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## Article

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# What do the value-at-risk measure and the respective legislative framework really offer to financial stability? Critical views and pro-cyclicality

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*In this paper, we examine how value at risk (VaR) contributes to the financial market's stability. We apply the Guidelines on Risk Measurement and the Calculation of Global Exposure and Counterparty Risk for UCITS of the Committee of European Securities Regulators (CESR 2010) to the main indices of the 12 stock markets of the countries that have used the euro as their official currency since its initial circulation. We show that gaps in the legislative framework give incentives to investment funds to adopt conventional models for the VaR estimation in order to avoid the increased costs that the advanced models involve. For this reason, we apply the commonly used historical simulation VaR (HVaR) model, which is: (i) taught at most finance classes; (ii) widely applied in the financial industry; and (iii) accepted by CESR (2010). The empirical evidence shows the HVaR does not really contribute to financial stability, and the legislative framework does not offer the appropriate guidance. The HVaR model is not representative of the real financial risk, and does not give any signal for trends in the near future. The HVaR is absolutely backward-looking and this increases the stock market's overreaction. The fact that the suggested confidence level in CESR (2010) is set at 99 percent leads to hidden pro-cyclicality. Scholars and researchers should focus on issues such as the abovementioned, otherwise the VaR estimations will become, sooner or later, just a formality, and such conventional statistical measures rarely contribute to financial stability.*

**Keywords:** value at risk, pro-cyclicality, early warning indicators, efficient legislative framework, estimations accuracy

**JEL codes:** G01, G15, G28, G32

## 1 INTRODUCTION

In recent years, several crises have emerged throughout the world. In most of the cases, these crises were not limited to a specific country but spread to wider regions and became

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continental or global crises. The banking and financial sectors are considered to be the most regulated sectors because of their exceptional intermediary role and that is why there is increased interest regarding the estimation of risk in the financial environment. In the financial industry, one of the most widely used measures for risk estimation is the value at risk (VaR).

In VaR literature, numerous studies suggest several VaR estimation models: extreme value theory (Gencay/Selcuk 2004); non-parametric Kernel Estimators (Yi-Hou Huang/Tseng 2009); GARCH family modeling (Angelidis et al. 2004; Engle 2004); Markov Switching Regime (Hull/White 1998; Billio/Pelizzon 2000); filtered volatility regimes (Vasileiou 2017). Despite significant advances in econometric modeling and the estimation of VaR, there has been little interest in examining whether the current legislative framework really contributes to averting the next crisis.

It is not only scholars, financial economists, and practitioners who pay significant attention to VaR modeling, but the legislative framework has also dealt with the subject extensively. The Basel Accord focuses mainly on the risk issues regarding the banking sector while the Committee of European Securities Regulators (CESR)<sup>1</sup> is mainly focused on the investment funds sector. Risk information is a crucial aspect for an efficient financial system, and only an efficient financial system could contribute to long-term financial growth (Levine/Zervos 1998). Therefore, the two main distribution channels of a financial system, the banks and the markets, should allow risk to be shared and specify who bears it (Allen et al. 2004), and the legislative framework should protect the participant.<sup>2</sup>

There are plenty of studies which examine the VaR issues for the banking sector and the Basle Accord's suggestions in particular (Jiménez-Martín et al. 2009; Goodhart 2011), but there are not many studies which are focused on deficiencies in the legislation on financial markets. This study's scope is to highlight this gap, focusing on the Committee of European Securities Regulators' Guidelines on Risk Measurement and the Calculation of Global Exposure and Counterparty Risk for UCITS (CESR 2010).<sup>3</sup>

According to the CESR (ibid.: 22), 'VaR is a measure of the maximum potential loss due to market risk rather than leverage. More particularly, the VaR approach measures the maximum potential loss at a given confidence level (probability) over a specific time period under normal market conditions.' What does the term 'normal market conditions' really mean? Do we need a VaR measure only during normal periods, if the term 'normal market conditions' means the non-crisis periods? Do the commonly used VaR measures inform us in time that a crisis emerges or that a normal period follows?

This study tries to empirically reply to questions such as the abovementioned by examining the main stock indices of the countries that adopted the euro on the first day of its circulation: Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Greece, and Luxembourg, for the time span 2 January 2002–31 October 2017. The empirical evidence shows that the legislative framework and the commonly used conventional approaches not only fail to protect the financial system from the upcoming crises, but also increase the stock market's overreaction.

The rest of this paper continues as follows: Section 2 presents the legislative framework and the literature review. Section 3 simulates the VaR estimation processes. Section 4 extends the discussion to some deeper issues, such as the pro-cyclicality. Finally, Section 5 concludes the study.

1. Which has been replaced by the European Securities and Markets Authority (ESMA). In this study, we use both terms to mean the same authority.
2. And especially those who invest and lend their money to enterprises and to borrowers.
3. The specific guidance dominates the investments sector even after the CESR was replaced by the ESMA.

## 2 CESR, VaR LITERATURE, AND THE REALITY

In this section, we present in detail some regulatory texts from the CESR (2010) guidelines and how these restrictions could lead to non-desirable outcomes.

