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Konjunkturforschungsstelle Liechtenstein (KOFL)

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Abstract[*]

Additionally to the financial crisis causing a world recession, Liechtenstein's financial sector has been challenged by the so-called "Zumwinkel-Affair", when a whistle-blower sold data of hundreds of tax evaders to international tax authorities. This paper investigates the impact of this affair, separated from the financial crisis, on the daily stock prices of banks from Liechtenstein. An "unconventional" augmented GARCH-model (labelled as "augmented amalGARCH"), which outperforms conventional models here, is introduced and analyses the dynamical pattern and other influences on risk and average performance. Besides other findings, it can be concluded that the Zumwinkel-Affair had an (accumulating) effect on risk of stocks, but surprisingly no impact on average stock returns could be detected.

Keywords: Tax Evasion; Liechtenstein; Financial Institutions; Stock Price Volatility; Augmented GARCH-models; amalGARCH

JEL-Classification: C01; C22; C32; G01; G21

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Contents

1. Introduction

On February 14th (2008), German authorities arrested Klaus Zumwinkel, Chief Executive Officer and Chairman of Deutsche Post, in a very spectacular way at his home and in front of several TV-cameras: He was accused of tax evasion and subsequently resigned from office just a few days afterwards. Zumwinkel was convicted by the beginning of 2009. Along with about 600 other German tax evaders, Zumwinkel's tax fraud was unveiled by data provided by a whistle-blower named Heinrich Kieber, a Liechtenstein citizen, who is a former employee of the LGT Bank. He sold the data to the German Intelligence Service (Bundesnachrichtendienst) for an estimated 5 Million Euros and also distributed the data to at least 13 other countries. Even though the identity of the whistle-blower was unveiled very soon, he could not be arrested yet and his domicile remains unknown despite the issue of an international arrest warrant in March 2008 by Liechtenstein's national police department.

This affair, named "Zumwinkel-Affair" or "Liechtenstein Tax-Affair" (or "German Tax Affair") by the press, led to stronger pressure on countries that were often called "tax-havens", especially Liechtenstein but as an indirect consequence later also on Luxemburg, Switzerland, Monaco and even Austria. The dramatic arrest of Zumwinkel ensured that the topic dominated the media for weeks not only in Germany and Liechtenstein, while harsh statements by several politicians and political pressure by Germany played an important role ensuring that the issue of tax information exchange remained on the diplomatic agenda of both countries and it still does.

Both international pressure and political debates within Liechtenstein, which had already been started before the data sale emerged, resulted in so far more than 25 tax information exchange agreements within the last three years- These new agreements led, among other things, to a still ongoing transformation process affecting all actors within the financial sector of Liechtenstein. Combined with the already severe economic aftermath of the financial crisis, the affair was a strong challenge especially for the financial sector but also for Liechtenstein's entire economy. The financial sector's challenge is still supplemented by the effort to pursue the now ongoing transformation process.

The presented paper puts emphasis on the analysis and quantification of the impact of the Zumwinkel-Affair on Liechtenstein's financial sector (in other words: the effect of the revelation of tax evasion on the stock market). This affair arose from the data theft and was followed by political pressure, irritated investors and was accompanied by a transformation process within Liechtenstein and recent tax information exchange agreements. So, the main question among others is: Did the Zumwinkel-Affair (data theft as an exogenous shock) affect the average return and influence the volatility of related stock values? And if yes, how?

As a reliable and frequently available indicator for the impact of the affair on Liechtenstein's financial sector, share prices of companies within the financial sector have been chosen: Daily return of stock prices of the financial institutes whose shares are traded at the Swiss stock market ("Swiss Exchange") are in main focus. These banks are "Verwaltungs- und Privatbank AG" and "Liechtensteinische Landesbank AG". The LGT Bank, from which the stolen bank data was, is not quoted at the Stock Exchange and therefore not investigated here.[1] A portrait of the mentioned banks, further facts to the economic impact of the financial crisis and the tax affair on Liechtenstein and additional examples describing the high international pressure are outlined in the appendix (chapter A.5.).

