rule of CFES being more negative than Historical ES does not apply. More specifically, most of these Unit-Linked seem to generate an extremely low negative value or even positive value when estimating their market risk with CFES, whereas, Historical ES seems to produce more consistent results. In this manner, the rule of Cornish-Fischer expansion of being the most fitting model for market risk measurement in periods of financial distress does not apply in these Unit-Linked products.

In order to decipher the reasons that cause CFES to misbehave, someone has to look closer in the columns of excess kurtosis and z-quantile. We notice that all 29 Unit-Linked that record an abnormal CFES have an excess kurtosis of larger than 25 and a z-quantile of -4 or lower. In this manner, we expect that the rest of the Unit-Linked which behave normally will not have an excess kurtosis and z-quantile of the aforementioned levels. It is observed that all 41 Unit-Linked with a normal behavior fulfill the rule of z_{cf} being larger than -4. However, 2 out of the 41 products do not fulfill the rule of excess kurtosis lower than 25. Although, EEP2EI and IP103 have an excess kurtosis of 36.234 and 93.111 accordingly their z-quantile and CFES values are quite normal. It is considered that their results are greatly affected by the values of their skewness. We observe that these products have a skewness of 1.462 and -7.373 accordingly while the rest 39 Unit-Linked have a skewness between -1 and 1. So, once more it is shown that Unit-Linked with excessive non-symmetrical distributions tend to defy the rules established above and generate questionable results.

Table 10 – Cornish-Fischer Value-at-Risk by ESAs & Cornish-Fischer Expected Shortfall

Unit-Linked	CFVaR by ESAs	CFES	Skewness	Kurtosis	z_{cf}
ADBMFV	-1.447%	-3.798%	0.169	7.423	-2.386
ALCINV1	-0.670%	-1.215%	-0.387	3.280	-2.347
ALCINV2	-0.907%	-1.887%	-0.665	5.569	-2.593
ALCINV3	-1.351%	-2.796%	-0.619	5.344	-2.564
ALCPR1	-0.846%	-1.615%	-0.637	4.106	-2.485
ALCPR2	-1.277%	-2.451%	-0.697	4.240	-2.510
AMI	-0.425%	-0.741%	-0.162	2.925	-2.234
AMIERTGB	-2.072%	-4.149%	-0.567	4.697	-2.504
AMIGHUK	-6.691%	-14.048%	-0.598	5.469	-2.567
AMII	-0.560%	-0.883%	-0.102	2.166	-2.155
AMV	-2.425%	-4.358%	-0.258	3.106	-2.286
AMVV	-1.848%	-2.925%	0.126	2.538	-2.072
APFI	-1.954%	-4.061%	-0.849	6.129	-2.678
CITI_1	-1.214%	-2.589%	-0.380	5.193	-2.476
CITI_2	-1.576%	-3.493%	-0.622	7.878	-2.739
CITI_3	-1.688%	-3.695%	-0.678	7.725	-2.745
CITI_FU	-1.464%	-2.871%	-0.444	4.179	-2.429
EEP2EI	-9.088%	-20.195%	1.462	36.234	-3.445
ETHBO	-0.463%	-0.984%	-0.574	10.557	-2.909
ETHCH	-0.824%	-1.465%	-0.932	12.352	-3.123