CESR (*ibid.*: 23) enables Undertakings for the Collective Investment of Transferable Securities (UCITS)<sup>4</sup> to use the Relative or the Absolute VaR approach. The relative VaR aims to place restrictions on the UCITS VaR so that it is not more than twice the VaR of the reference portfolio, which means that this approach is suited to UCITS where a leverage-free benchmark is defined.<sup>5</sup> The absolute VaR approach suggests that the UCITS 20-day holding period VaR<sup>6</sup> cannot exceed the 20 percent of its net asset value (NAV). The absolute VaR approach is more appropriate for multi-asset UCITS which have set an absolute return target. There is no obligation for the UCITS to announce the VaR estimations on a regular short-term basis,<sup>7</sup> so in this case most investors may not be aware of the financial risk their investments bear.

Some scholars noted this gap (Vasileiou 2016), which may lead to the following situation: assuming that an investor wants to bear the risk of a volatile market via a UCITS, s/he may not be aware of the VaR in absolute terms, and this piece of information could be significant for his/her choice. On the other hand, a UCITS which uses the absolute VaR may bear more risk than the investor wishes. Therefore, in a bond or in a money market UCITS, it is difficult for the absolute 20-day holding period (h.p.) VaR to overshoot the 20 percent limit, so a UCITS manager may include risky assets and still be in line with the law.<sup>8</sup>

The abovementioned may constitute significant deficiencies for the transparency of the financial markets in risk issues. The specific gap may be bridged if it were mandatory for the UCITS to report VaR estimations on a monthly or quarterly basis, including the VaR in absolute and relative terms<sup>9</sup>.

We should highlight that the specific gap in risk information provided by UCITS exists even if we assume that the VaR models that are used in the financial industry are accurate and represent the real financial risk conditions. The main objective of this study is to examine whether the legislative framework forces UCITS to use not only accurate but also representative risk models, as well as to examine the consequences of these models on economic growth and stability.

Particularly, the law is extremely flexible as far as the appropriate models for the VaR estimation are concerned. CESR (2010) recognizes that there is a variety of VaR models, each of which has its own set of assumptions, advantages and drawbacks, and enables UCITS to select the most appropriate. However, the CESR (2010: 28, explanatory text 54) recognizes the parametric (or variance–covariance) model, and the Historical and the Monte Carlo models, as the most commonly used models.<sup>10</sup> An explanation for why these

4. UCITS and investment funds terms are considered the same for the regulators.

5. Moreover, as the CESR (2010) guidance suggests in explanatory text, the relative VaR would be more transparent for the investors who might have an idea of the benchmark's VaR. How many investors belong to this group?

6. For the VaR estimation, the other parameters are: 99 percent confidence level, and an effective observation period (history) of at least 1 year (250 trading days).

7. Only in its annual report (CESR 2010: 35).

8. A UCITS manager will provide this information only at the end of the quarter, and only if s/he holds risky assets in the portfolio (usually UCITS managers adopt the window-dressing technique).

9. Even in the case of an absolute return UCITS a risk benchmark should be mentioned, in order for investors to be informed of their relative risk–reward ratio.

10. This view is widely accepted in the financial industry and the academic community (Jorion 2007: 379).

approaches are still widely used in the financial industry could be the reduced cost. Risk departments in asset management companies are usually cost center units. Advanced models need increased implementation and maintenance cost, and possibly highly paid analysts to take advantage of such financial risk management systems' outputs and/or more detailed costly data. These costs could be low if easy-to-apply models are implemented and are hence considered preferable by many UCITS, especially by those that come from medium and smaller fund companies.<sup>11</sup>

Therefore, we should simply examine why the contemporary VaR models are so complex and what the CESR (2010) can do about it. Fama (1995) observes that in many cases models cannot be comprehended by financial economists due to their mathematical complexity. Ross (1993) notes that if you torture the data, they will confess to any crime. How can these distinguished professors' words be linked to the VaR legislative framework?

The CESR (2010: 26) reports that models should use 'effective observation period (history) of risk factors of at least 1 year (250 business days).' Financial models usually need a standard sample period for data inputs, due to consistency issues. However, as is said in computer science and mathematics, GIGO (Garbage In, Garbage Out). When a scholar has to use a stable data-length period in order to make efficient estimations, this means that s/he should torture the data using complex models.

However, in the financial market, as mentioned before, simple models are usually applied for the VaR estimations. The limitation of the at-least-250-day observation period may be that conventional models fail to estimate the VaR accurately. Hendricks (1996) suggests that a variance–covariance VaR model heavily based on a shorter observation period better captures the volatility changes, but in some cases it is inaccurate due to the small-sized sample. Vasileiou (2017) shows that the Historical VaR model (HVaR) presents more accurate and more representative VaR estimations when the data inputs are not the last-250-day observations (that are not always appropriate), but a data sample consisting of observations selected from past financial trends which are similar to the current ones. Therefore, the obviation of the one-year data observation period could be a step towards more accurate and representative VaR estimations. The last-250-day observations are appropriate data inputs under the assumption that the future conditions will be similar to them. This is not always true and in the next section we quantitatively present how the inappropriate data length period may influence investor behavior and lead to over-cyclicality.