To separate the effect of the financial crisis on the market and on the investigated stock prices from the effect of the data theft, other factors, which account for the impact of the financial crisis and other market fluctuations, are included such as the SMI (Swiss Market Index) and other measures capturing the financial crisis. Though the impact of the financial crisis is also of interest, its analytical and econometric inclusion mainly contains the importance of isolating the effect of the "Zumwinkel-Affair" from other interference.

The econometric analysis carried out implies a modified Generalized Autoregressive Heteroskedasticity (GARCH)-model, named here as augmented amalGARCH. The basic GARCH-approach was introduced by ENGLE [1982], TAYLOR [1986] and BOLLERSLEV [1986]. This popular class of models has its main advantage in the explicit modelling of the conditional variance. These models basically feature two linked regression equations: One to estimate different influences on the investigated dependent variable (conditional mean equation) and a linked second equation to evaluate the influence of different sources on the residual's conditional variance (conditional variance equation). As additional yet "unconventional" feature of this analysis the lagged squared residuals have been removed

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[1] As to be seen later on, it is remarkable how affected the other two banks were by the LGT's data theft. This also reflects the high level of following insecurity in the whole financial sector of Liechtenstein.

from the GARCH-specification and replaced by squared lagged observed variables such as past stock return and past stock market performance. This unconventional replacement revisits to some extent the approach of WEISS [1984].[2] A general to specific-approach trying to detect the optimal combinations of the just mentioned literature has been executed. Hence, in order to systematically classify the different approaches into a broader group, this family of possible amalgams will be termed later on as amalGARCH. This new term and the chosen specification, an augmented amalGARCH(0,1,1), will be described in more detail in chapter 2.2., when the development of the model setup is described. It turns out that the chosen specification featuring this replacement is superior in this application, which is rather exceptional. To evaluate the impact of the financial crisis and the effect of the Zumwinkel-Affair on equity risk, additional explanatory dummy variables have been incorporated into the (therefore augmented) variance equation. Including additional explanatory variables into the variance equation is unusual but appears to be valuable in this context of investigation.

The applied approach is beneficial from two points of view: First of all, we are directly interested in the effect of the Zumwinkel-Affair on average returns <u>and</u> volatility. It therefore makes sense to incorporate some measure regarding the impact of this affair into the mean equation <u>and</u> into the variance equation. Secondly, different channels of influence of past shocks are made visible by introducing additional explanatory variables such as the past squared returns of the particular stock value and the squared percentage change of the whole market index and also potential shocks on either or both of them. These are valuable supplements to the conventional components of the variance equation, the past conditional variance and undefined past shocks via the past squared residual. In this manner, we obtain a more precise understanding via which channels past shocks translate into rising volatility of the stock prices.[3] Thirdly, from an econometric point of view, the chosen "unconventional" augmented GARCH-model appears to be an improved alternative to the popular

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2 KUNST [1997] investigated both specifications after ENGLE [1982] and after WEISS [1984] considering stability conditions and empirical evidence. See also TSAY [1987] for the discussion of related model classes.

3 The introduction of KOLLIAS, PAPADAMOU AND SIRIOPOULOS [2012] gives a broad overview on studies considering exogenous events, such as terrorist attacks, natural disasters, aviation crashes and many more. Other contributions that investigate the impact of certain events, such as shocks on the mean and volatility of markets or even whole economies (as well in an ARCH-framework like it is done in the contribution here) are for example ASTERIOU AND PRICE [2001], ELYASIANI, MANSUR AND ODUSAMI [2011] and HAMMOUDEH AND YUAN [2007]. They generally apply an ordinary GARCH(p,q)-approach. These would be amalGARCH(p,q,0) models (in the notion introduced later), supplemented by dummies and other explanatory variables. Here, in this unconventional approach, the past squared residuals are dropped from the variance equation that includes lagged squared terms of the dependent variable instead, also augmented by dummies and lagged squared independent variables. This corresponds to an augmented amalGARCH(0,q,s).

GARCH(1,1)-model, which is the usually applied benchmark and would represent a non-augmented amalGARCH(1,1,0) in the introduced notation.