GFO	-1.131%	-3.148%	0.043	11.141	-2.705
GFZ	-0.857%	-2.236%	0.758	23.901	-3.160
GROU	-1.517%	-2.490%	-0.311	2.443	-2.261
GROUP	-0.946%	-1.665%	-0.528	3.149	-2.386
GROUPA	-0.401%	-0.854%	-0.641	6.175	-2.628
GROUPF	-7.165%	-15.385%	-0.762	7.005	-2.717
HELF1	-0.636%	-1.197%	-0.332	3.621	-2.350
HELF2	-1.465%	-2.986%	-0.709	5.188	-2.579
HELF3	-2.499%	-5.253%	-0.828	6.387	-2.691
HEZMA	-1.003%	-1.954%	-0.420	4.043	-2.411
INKZ21	-0.968%	-1.925%	-0.742	11.385	-3.013
IP103	-0.622%	-2.519%	-7.373	93.111	-3.910
JGABAE	-1.146%	-2.632%	0.084	5.666	-2.309
METR_LIIIIEU	-1.700%	-3.152%	-0.444	3.538	-2.385
METR_LIIIIVEU	-0.728%	-1.313%	-0.463	3.272	-2.373
METR_LIVEU	-1.293%	-2.476%	-0.490	3.942	-2.428
METR_LIVIEU	-0.526%	-0.912%	-0.525	2.918	-2.369
METR_LIVIEUII	-0.659%	-0.852%	-0.395	18.497	-3.395
MEU1	173.330%	-0.054%	-32.437	1081.432	62.051
MEU2	173.147%	-0.054%	-32.464	1082.766	62.206
MI21	-1.554%	-3.593%	-0.314	6.570	-2.546
MSCU	205.505%	-0.065%	-32.508	1084.324	62.494
MTRSEE	-0.359%	-0.741%	-0.827	5.536	-2.632
MWU	-1.102%	-3.004%	0.259	16.214	-2.942
AGROZ1	-789.542%	0.029%	-0.001	327.230	-24.447
AGROZ2	-5.116%	0.024%	0.173	117.766	-9.966
AL	-6.983%	-0.081%	-2.084	39.911	-5.055
AMM	-0.402%	0.000%	9.437	471.710	-16.897
EEI3E	-7.019%	0.001%	1.822	375.966	-26.448
EEPL2E	-4.656%	0.008%	2.260	226.042	-15.677
EES	-4.111%	-1.366%	-0.955	25.404	-4.025
EESE1	-50.157%	0.001%	0.465	199.836	-15.440
EESE2	-33.028%	0.004%	-2.898	133.238	-11.262
EESE3	-52.905%	0.005%	0.006	193.087	-15.226
EESE4	-35.807%	-0.001%	-2.286	117.713	-10.368
EESE6	-49.094%	0.002%	1.020	221.441	-16.542
EESE7	-55.367%	0.005%	1.390	269.668	-19.551
EESE8	-49.436%	0.004%	2.388	235.481	-16.178
EESE9	-50.022%	0.000%	0.767	206.969	-15.733
ETHSYN	-241.776%	0.011%	-0.006	594.103	-42.789
GROPFA	-0.005%	-0.002%	0.201	32.493	-4.092
HEZEE	-38.607%	0.006%	-0.020	505.191	-36.685
HEZY	-49.156%	0.012%	0.187	426.994	-31.208

INE26	-3.663%	-0.006%	-0.064	234.017	-18.071
INE31	-6.715%	-0.006%	0.435	329.527	-24.371
INKZBO	-0.237%	-0.089%	-1.810	25.279	-4.076
MDE5U	-12.239%	0.010%	0.426	333.864	-24.674
MI2I	-4.897%	0.016%	-1.212	87.926	-8.361
MTRVPL2	-4.818%	-0.980%	-1.829	28.206	-4.276
TES	-45.928%	-0.004%	-1.629	166.064	-13.755

In Table 10, it is attempted to realize whether CFVaR by ESAs or CFES is the most appropriate methodology to estimate the market risk of the Unit-Linked products. Initially, it is researched the theorem of Expected Shortfall being a more coherent market risk measure than Value-at-Risk. Additionally, it is incorporated the perspective of financial distress in the context. The order of the Unit-Linked products is again modified as in Table 9. More particularly, the top 44 rows demonstrate the Unit-Linked products that generate a CFES value which is more negative than the equivalent CFVaR value. On the other hand, the bottom 26 rows present the products that generate positive CFES values or CFES values which are by far less negative than the equivalent CFVaR ones. Getting into detail, it is noticed that the 26 bottom Unit-Linked products follow the restrictions of excess kurtosis being larger than 25 and z-quantile lower than -4.

However, 5 out of the 44 normal Unit-Linked products seem to wrongfully generate normal results. By observing the data of Table 10, someone can realize that these 5 Unit-Linked products record disturbing third and fourth moments. More particularly, 2 out of the 5 controversial products are the same as the ones mentioned in Table 9, with a skewness of larger than 1 in absolute values. The remaining 3 out of the 5 products are MEU1, MEU2 and MSCU. These products record extraordinary values of z-quantile, skewness and excess kurtosis. Although CFVaR by ESAs produces a large positive value, the CFES generates a negative value of higher than -0.1%. That is mainly the reason for these 3 products falling in the basket of normal behavior when comparing CFES with CFVaR by ESAs. However, it is regarded that products with a market risk greater than -0.1% are unrealistic and should be treated with reasonable doubt.

4.6 Healthy, Problematic and Controversial

In this subchapter, it will be attempted to gather and compare the findings from Tables 1 up to 10. We will try to categorize the Unit-Linked products in Healthy, Problematic and Controversial. The rationale for categorizing these products is based on two points. Firstly, they will be judged for their consistency with the general rules of the various methodologies and secondly for their success in following the restrictions which are established in the process of this research.