In order to assure the investors that the VaR estimations are accurate, back-testing procedures are performed at least on a monthly basis. If the overshootings of the last 250 observations amount to more than four (in the case of the 99 percent confidence level (c.l.)), the model is not considered as valid and the UCITS should take measures and revise its model. Scholars adopt the Kupiec (1995) test which suggests that the model is valid if it documents up to five overshootings out of the 250 observations (at the 99 percent c.l.). In this study, we make our judgments concerning the validity of the model(s) based on the four-overshootings rule. More than four overshootings means that the model underestimates the risk, and the model is unacceptable. However, a drawback that the CESR (2010) has is that it does not examine whether the VaR model overestimates the risk, which is also an indication that the model is not representative of the real financial risk.

As mentioned above, the UCITS has motivation to use strict VaR models in order to reduce VaR overshootings because, when the relative VaR approach is adopted, the strict

11. Vasileiou (2016), using evidence from the Greek case, shows why and how UCITS have motivation to avoid the VaR estimations' increased costs. In Jorion (2007: 397) there is a comparison of the advantages/disadvantages of the commonly used approaches.

VaR estimations do not have any influence on its strategy.<sup>12</sup> Even if the VaR literature is vast, scholars and practitioners focus on the number of overshootings and do not examine whether the VaR models enable the participants in the financial industry to understand in time that financial markets' conditions are about to change. This study empirically examines whether the conventional commonly used models could contribute to the financial market's protection as early warning indicators.

### 3 VaR IN PRACTICE: WHAT THE DATA SAY

In order to examine the contribution of the VaR legislative framework as far as the protection of the financial markets and the investors, we present the empirical findings after applying the historical model at the 99 percent c.l. using one-year historical data inputs (250 trading days).<sup>13</sup> Table 1 presents the data sample of the 12 countries that initially adopted the euro and their selected indices.

This study tries to provide empirical evidence that the assumptions of the commonly used methods are not realistic. We use the Austrian case as a basic example. In Figure 1 (overleaf), we present the Austria Index performance, the one-year standard deviation and the daily returns. Assuming that we should estimate the VaR at point period A, the previous 250-day observations are data inputs from a growth period, but a crisis period follows (in 2008). The index declines sharply, but the 250-day observations do not capture instantly the negative trend and this is obvious when we look at the standard deviation line. In this period, the VaR estimations certainly underestimate the real financial risk. The opposite happens in periods

*Table 1 Data sample: list of countries and their main indices (data length 2 January 2002–31 October 2017)*

Country	Index
Austria	Austrian Traded Index (ATX) – price index
Belgium	BEL 20 – price index
Finland	OMX Helsinki (OMXH) – price index
France	France CAC 40 – price index
Germany	DAX 30 Performance (XETRA) – price index
Ireland	Ireland SE Overall (ISEQ) – price index
Italy	FTSE MIB Index – price index
Netherlands	AEX Index (AEX) – price index
Portugal	Portugal PSI-20 – price index
Spain	IBEX 35 – price index
Luxembourg	Luxembourg SE (LuxX) – price index
Greece	Athex Composite – price index

12. There are many ways to make the VaR estimations more conservative and to avoid the increased costs of an advanced VaR estimations program. Vasileiou (2016) analytically presents such cases. More conservative VaR estimations for the portfolio and the benchmark will not significantly influence their relative value, but they will reduce the violations' numbers.

13. Delta-normal (or variance–covariance) and HVaR models are considered to be the most popular VaR models in the financial industry. We choose the historical method which presents better results (less violations) than the delta-normal, for the examined period. The delta-normal results are available upon request.

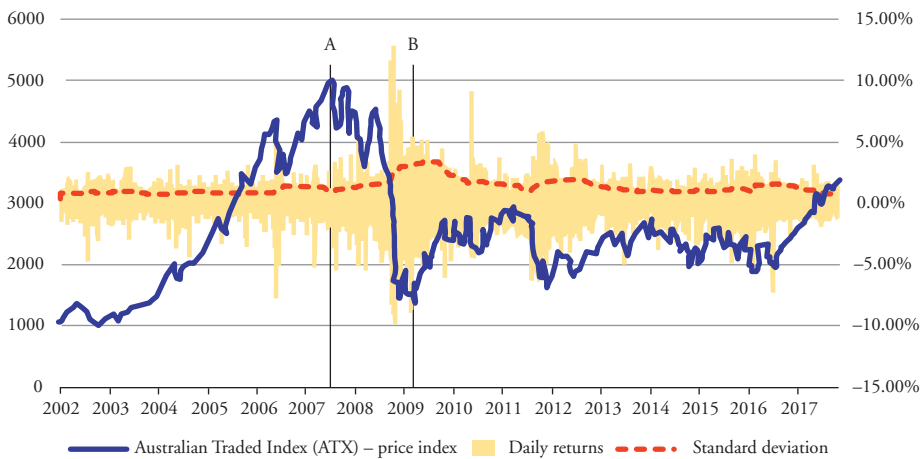


Figure 1 Austria Index performance, the one-year standard deviation, and the daily returns

such as point B (around 2009), when the stock market moves from recession to growth. In this case, the standard deviation is significantly higher than during period A, even if a growth period follows. Therefore, the VaR estimations certainly overestimate the real risk.