After this introduction, the second section deals with the estimation of the augmented amalGARCH-model for the two different stock prices. To obtain an auxiliary classification, the applied models and especially the chosen optimal model are systematically integrated into this new term “amalGARCH”. Following a descriptive and visual investigation of the used data series, further econometric considerations are presented and the estimation process of the daily stock prices of the banks Verwaltungs- und Privatbank and Liechtensteinische Landesbank are presented. Furthermore, the impacts of the financial crisis and the Zumwinkel-Affair on performance and risk are assessed. Also, the results of the two investigated stocks are compared. In the third section, the text concludes with some summarizing and complementary remarks.

2. Investigating the Impact on Stock Prices and Stock Price Volatility (Risk)

After having shortly introduced the main motivation and goals of this paper's economic examination using linear and nonlinear econometric techniques, the first step would be to carry out visual explorations and to calculate descriptive statistics of the relevant time series. The used data series in the presented paper are the two stock prices of the two banks "Verwaltungs- und Privatbank AG" (VPB) and "Liechtensteinische Landesbank AG" (LLB) which have their headquarters in Vaduz (Liechtenstein).[4] Both stocks are traded at the Swiss Stock Exchange in Zürich. Also, the Swiss Market Index (SMI) is taken into account to capture the fluctuations of the whole market. The Swiss Market Index (SMI) is an index including the values of the twenty most important Swiss stocks (called blue chips) which normally account for approximately 90 percent of the whole trading volume at the Swiss Stock Exchange. The investigated time frame for all the series spans from 2006 (January 1st) to 2011 (January 4th), including about 1'260 observations. Additional to these variables two time dummy variables are introduced to capture the impact of the "Zumwinkel-Affair" and the additional effect of the financial crisis on the banks' stock prices (that was not already captured by the impact of the financial crisis on the SMI, that in turn is correlated with the stock prices of the two investigated financial institutes). Also their impact on the conditional variance (volatility) of the stock prices is analysed.

2.1. Visual and Descriptive Analysis of Data Series

Before the adopted model will be illustrated in further detail, it is important to pay deeper attention to the used data series. Inspecting the graphical movement of the employed time series (plotted in figure 1) provides a few crucial insights. After the economic expansion phase that affected most sectors of the economy up to 2007, there is a clear downward tendency beginning to be evident from the end of that year on. There was a certain period of consolidation during 2008, before the dramatic worldwide downturn on the international stock markets took place, following the crash of Lehman Brothers in September 2008 that led to a long lasting decrease. In the Swiss Market Index the financial crisis, which had its origin

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[4] All the mentioned banks and further information regarding the Zumwinkel-Affair are outlined in the appendix (A.5. and A.6.).

already in the American sub-prime crisis, is clearly visible with its extremum at the trough in March 2009.

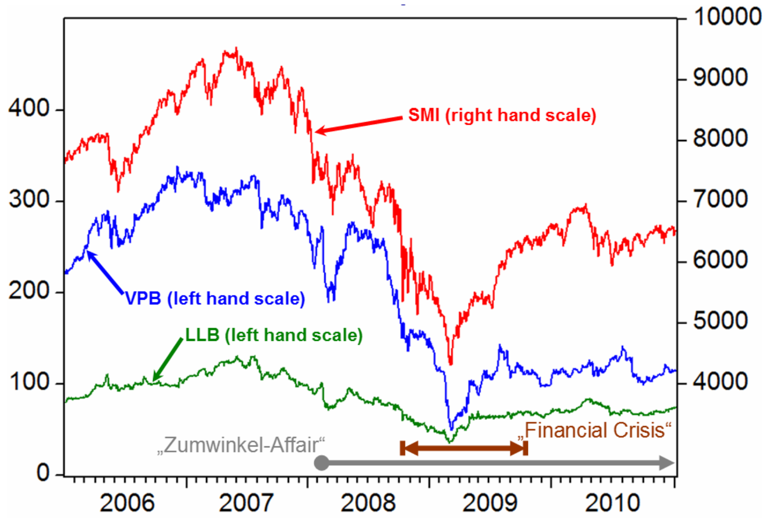

FIGURE 1: Daily stock prices of the VPB and the LLB compared to the Swiss Market Index (SMI)