Table 11 – Healthy, Problematic & Controversial

Table 3	Table 5	Table 6	Table 8	Table 9	Table 10
ADBMFV	ADBMFV	ADBMFV	ADBMFV	ADBMFV	ADBMFV
AGROZ1	**AGROZ1**	**AGROZ1**	**AGROZ1**	**AGROZ1**	**AGROZ1**
AGROZ2	AGROZ2	**AGROZ2**	**AGROZ2**	**AGROZ2**	**AGROZ2**
AL	AL	**AL**	**AL**	**AL**	**AL**
ALCINV1	ALCINV1	ALCINV1	ALCINV1	ALCINV1	ALCINV1
ALCINV2	ALCINV2	ALCINV2	ALCINV2	ALCINV2	ALCINV2
ALCINV3	ALCINV3	ALCINV3	ALCINV3	ALCINV3	ALCINV3
ALCPR1	ALCPR1	ALCPR1	ALCPR1	ALCPR1	ALCPR1
ALCPR2	ALCPR2	ALCPR2	ALCPR2	ALCPR2	ALCPR2
AMI	AMI	AMI	AMI	AMI	AMI
AMIERTGB	AMIERTGB	AMIERTGB	AMIERTGB	AMIERTGB	AMIERTGB
AMIGHUK	AMIGHUK	AMIGHUK	**AMIGHUK**	AMIGHUK	AMIGHUK
AMII	AMII	**AMII**	AMII	AMII	AMII
AMM	AMM	**AMM**	**AMM**	**AMM**	**AMM**
AMV	AMV	AMV	AMV	AMV	AMV
AMVV	AMVV	AMVV	AMVV	AMVV	AMVV
APFI	APFI	APFI	APFI	APFI	APFI
CITI_1	CITI_1	CITI_1	CITI_1	CITI_1	CITI_1
CITI_2	CITI_2	CITI_2	CITI_2	CITI_2	CITI_2
CITI_3	CITI_3	CITI_3	CITI_3	CITI_3	CITI_3
CITI_FU	CITI_FU	CITI_FU	CITI_FU	CITI_FU	CITI_FU
EEI3E	EEI3E	**EEI3E**	**EEI3E**	**EEI3E**	**EEI3E**
EEP2EI	EEP2EI	**EEP2EI**	**EEP2EI**	**EEP2EI**	**EEP2EI**
EEPL2E	EEPL2E	**EEPL2E**	**EEPL2E**	**EEPL2E**	**EEPL2E**
EES	EES	**EES**	EES	**EES**	**EES**
EESE1	EESE1	**EESE1**	**EESE1**	**EESE1**	**EESE1**
EESE2	EESE2	**EESE2**	**EESE2**	**EESE2**	**EESE2**
EESE3	EESE3	**EESE3**	**EESE3**	**EESE3**	**EESE3**
EESE4	EESE4	**EESE4**	**EESE4**	**EESE4**	**EESE4**