As Figure 1 shows, conventional approaches do not provide representation of the real financial risk VaR estimations, and this is a gap that neither the legislative framework nor the financial risk literature usually examines. Most studies try to present new methodologies which reduce the overshootings, and do not show whether these models provide more representation of the real financial risk estimations.<sup>14</sup> An explanation for this may be the fact that at the 99 percent c.l., which the legislative framework sets as a parameter, the accepted number of violations is in the zero-to-four range. Therefore, underestimation of risk is examined (when the number of violations is higher than four), but overestimation is not (the number of violations cannot be less than zero). The examination at the 95 percent c.l. enables us to examine whether the one-year HVaR model is not only accurate but also representative, because at this c.l. we can test whether the model is inaccurate not only due to risk underestimation but also due to overestimation. This case is presented in the next section.

In the present section we examine, using empirical data, some issues that are useful in the VaR industry. We examine whether:

- the last 250 observations that the legislative framework sets as a limit for the VaR estimations is an appropriate input; and whether
- the widely applied one-year HVaR estimations could be an early warning indicator.

The first point is a typical back-testing procedure that the legislative framework demands, but the second tries to shed some light on representativeness issues, beyond accuracy. Assuming that a methodology is extremely accurate, if information on upcoming changes

14. Fewer violations than the conventional methodologies may be recorded because these methods are more conservative (stricter). Fewer overshootings do not necessarily indicate more representative VaR estimations.

is not available in time neither the market participants nor the regulators will be able to act in time. Therefore, in this study, we examine whether the VaR estimation could accurately forecast even a short period of time. For this reason, we test whether the VaR estimations could inform the participants about the next five-day real cumulative losses, and whether the daily VaR estimation could be accurate for the next five days.<sup>15</sup> Practically,

- if  $\frac{P_{i+5}}{P_i} < VaR_i \times \sqrt{5}$ , there is an overshooting because the next five-day real losses are more than those estimated at time  $i$  (Table 2, columns headed ‘Cumulative next-5-days VaR overshootings’); and
- if  $\min(R_{i+1, i+2, i+3, i+4, i+5}) < VaR_i$ , there is an overshooting because VaR estimations are not valid for the following five days (Table 2, columns ‘VaR overshootings from the next-5-day min. return’),

where  $P_i$  is the index price on current day  $i$ ,  $i + n$  ( $n = 1, 2, 3, 4$ , and  $5$  is  $1, 2, 3, 4$ , and  $5$  days after the current day), and  $R$  is the daily return.

The abovementioned are quantitatively presented in Table 2 (overleaf). We present as a basic example the Austrian market’s case; however, similar analysis could be done for the other stock markets. The daily overshootings column presents the overshootings following the legislative framework’s four-overshootings rule. The numbers in bold indicate the cases where the four-overshootings rule has been violated (we assume that each year has 250 trading days<sup>16</sup>). As we can see, the historical model is not valid in four out of the sixteen cases, while, when examining the whole period, VaR overshootings comprise 1.16 percent of the data set. The ‘Cumulative next-5-days VaR overshootings’ columns show that we cannot trust the VaR estimations even for the prediction of the next-five-day potential losses. If we apply the four-overshootings rule in this case we observe that back-testings show that the historical VaR model is not valid in five out of the sixteen years.

The ‘VaR overshootings from the next 5-day min. return’ columns show in another way that VaR estimations do not have any information regarding the real risk even in a very short-term period. Therefore, these models are backward-looking and cyclical as we show in Figure 1 and as the literature suggests (Youngman 2009; Adrian/Shin 2013).<sup>17</sup>

So, in order for VaR estimations to be useful as early indicator measures, they should present better performance in such tests. Scholars and R&D departments who make the innovations in the field of financial econometrics may find it useful to examine VaR from the representativeness and forecasting perspective. Moreover, the legislative framework should give incentives to UCITS and asset management companies to adopt really innovative and effective models. In other words, scholars and regulators should not focus only on the accuracy issue, but also on the representativeness and the early indicators issues.<sup>18</sup>

15. We did not use a time horizon of 20 days as the legislation framework suggests, because 20 days may be too long a time span in financial markets. However, even in this case, this test shows whether the HVaR could be assumed as an early warning measure.

16. The real trading days are presented in the second column. The data were collected from Data-Stream, and we have collected them as common samples. This means that in some markets more holidays were included in the VaR estimation process, which may lead to data-noise errors. However, the conclusions regarding the VaR pro-cyclicality are not influenced by this noise.

17. The models for this case are not evaluated under the four-overshootings rule.

18. Vasileiou (2017) presents measures for the representativeness at the 99 percent c.l. such as average VaR estimations, average deviations of the VaR estimations minus the real losses when violations are observed, etc.