The two arrows in the graph of figure 1 mark the chosen time periods for the two important time dummies (accounting for the financial crisis and the "Zumwinkel-Affair") which are used in the regressions later on. To identify the time period where the financial crisis was at its maximum the SMI has been chosen as reference. It is important to note that the time span also includes the period of recovery to the level, where the beginning of the crisis has been detected. The chosen timing of the two dummies is motivated as follows: The time period of the dummy of the financial crisis starts with the crash of Lehman Brothers on October 6th 2008 and ends where the SMI was back again on the same index level before the crash on October 16th 2009. The time dummy for the Zumwinkel-Affair starts one day after the arrest of Klaus Zumwinkel on February 15th (this event has also induced a notable temporary downturn shock in the SMI) until the end of the inspected sample period on January 4th 2011.

It is important to stress some facts which might not be fully apparent at first sight due to the different scaling of both axes in figure 1: On the one hand, it is easily visible that the SMI and the two banks' shares are strongly related and that all of them experienced a sharp decrease in their stock values after the peak in the middle of 2007 until the trough in March 2009. But on the other hand, the investigated banks suffered from even more dramatic losses than the market. While the SMI lost around 55%, the LLB-stock decreased around 75% and the VPB-stock value even diminished around 85%. Inspecting the two stocks an additional drop is visible in February 2008, exactly when the "Zumwinkel-Affair" began. It is evident from figure 1 that the recovery of the SMI after the financial crisis was stronger compared to the LLB and VPB, not in percentage recovery compared to the lowest through but compared to the level in the boom-year 2007. One possible explanation is the data theft that resulted in the "Zumwinkel-Affair", which was followed by high international pressure on Liechtenstein leading to a deep and still ongoing transformation process within the financial sector, as reasoned in the introduction of this paper.

All the three used data series are integrated of order one[5], so if we just plug them in original form into the estimation process, we are running a high risk of generating estimates which have been affected by spurious regression, an instance that could result in misleading estimation results.[6] The original data series have been transformed in order to obtain the daily percentage changes that are from now on denoted as $\%\Delta SMI$, $\%\Delta VPB$ and $\%\Delta LLB$. The plot of the transformed series is shown in figure 2. Even though the transformation into percentage differences makes it more difficult to judge the long-term effects (which are not in main focus, however), especially of the "Zumwinkel-Affair" on the performance of the stock prices, it has one important benefit compensating for the just mentioned shortcoming: It provides a sort of "standardized" conditional variance since the models all contain the included series in percentage figures which make the conditional variances directly comparable over the whole time span and also between the two stocks used as dependent variables.

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5 Augmented Dickey Fuller-test (DICKEY AND FULLER [1979]), KPSS-test (KWIATKOWSKI ET AL. [1992]) and Phillip/Perron-test (PHILLIPS AND PERRON [1988]) all suggest that the series feature a unit root (follow a random walk). After differencing, the series are integrated of order zero (same tests indicate no unit root anymore).

6 GRANGER AND NEWBOLD [1974] pointed out the problem and consequences of spurious regression potentially leading to falsely low p-values and high R^2. They also proposed a rule of thumb for the detection of spurious regression: If the goodness-of-fit measure R^2 is almost equal to 1 or higher than the reported value of the Durbin-Watson statistic, then spurious regression "must" be present. The Durbin-Watson test checks the presence of serial correlation of first order among the errors of the model and was introduced by DURBIN AND WATSON [1950]. Especially the high R^2 or the very low durbin-watson statistics (of different specifications of the model, also with and without incorporation of a GARCH-specification) led to only one possible conclusion that spurious regression is existent if we use the variables in levels. The durbin-watson test should be treated with care if there is a lagged dependent variable in the estimated equation (or if the constant is dropped). Nonetheless, the impression of spurious regression was independent from different executed specifications excluding/including a constant or a lagged dependent variable.