EESE6	EESE6	**EESE6**	**EESE6**	**EESE6**	**EESE6**
EESE7	EESE7	**EESE7**	**EESE7**	**EESE7**	**EESE7**
EESE8	EESE8	**EESE8**	**EESE8**	**EESE8**	**EESE8**
EESE9	EESE9	**EESE9**	**EESE9**	**EESE9**	**EESE9**
ETHBO	ETHBO	ETHBO	ETHBO	ETHBO	ETHBO
ETHCH	ETHCH	ETHCH	ETHCH	ETHCH	ETHCH
ETHSYN	**ETHSYN**	**ETHSYN**	**ETHSYN**	**ETHSYN**	**ETHSYN**
GFO	GFO	GFO	GFO	GFO	GFO
GFZ	GFZ	GFZ	GFZ	GFZ	GFZ
GROPFA	**GROPFA**	**GROPFA**	**GROPFA**	**GROPFA**	**GROPFA**
GROU	GROU	**GROU**	GROU	GROU	GROU
GROUP	GROUP	GROUP	GROUP	GROUP	GROUP
GROUPA	GROUPA	GROUPA	GROUPA	GROUPA	GROUPA
GROUPF	GROUPF	GROUPF	**GROUPF**	GROUPF	GROUPF
HELF1	HELF1	HELF1	HELF1	HELF1	HELF1
HELF2	HELF2	HELF2	HELF2	HELF2	HELF2
HELF3	HELF3	HELF3	HELF3	HELF3	HELF3
HEZEE	HEZEE	**HEZEE**	**HEZEE**	**HEZEE**	**HEZEE**
HEZMA	HEZMA	HEZMA	HEZMA	HEZMA	HEZMA
HEZY	HEZY	**HEZY**	**HEZY**	**HEZY**	**HEZY**
INE26	INE26	**INE26**	**INE26**	**INE26**	**INE26**
INE31	INE31	**INE31**	**INE31**	**INE31**	**INE31**
INKZ21	INKZ21	INKZ21	INKZ21	INKZ21	INKZ21
INKZBO	INKZBO	**INKZBO**	**INKZBO**	**INKZBO**	**INKZBO**
IP103	IP103	**IP103**	IP103	**IP103**	**IP103**
JGABAE	JGABAE	JGABAE	JGABAE	JGABAE	JGABAE
MDE5U	MDE5U	**MDE5U**	**MDE5U**	**MDE5U**	**MDE5U**
METR_LIIIIEU	METR_LIIIIEU	METR_LIIIIEU	METR_LIIIIEU	METR_LIIIIEU	METR_LIIIIEU
METR_LIIIIVEU	METR_LIIIIVEU	METR_LIIIIVEU	METR_LIIIIVEU	METR_LIIIIVEU	METR_LIIIIVEU
METR_LIVEU	METR_LIVEU	METR_LIVEU	METR_LIVEU	METR_LIVEU	METR_LIVEU
METR_LIVIEU	METR_LIVIEU	METR_LIVIEU	METR_LIVIEU	METR_LIVIEU	METR_LIVIEU
METR_LIVIEUII	METR_LIVIEUII	METR_LIVIEUII	METR_LIVIEUII	METR_LIVIEUII	METR_LIVIEUII
MEU1	**MEU1**	**MEU1**	**MEU1**	**MEU1**	**MEU1**
MEU2	**MEU2**	**MEU2**	**MEU2**	**MEU2**	**MEU2**
MI21	MI21	MI21	MI21	MI21	MI21
MI2I	MI2I	**MI2I**	**MI2I**	**MI2I**	**MI2I**
MSCU	**MSCU**	**MSCU**	**MSCU**	**MSCU**	**MSCU**
MTRSEE	MTRSEE	MTRSEE	MTRSEE	MTRSEE	MTRSEE
MTRVPL2	MTRVPL2	**MTRVPL2**	MTRVPL2	**MTRVPL2**	**MTRVPL2**
MWU	MWU	MWU	MWU	MWU	MWU
TES	TES	**TES**	**TES**	**TES**	**TES**

Table 11 shows the aggregated results of all tables. However, only 6 main tables are presented since these are the ones that produce material criteria. The remaining 4 tables act as supporting tables that generate data which are used to produce the main tables. Before decomposing Table 11, we should provide some explanations regarding the meaning behind the different illustration accompanying each Unit-Linked product. The Unit-Linked products which bear no particular modification are considered as Healthy. The ones with the bold letters are considered as **Controversial** and the ones which are both bold and underlined are the **<u>Problematic</u>**. When a Unit-Linked is labeled as Healthy, it means that it fulfills the rules of the relevant Table and it is eligible for assessing its market risk. If it is labeled as Problematic, it means that the Unit-Linked does not follow the rationale of the methodology implemented in the relevant table and its result should not be considered valid. Controversial products are the ones which do follow the rules of the relevant table but either they should not or there is reasonable doubt about their validity. In this case, it is proposed that a refined or different methodology would be preferable for calculating their market risk.

Getting into further detail, in Table 3 where the Historical ES is tested against the Historical VaR, it is noticed that most of the Unit-Linked are labeled as Healthy which means that Historical ES in its majority is a more coherent risk measure than Historical VaR. Moving on, Table 5 provides an illustration of the validity of CFVaR by ESAs without any material counterweight included. In this manner, we observe that almost all products are labeled as Healthy. However, in Table 6 where the Historical VaR is introduced as an offset to CFVaR, we realize that more than 20 products are turning from Healthy to Controversial ones. This observation indicates that CFVaR by ESAs may not be such an ideal methodology to assess the market risk of Unit-Linked products in turbulent economic periods. As the research advances, CFES is calculated and Table 8 is constructed. At this point, it is witnessed that most of the Unit-Linked products which were once labeled as Controversial in Table 6, gradually start to shift to Problematic ones. In this manner, someone could interpret these findings as a sign that even CFES is having trouble in correctly assessing the market risk of Unit-Linked products in extreme events. In Table 9 the CFES methodology is tested against the Historical ES. It is worth mentioning, that only 39 out of the 70 Unit-Linked products are labeled as

Healthy at this point of the research. The verdict of this outcome is that the Cornish-Fischer expansion is having trouble correctly assessing the market risk of Unit-Linked products when large excess kurtosis or excessive non-symmetrical distributions of returns are present. Reaching the terminal point of this research, Table 10 is introduced which provides a comparison between the CFVaR by ESAs and CFES. Table 10 confirms the verdict of Table 9 but also adds the realization that CFES is a more coherent risk measure than CFVaR by ESAs.