Table 2 Back-testing procedure at 99 percent c.l. (one-year daily observations)

Year	Observations	Austria				Belgium				
		Daily overshootings	Cumulative next-5-days overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days overshootings	VaR overshootings from the next-5-day min. return
2002	261	2	2	12	4	9	19			
2003	261	1	0	5	0	3	0			
2004	262	3	5	18	2	1	10			
2005	260	3	1	16	3	2	14			
2006	260	6	10	21	5	7	17			
2007	261	4	1	22	5	4	28			
2008	262	7	11	36	6	10	31			
2009	261	1	0	6	0	0	0			
2010	261	0	1	0	2	1	12			
2011	260	8	8	40	6	7	32			
2012	261	0	0	0	0	0	0			
2013	261	1	3	6	2	2	12			
2014	261	5	7	24	3	5	17			
2015	261	3	1	13	5	3	25			
2016	261	4	1	24	2	4	12			
2017	231	0	0	0	0	1	0			
	4.145	48	51	243	45	59	229			
		1.16%	1.23%	5.86%	1.09%	1.42%	5.52%			

(continues opposite)

Table 2 (continued)

Year	Observations	Finland				France				
		Daily overshootings	Cumulative next-5-days overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days overshootings	VaR overshootings from the next-5-day min. return
2002	261	4	4	24	3	4	16			
2003	261	1	0	6	1	0	6			
2004	262	2	4	12	1	0	6			
2005	260	1	1	6	1	0	6			
2006	260	4	6	17	5	5	23			
2007	261	4	1	21	4	5	22			
2008	262	7	6	41	7	6	28			
2009	261	0	0	0	0	0	0			
2010	261	2	1	12	4	1	19			
2011	260	10	9	40	7	9	32			
2012	261	0	0	0	0	0	0			
2013	261	3	1	17	2	1	11			
2014	261	2	2	12	3	2	20			
2015	261	6	9	31	3	2	15			
2016	261	4	4	19	2	0	12			
2017	231	2	1	11	1	0	6			
	4,145	52	49	269	44	35	222			
		1.25%	1.18%	6.49%	1.06%	0.84%	5.36%			

(continues overleaf)

Table 2 (continued)

Year	Observations	Germany				Ireland				
		Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return
2002	261	2	4	11	2	3	9			
2003	261	1	0	6	0	0	0			
2004	262	0	0	0	3	0	18			
2005	260	1	0	6	2	7	12			
2006	260	<b>5</b>	<b>6</b>	23	<b>5</b>	<b>9</b>	23			
2007	261	2	3	11	<b>5</b>	7	27			
2008	262	<b>5</b>	<b>8</b>	22	<b>9</b>	<b>10</b>	49			
2009	261	0	0	0	1	0	6			
2010	261	1	1	6	2	3	11			
2011	260	7	<b>11</b>	31	4	<b>6</b>	19			
2012	261	0	0	0	0	0	0			
2013	261	1	1	6	2	0	12			
2014	261	<b>5</b>	1	29	<b>5</b>	4	25			
2015	261	<b>6</b>	3	37	4	3	19			
2016	261	2	1	8	4	<b>6</b>	18			
2017	231	2	0	9	1	0	<b>6</b>			
	4.145	40	39	205	49	58	254			
		0.97%	0.94%	4.95%	1.18%	1.40%	6.13%			

(continues opposite)

Table 2 (continued)

Year	Observations	Italy			Netherlands		
		Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return
2002	261	2	2	11	2	4	11
2003	261	0	0	0	1	2	6
2004	262	0	0	0	1	0	6
2005	260	3	4	12	2	0	11
2006	260	3	3	15	<b>6</b>	<b>5</b>	28
2007	261	3	4	16	4	<b>5</b>	17
2008	262	<b>7</b>	<b>6</b>	26	<b>10</b>	<b>12</b>	38
2009	261	0	1	0	0	0	0
2010	261	3	2	14	3	2	14
2011	260	<b>7</b>	<b>9</b>	32	<b>7</b>	<b>7</b>	28
2012	261	0	0	0	0	0	0
2013	261	1	0	6	2	2	12
2014	261	4	2	27	4	4	27
2015	261	3	1	15	<b>6</b>	3	27
2016	261	3	3	17	1	1	6
2017	231	0	0	0	1	1	6
	4,145	39	37	191	50	48	237
		0,94%	0,89%	4,61%	1,21%	1,16%	5,72%

(continues overleaf)

Table 2 (continued)

Year	Observations	Portugal				Spain				
		Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return
2002	261	3	4	14	3	4	14	3	4	14
2003	261	1	1	6	1	1	6	1	1	6
2004	262	4	5	23	4	5	23	4	5	23
2005	260	3	0	15	3	0	15	3	0	15
2006	260	3	6	14	3	6	14	3	6	14
2007	261	7	9	38	7	9	38	7	9	38
2008	262	5	14	25	5	14	25	5	14	25
2009	261	0	0	0	0	0	0	0	0	0
2010	261	5	7	18	5	7	18	5	7	18
2011	260	6	8	33	6	8	33	6	8	33
2012	261	0	0	0	0	0	0	0	0	0
2013	261	5	2	23	5	2	23	5	2	23
2014	261	4	14	19	4	14	19	4	14	19
2015	261	3	1	16	3	1	16	3	1	16
2016	261	1	1	6	1	1	6	1	1	6
2017	231	1	0	2	1	0	2	1	0	2
	4.145	51	72	252	51	72	252	51	72	252
		1.23%	1.74%	6.08%	1.23%	1.74%	6.08%	1.23%	1.74%	6.08%

(continues opposite)

Table 2 (continued)

Year	Observations	Greece				Luxembourg				
		Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return
2002	261	0	2	0	3	5	17	3	5	17
2003	261	1	0	6	0	0	0	0	0	0
2004	262	3	1	17	3	2	18	3	2	18
2005	260	2	5	8	2	0	12	2	0	12
2006	260	7	12	25	5	4	22	5	4	22
2007	261	3	3	16	3	1	18	3	1	18
2008	262	9	18	44	7	14	30	7	14	30
2009	261	2	1	12	0	0	0	0	0	0
2010	261	2	1	11	2	1	12	2	1	12
2011	260	5	10	27	7	7	26	7	7	26
2012	261	3	1	18	0	0	0	0	0	0
2013	261	1	0	5	1	2	6	1	2	6
2014	261	6	6	25	2	2	14	2	2	14
2015	261	2	1	12	6	3	33	6	3	33
2016	261	1	1	6	3	3	14	3	3	14
2017	231	1	0	6	3	0	16	3	0	16
	4,145	48	62	238	47	44	238	47	44	238
		1.16%	1.50%	5.74%	1.13%	1.06%	5.74%	1.13%	1.06%	5.74%

The next section of this study presents some practical suggestions which could be easily adopted by the legislative framework in order to test the representativeness issue.

#### 4 FURTHER EVIDENCE AND DISCUSSION

In this section, we focus on the issues of representativeness and accuracy. As mentioned in the previous section, the financial markets industry works at the 99 percent c.l. and the accepted number of overshootings is zero to four, so we only care whether the upper limit is violated (the overshootings number could not be negative), which examines in practice whether the models underestimate the risk. The findings presented in the previous section show that HVaR is not always accurate, but in most of the trading years the HVaR model does not violate the four-overshootings-per-trading-year threshold.

However, at the 99 percent c.l. we are able to examine whether the VaR estimations underestimate the risk, though we are not able to examine whether the VaR estimations overestimate it.<sup>19</sup> This means that the overestimations issue is not examined, therefore we do not know whether the model is representative of the real financial risk. If we test the models at the 95 percent c.l., we will be able to evaluate both limits (upper and lower), and representativeness in total. The widely used binomial Kupiec (1995) test assumes an accurate model whose overshootings of the last year's observations (around 250 days) are up to five, at 99 percent c.l., or between seven and twenty at the 95 percent c.l.

The 95 percent c.l. case is presented in Table 3. Taking again as an indicative example the Austrian case,<sup>20</sup> when a crisis period emerges the model is not valid due to the increased number of overshootings (higher than 20) in 2008 and 2011. At the 99 percent c.l. the model also underestimates the risk in the years 2008 and 2011. The interesting issue is that the back-testing at the 95 percent c.l. reveals that the next years' estimations are also invalid because the financial risk is overestimated (in 2009 and 2012 the overshootings are fewer than the lower limit of seven).<sup>21</sup> This means that during all these years the VaR model fails according to the Kupiec test and does not represent the real financial risk. The pro-cyclical behavior is obvious because:

- in one year the model underestimates the risk (2007 and 2011), so the investors may suffer significant losses in the near future; and
- in the next year the market's systematic risk is overestimated (2009 and 2012, respectively), which means that investors may be more hesitant toward new investments.

Therefore regulators, scholars, and practitioners should pay particular attention to the representativeness issue, because it leads to the cyclical behavior, which is against financial stability. We can understand that the regulators' loss/target function may be asymmetric and that in some cases risk overestimation is preferable to violations. A solution could be similar to what happens today in the industry: the binomial test (Kupiec 1995) indicates that a method is considered accurate up to five violations, but the law defined a four-violations threshold. Similarly, the law may set at the 95 percent c.l., a less than seven-to-twenty-accepted-violations threshold. Such a modified Kupiec test at the 95 percent c.l. could be an extra back-testing procedure in order to examine the model's ability to representatively forecast the financial trend, as well as its ability to avoid pro-cyclicality.

19. That could be considered as a part of the VaR representative issue.

20. The reader may reach similar conclusions when s/he examines the other countries.

21. Risk overestimation is also documented in 2003.

Table 3 Back-testing procedure at 95 percent c.l. (one-year seasonality)

Year	Observations	Austria				Belgium			
		Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	
2002	261	12	15	56	24	25	93		
2003	261	5	2	27	3	7	17		
2004	262	17	13	85	9	8	33		
2005	260	12	18	48	10	9	55		
2006	260	19	18	63	16	24	67		
2007	261	23	28	107	21	28	85		
2008	262	42	44	133	31	36	105		
2009	261	5	5	29	3	3	18		
2010	261	9	7	36	13	10	54		
2011	260	22	30	95	24	26	94		
2012	261	2	1	12	3	0	15		
2013	261	10	8	50	11	6	53		
2014	261	14	21	70	14	16	70		
2015	261	14	8	75	16	22	85		
2016	261	11	17	46	10	14	37		
2017	231	8	2	37	4	5	17		
	4.145	225	237	969	212	239	898		
		5.43%	5.72%	23.38%	5.11%	5.77%	21.66%		

(continues overleaf)



Table 3 (continued)