Summing up, it is noticed that as the research proceeds and different methodologies are introduced more complex tables are created. These tables provide interesting observations and set more criteria for the successful validation of the Unit-Linked products. In this rationale, Table 11 depicts a brief history of the research conducted. Someone can realize that as the research advances, Unit-Linked products tend to convert from Health to Controversial and from Controversial to Problematic. This is not a surprising outcome since the more criteria added to a cluster of data the more adverse are going to be the expected results.

Table 12 – Unit-Linked & Compatibility

Healthy	Problematic	Controversial
ADBMFV	AGROZ1	AMIGHUK
ALCINV1	AGROZ2	AMII
ALCINV2	AL	EEP2EI
ALCINV3	AMM	GROU
ALCPR1	EEI3E	GROUPF
ALCPR2	EEPL2E	IP103
AMI	EES	
AMIERTGB	EESE1	
AMV	EESE2	
AMVV	EESE3	
APFI	EESE4	
CITI_1	EESE6	
CITI_2	EESE7	
CITI_3	EESE8	
CITI_FU	EESE9	
ETHBO	ETHSYN	
ETHCH	GROPFA	
GFO	HEZEE	

GFZ	HEZY
GROUP	INE26
GROUPA	INE31
HELF1	INKZBO
HELF2	MDE5U
HELF3	MEU1
HEZMA	MEU2
INKZ21	MI2I
JGABAE	MSCU
METR_LIIIIEU	MTRVPL2
METR_LIIIIVEU	TES
METR_LIVEU	
METR_LIVIEU	
METR_LIVIEUII	
MI21	
MTRSEE	
MWU	

Table 12 attempts to gather and organize all the findings from Table 11. The scope of Table 12 is to offer a formal label to each Unit-Linked according to their compatibility with the methodologies of CFVaR by ESAs and CFES. In order to achieve the best possible interpretation, it was decided to follow a strict approach and pick the most unfavorable scenario for each Unit-Linked according to Table 11. Therefore, it is noticed that 6 out of the 70 Unit-Linked products are labeled as Controversial. This means that these Unit-Linked should be treated with doubt and it is possible that either CFVaR by ESAs or CFES may not be the best methodologies for assessing their market risk. When it comes to the Problematic ones, 29 out of the 70 products are considered to be incompatible with the methodologies mentioned above. In other words, Cornish-Fischer expansion is not able to successfully predict the market risk of these Unit-Linked and therefore should not be applied to products with such characteristics. More importantly, 35 out of the 70 Unit-Linked products are considered as Healthy ones. It is worth mentioning that the Unit-Linked products which are signified as Healthy are eligible to be treated with the CFVaR methodology as proposed by ESAs. At the same time though, the characterization of Healthy indicates that the market risk of these products can be also estimated with CFES which provides a more coherent outcome than CFVaR by ESAs.

The following Figure depicts a scatter plot of the 70 Unit-Linked products used in this research:

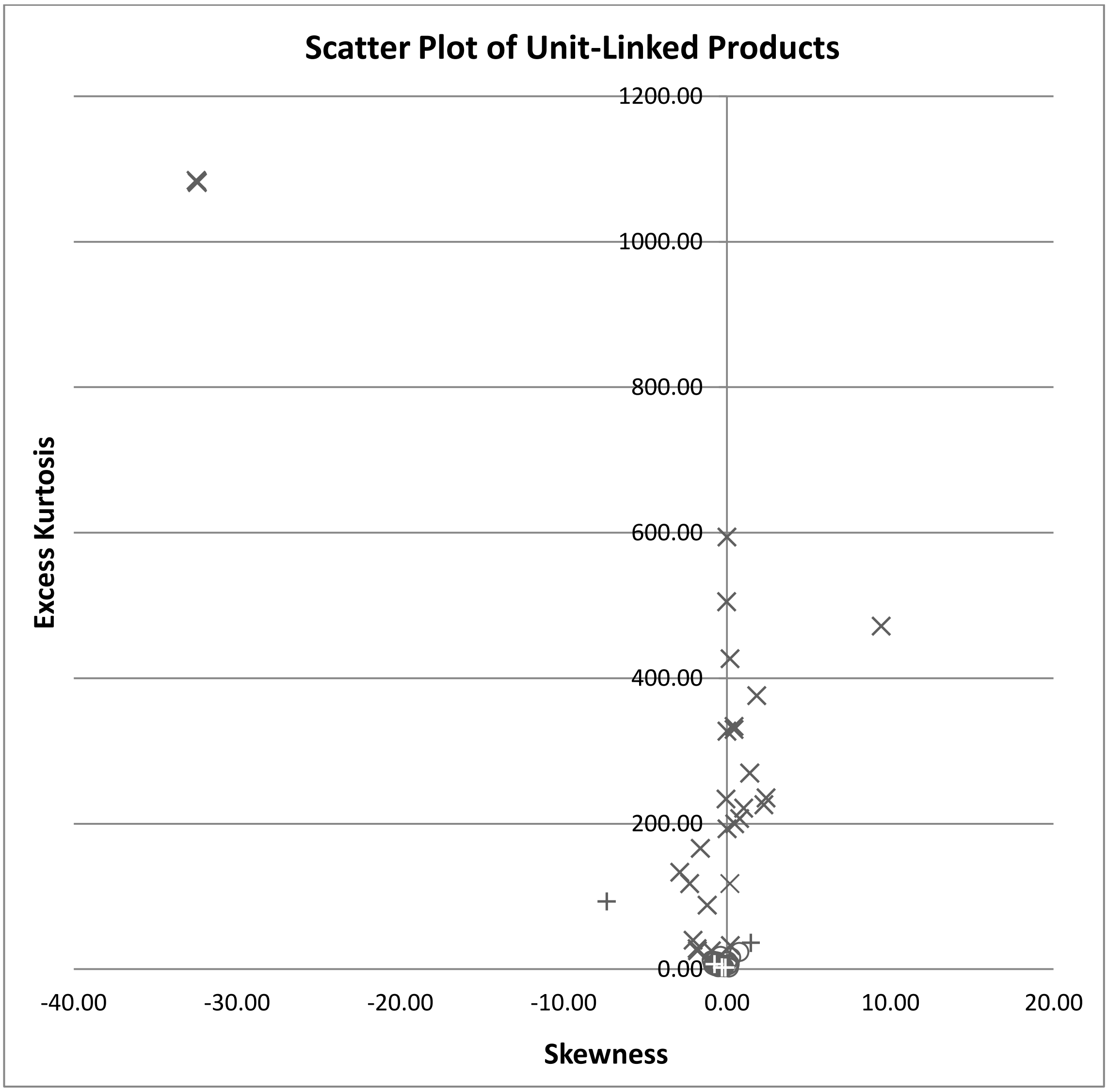

Figure 1 – Healthy, Problematic & Controversial

It is decided to use the moments of excess kurtosis and skewness as the horizontal and vertical axis accordingly. For illustrative reasons, the Problematic Unit-Linked products are presented with an X, the Controversial ones with a cross and the Healthy ones with a circle. The rationale for denoting each observation is based on the findings of Table 12. Someone can observe that the 35 Healthy products are congregated around zero where the two axes are intersected. It is also noticeable that as excess kurtosis gets larger, the observations turn to Problematic ones. Moreover, a remarkable observation is that of excess negative or positive skewness. It is witnessed that as observations tend to record a skewness larger than one in absolute values they turn to either a Problematic or Controversial one. However, some of the Controversial observations can be found inside the tight cluster of Healthy ones and some of the Problematic at the outer limits of the same cluster. These products are usually quite complex to efficiently recognize and separate them. The omission of the successful characterization of such products could raise material problems for risk managers and financial institutions when periods of financial distress are present.

Chapter 5. Conclusions

European Supervisory Authorities (ESAs) intend to add a new refined protective layer for the retail investors interested in purchasing Packaged Retail and Insurance-based Investment Products (PRIIPs). The new Regulation Technical Standards which are approved by the European Parliament and the European Commission intend to define a common line of approach for the financial products that are labeled as PRIIPs. More specifically, commencing from the 1st of January, 2018, all financial organizations and banks operating in the countries of European Union and offering this kind of products, are obliged to align with the new directives and provide a Key Information Document (KID) for every PRIIP. The core target of the new Regulation is to provide uniformity and comparability among the PRIIPs regardless of the company providing them.

One of the most important points in the regulation is that the manufacturer of the investment product has to assess its market and credit risk and present those in a standardized form to the retail investors. The research performed within this dissertation focuses on evaluating the appropriateness of the methodology used by the regulation to measure the market risk element. This is done by comparing the results produced by the prescribed methodology against robust and well-established methodologies currently used by the investment industry or proposed by experts on the subject of market risk assessment.

In order to assess the market risk of Category II PRIIPs, there are picked 70 Unit-Linked products which are traded in the Greek market and there are applied five different risk methodologies at 97.5% confidence level. Initially, Historical Value-at-Risk and Historical Expected Shortfall are tested. These models offer a more simplistic approach to the market risk assessment. It is noticed that both models tend to underestimate the amount of capital that could be lost in case of an unfortunate turning of events. Moreover, both models do not take into account the scenario of financial distress and very few Unit-Linked are labeled as Problematic. It is worth mentioning, that in some cases Historical ES produces 2.5% higher possible losses than the relative VaR model which is considered a material difference and therefore should be treated with suspicion.

Moving on, the regulation applies the Cornish-Fischer expansion to estimate the VaR at 97.5% confidence level. Since this expansion takes into account the possibility of financial instability, it is expected to generate more accurate results. It is well known that most countries of Europe and especially Greece are going through harsh and turbulent economic periods. As a first step, the Cornish-Fisher Value-at-Risk approach as proposed by ESAs is put into test. It is observed, that the z-quantile and volatility are the variables that drive the expected value of CFVaR. Moreover, it is demonstrated that highly volatile Unit-Linked products tend to produce large negative or even positive values which are regarded inconsistent. Furthermore, when CFVaR is tested against the simple Historical VaR, it is shown that large values of excess kurtosis or skewness cause CFVaR to generate extreme values.

For completeness purposes, the classic CFVaR approach was tested against the one proposed by ESAs. It is shown that if the mean return is negative, the classic CFVaR appears to be a more appropriate risk measure. More importantly, it is observed Unit-Linked products whose prices follow a non-symmetrical distribution are leaning towards defying any rules of the risk models applied.

When Cornish-Fischer Expected Shortfall is introduced, a series of previous hypotheses and observations are eventually ratified. The inclusion of this additional criterion render the findings of this thesis as robust and reliable. More particularly, the allegations of Cornish-Fisher expansion of being a more accurate risk measure than the simpler methodologies is partly validated when the theorem of Expected Shortfall being a more coherent risk measure than Value-at-Risk is fully confirmed.

Getting into detail, this thesis demonstrates that for Unit-Linked products with distributions of returns that record an excessive kurtosis of higher than 25 or a skewness of larger than 1 in absolute terms, the Cornish-Fischer expansion is not able to correctly assess their market risk. In this manner, it is strongly suggested that Cornish-Fischer is not to be applied to Unit-Linked products with excessive fat-tailed or non-symmetrical distributions. Another indication that can serve as a sign of this abnormality is the value of z-quantile. It is shown that if z-quantile produces a value of -4 or lower, the results that are generated are inconclusive. On the other hand, it is worth noting that when normal distributions are formed and no financial distress is apparent, then the simple historical models can deliver more accurate results than the Cornish-Fischer ones.

Summing up, Cornish-Fischer expansion and hence CFVaR by ESAs deliver a 50% accuracy when the market risk of Unit-Linked products in financial distress is assessed. Moreover, Cornish-Fischer Expected Shortfall is preferable to CFVaR by ESAs since Expected Shortfall is considered to be a more coherent risk measure than Value-at-Risk even in these extreme conditions. However, 41% of the Unit-Linked products are considered Problematic and 9% Controversial. Thus, it is considered that CFVaR by ESAs is not able to correctly predict the market risk of Category II PRIIPs in almost half of the occasions. Such a percentage is regarded to be of material importance and it would not be pointless if the Regulation Technical Standards were to be further reviewed.

Even though this thesis concludes with certain results, it is considered appropriate that more extensive research is carried out. We propose, for future investigation, that a larger cluster of data could be tackled with the Cornish-Fischer expansion at stricter confidence levels than the ones decided by ESAs. On a different note, it is suggested that the Shortfall Deviation Risk (SDR) methodology of Righi and Ceretta (2016) could be applied since they claim that SDR is a more appropriate model for market risk assessment than Value-at-Risk and Expected Shortfall in periods of financial crisis.