Year	Observations	Finland				France			
		Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return		
2002	261	11	6	61	21	20	86		
2003	261	3	6	18	3	1	16		
2004	262	8	19	43	10	7	45		
2005	260	10	12	52	14	9	65		
2006	260	15	19	56	15	18	64		
2007	261	24	23	101	23	18	96		
2008	262	26	34	100	28	31	117		
2009	261	3	4	18	3	1	17		
2010	261	9	7	42	14	12	53		
2011	260	26	28	102	21	29	88		
2012	261	3	1	18	2	0	12		
2013	261	8	12	42	8	7	46		
2014	261	18	21	78	22	22	95		
2015	261	19	22	86	18	12	83		
2016	261	8	8	29	7	9	29		
2017	231	5	9	30	9	7	45		
	4.145	196	231	876	218	203	957		
		4.73%	5.57%	21.13%	5.26%	4.90%	23.09%		

(continues opposite)

Table 3 (continued)

Year	Observations	Germany				Ireland				
		Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return
2002	261	18	20	80	16	20	72			
2003	261	<b>1</b>	<b>1</b>	6	<b>3</b>	<b>2</b>	18			
2004	262	8	9	39	12	15	60			
2005	260	12	8	62	10	<b>21</b>	45			
2006	260	19	16	80	20	<b>23</b>	69			
2007	261	19	15	77	<b>28</b>	<b>44</b>	112			
2008	262	<b>31</b>	<b>33</b>	130	<b>29</b>	<b>31</b>	121			
2009	261	<b>5</b>	<b>3</b>	30	<b>3</b>	<b>5</b>	15			
2010	261	7	<b>5</b>	34	11	10	46			
2011	260	<b>28</b>	<b>29</b>	106	16	14	60			
2012	261	<b>3</b>	<b>0</b>	18	<b>4</b>	<b>1</b>	21			
2013	261	9	<b>4</b>	54	12	<b>6</b>	65			
2014	261	18	<b>24</b>	84	16	<b>23</b>	65			
2015	261	18	16	79	15	12	66			
2016	261	7	<b>6</b>	30	10	12	44			
2017	231	<b>6</b>	8	33	9	10	49			
	4.145	209	197	942	214	249	928			
		5.04%	4.75%	22.73%	5.16%	6.01%	22.39%			

(continues overleaf)

Table 3 (continued)

Year	Observations	Italy			Netherlands		
		Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return
2002	261	17	18	79	<b>24</b>	<b>22</b>	84
2003	261	<b>4</b>	7	24	<b>5</b>	7	29
2004	262	7	10	32	7	<b>5</b>	31
2005	260	16	15	73	10	8	57
2006	260	18	12	85	18	19	79
2007	261	<b>21</b>	<b>21</b>	100	20	19	76
2008	262	<b>28</b>	<b>33</b>	109	<b>32</b>	<b>38</b>	115
2009	261	<b>6</b>	7	30	<b>4</b>	<b>0</b>	21
2010	261	12	10	55	11	9	53
2011	260	<b>27</b>	<b>25</b>	115	20	<b>25</b>	85
2012	261	<b>4</b>	<b>0</b>	24	<b>2</b>	<b>0</b>	12
2013	261	10	<b>6</b>	53	9	<b>5</b>	48
2014	261	20	19	101	15	<b>29</b>	71
2015	261	12	9	60	<b>22</b>	<b>21</b>	95
2016	261	11	16	40	8	10	30
2017	231	<b>2</b>	<b>0</b>	12	<b>3</b>	<b>4</b>	18
	<b>4.145</b>	<b>215</b>	<b>208</b>	<b>992</b>	<b>210</b>	<b>221</b>	<b>904</b>
		<b>5.19%</b>	<b>5.02%</b>	<b>23.93%</b>	<b>5.07%</b>	<b>5.33%</b>	<b>21.81%</b>

(continues opposite)

Table 3 (continued)

Year	Observations	Portugal				Spain				
		Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return
2002	261	23	25	89	23	25	89	23	25	89
2003	261	3	3	17	3	3	17	3	3	17
2004	262	11	14	49	11	14	49	11	14	49
2005	260	13	12	54	13	12	54	12	12	54
2006	260	9	12	37	9	12	37	9	12	37
2007	261	28	33	100	28	33	100	28	33	100
2008	262	31	44	113	31	44	113	31	44	113
2009	261	3	1	18	3	1	18	3	1	18
2010	261	15	22	53	15	22	53	15	22	53
2011	260	21	19	88	21	19	88	21	19	88
2012	261	5	8	28	5	8	28	5	8	28
2013	261	9	12	44	9	12	44	9	12	44
2014	261	23	35	87	23	35	87	23	35	87
2015	261	8	8	38	8	8	38	8	8	38
2016	261	8	14	31	8	14	31	8	14	31
2017	231	4	2	24	4	2	24	4	2	24
	4.145	214	264	870	214	264	870	214	264	870
		5.16%	6.37%	20.99%	5.16%	6.37%	20.99%	5.16%	6.37%	20.99%

(continues overleaf)

Table 3 (continued)

Year	Observations	Greece				Luxembourg				
		Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return	Daily overshootings	Cumulative next-5-days VaR overshootings	VaR overshootings from the next-5-day min. return
2002	261	<b>23</b>	<b>25</b>	89	<b>23</b>	<b>25</b>	89	<b>23</b>	<b>25</b>	89
2003	261	<b>3</b>	<b>3</b>	17	<b>3</b>	<b>3</b>	17	<b>3</b>	<b>3</b>	17
2004	262	11	14	49	11	14	49	11	14	49
2005	260	13	12	54	13	12	54	13	12	54
2006	260	9	12	37	9	12	37	9	12	37
2007	261	<b>28</b>	<b>33</b>	100	<b>28</b>	<b>33</b>	100	<b>28</b>	<b>33</b>	100
2008	262	<b>31</b>	<b>44</b>	113	<b>31</b>	<b>44</b>	113	<b>31</b>	<b>44</b>	113
2009	261	<b>3</b>	<b>1</b>	18	<b>3</b>	<b>1</b>	18	<b>3</b>	<b>1</b>	18
2010	261	15	<b>22</b>	53	15	<b>22</b>	53	15	<b>22</b>	53
2011	260	<b>21</b>	19	88	<b>21</b>	19	88	<b>21</b>	19	88
2012	261	<b>5</b>	8	28	<b>5</b>	8	28	<b>5</b>	8	28
2013	261	9	12	44	9	12	44	9	12	44
2014	261	<b>23</b>	<b>35</b>	87	<b>23</b>	<b>35</b>	87	<b>23</b>	<b>35</b>	87
2015	261	8	8	38	8	8	38	8	8	38
2016	261	8	14	31	8	14	31	8	14	31
2017	231	<b>4</b>	<b>2</b>	24	<b>4</b>	<b>2</b>	24	<b>4</b>	<b>2</b>	24
	<i>4.145</i>	<i>214</i>	<i>264</i>	<i>870</i>	<i>214</i>	<i>264</i>	<i>870</i>	<i>214</i>	<i>264</i>	<i>870</i>
		<i>5.16%</i>	<i>6.37%</i>	<i>20.99%</i>	<i>5.16%</i>	<i>6.37%</i>	<i>20.99%</i>	<i>5.16%</i>	<i>6.37%</i>	<i>20.99%</i>

These issues may be linked to the vast literature on markets overreaction (De Bondt/Thaler 1985; 1990). For example, VaR estimation places some limitations on the decisions of portfolio managers when it comes to taking risk. Before a crisis, the portfolio manager may be eligible to bear increased risk, which is not a good decision because losses will be documented, and afterwards s/he will try to reduce the risk. After a crisis, the VaR estimations will overestimate the risk, therefore the manager may not be able to bear as much risk as s/he believes could give her/him the opportunity to achieve more profits from the change in the financial trend<sup>22</sup> and this may delay the economy's rebound. So, we believe that participants in the financial industry and financial economists should focus on the representativeness issue, because its potential benefits are multi-dimensional and substantial for the financial stability of the markets.

## 5 CONCLUSIONS

This paper presents some deficiencies of the VaR regulatory framework and proposes some issues to which the VaR literature should pay significant attention. Particularly, the commonly used models seem to be accurate only when the past is repeated. The empirical findings for the major euro-area countries, when the four-overshootings rule is adopted, show that VaR is not accurate when volatility increases (Table 2). The fact that the evaluation tests (back-tests) examine the VaR models at the 99 percent c.l. enables us to examine only whether the VaR estimations underestimate the risk.

We suggest that the legislative framework should be modified to test whether VaR models are accurate not only when they underestimate the risk, but also when they overestimate it. The empirical findings show that the conventional historical VaR model is in many cases assumed inaccurate for both reasons (over- and underestimation). In other words, VaR is not representative of the real financial risk, and a non-representative measure sooner or later tends to be a measure without economic significance.

A possible counterargument regarding the overestimation issue is that we always need to be safe, so an overestimated VaR may not be a problem. However, if the VaR estimation is not representative, this may lead to increased risks before crisis, and reduced risk when the financial trend is positive (points A and B in Figure 1, respectively). Such investment behavior contributes to the market's overreactions and cyclical behavior. The regulators may set asymmetrical thresholds for the market's downside risk. Therefore, the legislators should take into serious consideration the trade-off between risk representativeness and risk protection, because the protection of the financial system and the information provided by participants is a priority for them.

Moreover, the VaR estimations do not present any significant information for the upcoming days. Even for the next five days the VaR estimations are inaccurate. This is another issue to which VaR research should pay attention. The VaR may make a significant contribution for analysts (portfolio and risk), if it presents some information about the market's future performance. If it works as early warning (or leading) indicators, it may give time to regulators, authorities, and market participants to take the appropriate measures in order to reduce the crisis impact.

In conclusion, we suggest that the VaR legislative framework should be modified in order to serve the market's real needs with regard to stability, and scholars—researchers should resolve issues as mentioned above. So, we should examine not only whether the VaR estimations are accurate, but also whether they are representative of the real

22. Such limitations may not influence the hedge funds, and this is a drawback that UCITS have.

financial risk. Therefore, academics should try to present accurate and representative VaR models that could be easily applied in the financial industry and easily understood by anyone.

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