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Appendix

Unit-Linked	Abbreviation
ASSET LINKED AGROTIKI LIFE 1	AGROZ1
ASSET LINKED AGROTIKI LIFE 2	AGROZ2
CITIFUTURE 1	CITI_1
CITIFUTURE 2	CITI_2
CITIFUTURE 3	CITI_3
CITIGOLD FUTURE	CITI_FU
EFG EUROLIFE INVEST 3 (EUR)	EEI3E
EFG EUROLIFE PENSION 2 - EQUITY INVEST	EEP2EI
EFG EUROLIFE PROFIT LOCK 2 (EUR)	EEPL2E
EMPORIKI INCOME PLUS	EES
EMPORIKI INCOME PLUS (VERSION 10)	EESE1
EMPORIKI INCOME PLUS (VERSION 2)	EESE2
EMPORIKI INCOME PLUS (VERSION 3)	EESE3
EMPORIKI INCOME PLUS (VERSION 4)	EESE4
EMPORIKI INCOME PLUS (VERSION 5)	TES
EMPORIKI INCOME PLUS (VERSION 6)	EESE6
EMPORIKI INCOME PLUS (VERSION 7)	EESE7
EMPORIKI INCOME PLUS (VERSION 8)	EESE8
EMPORIKI INCOME PLUS (VERSION 9)	EESE9
GROUPAMA PHOENIX DYNAMISME	GROU
GROUPAMA PHOENIX EQUILIBRE	GROUP
GROUPAMA PHOENIX MONETAIRE	GROPFA
GROUPAMA PHOENIX OBSIDIENNE	GFO
GROUPAMA PHOENIX PRUDENCE	GROUPA
GROUPAMA PHOENIX ZEN	GFZ
GROUPAMA PHOENIX XA 20	GROUPF
HELLENIC FUTURE PLUS 1 (BASIC)	HELF1
HELLENIC FUTURE PLUS 2 (STANDARD)	HELF2
HELLENIC FUTURE PLUS 3 (ADVANCED)	HELF3
HSBC EY ZHN SECURITY	HEZEE
HSBC EY ZHN BETTER PERFORMANCE	HEZMA
HSBC EY ZHN GOODWILL	HEZY
ING PIRAEUS 10 (VERSION 3)	IP103
INTERAMERICAN LIFE CAPITAL 2021	INKZ21
INTERAMERICAN LIFE CAPITAL 2026	INE26
INTERAMERICAN LIFE CAPITAL 2031	INE31
INTERAMERICAN BOND LIFE CAPITAL	INKZBO
JPMF GLOBAL AGGREGATE BOND A	JGABAE
MARFIN DJ EUROSTOXX 50 US06	MDE5U
MARFIN SMART CAPITAL US04	MSCU
MARFIN WEALTH US07	MWU
MARFIN LUMP SUM US03	MEU1

MARFIN LUMP SUM US03B	MEU2
MAXIMUM INCOME 2018 I	MI2I
MAXIMUM INCOME 2018 II	MI21
METLIFE COMMODITY MULTIFUND V	AMVV
METLIFE DOLLAR BOND MULTIFUND VII	ADBMFV
METLIFE EMERGING MARKETS EQUITY MULTIFUND VI	AMV
METLIFE EUROPE BOND MULTIFUND I	AMI
METLIFE GLOBAL BOND MULTIFUND IV	AMII
METLIFE GLOBAL EQUITY MULTIFUND III	AMIERTGB
METLIFE GREEK EQUITY MULTIFUND II	AMIGHUK
METLIFE INVEST 1	ALCINV1
METLIFE INVEST 2	ALCINV2
METLIFE INVEST 3	ALCINV3
METLIFE LINK	AL
METLIFE MONEY MARKET	AMM
METLIFE PENSION FUND I	ALCPR1
METLIFE PENSION FUND II	ALCPR2
METLIFE PENSION FUND III	APFI
METROLIFE-STAR LIFE I,II	METR_LIIIIEU
METROLIFE-STAR LIFE III,IV	METR_LIIIIVEU
METROLIFE-STAR LIFE V	METR_LIVEU
METROLIFE-STAR LIFE VI	METR_LIVIEU
METROLIFE-STAR LIFE VII	METR_LIVIEUVII
METROLIFE-VALUE PLUS II	MTRVPL2
METROLIFE-PENSION GUARANTEED 3%	MTRSEE
UNIT LINKED-NATIONAL & CHILD	ETHCH
UNIT LINKED-NATIONAL PENSION	ETHSYN
UNIT LINKED-INVESTMENT BOND	ETHBO