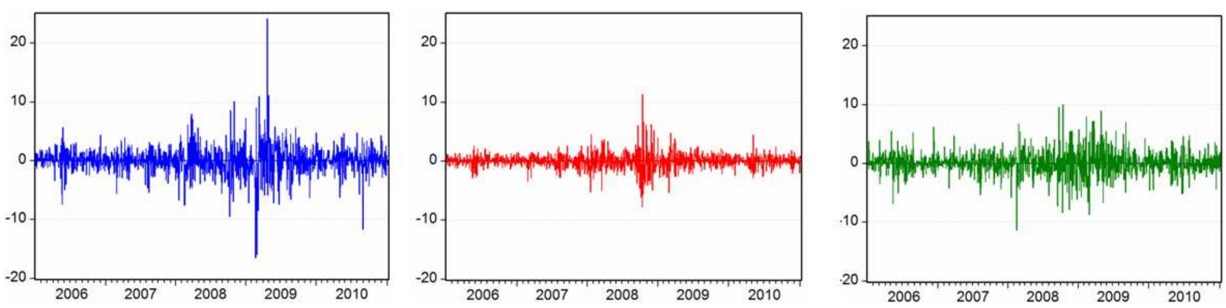

FIGURE 2: Daily percentage changes of the Swiss Market Index (red middle graph), the VPB-stock prices (blue left graph) and the LLB-stock prices (green right graph) from 2006 until 2010

If we compare the plot of the daily percentage change of the three time series, we recognize that all the series feature visible volatility clustering, which looks like a seismographic detection of equity risk. A rise of volatility is detectable during the period of the financial crisis (October 2008 until October 2009), but also (albeit comparably lower) at the time point when the data theft became public (in February 2008). We can also observe that both stocks have a higher range and volatility than the Swiss Market Index (especially the VPB-stocks), something that also becomes apparent when the descriptive statistics are calculated and compared (expressed in the table of figure 3). The standard deviations of the two stocks are higher than the standard deviations of the market index, while all are alike when it comes to comparing their fourth moments: They all have a kurtosis that is considerably higher than 3 (a kurtosis of 3 would correspond to a normal distribution). Thus, the three series have leptokurtic properties featuring “heavy-tails”.

Descriptive Statistics	%ΔVPB	%ΔSMI	%ΔLLB
Mean (1st moments)	-0.0224	-0.0035	0.0149
Median	0.0000	0.0496	0.0000
Maximum	24.1782	11.3910	10.0000
Minimum	-16.5276	-7.7881	-11.3918
Std. dev. (2nd moments)	2.4599	1.3427	2.0472
Skewness (3rd moments)	0.2726	0.3070	-0.0167
Kurtosis (4th moments)	15.0161	11.0651	6.3034

FIGURE 3: Descriptive statistics of the three series used in the explorations

More on the leptokurtic features and the pattern of autoregressive conditional heteroskedasticity regarding the two investigated stock series will be discussed in the appendix (section A.4.).

2.2. Model Setup

Neglecting the presence of ARCH (autoregressive conditional heteroskedasticity)-effects, that were detected in the last chapter, in regression models results in inefficient ordinary least squares estimates (yet, still being consistent). The covariance matrix of the parameters might be biased, with invalid t-statistics (see ASTERIOU AND HALL [2007, p.252-253]). Besides the lack of asymptotic efficiency (see ENGLE [1982]), it might also lead to over-parameterization of an (ARMA)-model (see WEISS [1984]) and to over-rejection of conventional tests (see MILHØJ [1985]), for example tests for serial correlation (see also FAN AND YAO [2005, p.165]). Setting up a model which explicitly accounts for the presence of ARCH-effects leads to an efficient estimator and will ensure the calculation of a valid covariance matrix. However, such a model is usually not estimated by an ordinary least squared estimator, but by the iterative solving of a nonlinear maximation problem, namely by using a maximum-likelihood procedure.[7] Hence, instead of only estimating the mean equation (Y_t) of the following equations, the variance equation with the conditional variance (h_t) is also included:

$$Y_t = \alpha_1 + \beta_1 X_{1t} + \ldots + \beta_k X_{kt} + u_t \qquad u_t \mid \Omega_t \sim \mathrm{N}(0, h_t) \qquad \sigma_t^2 := h_t$$
$$h_t = \alpha_2 + \sum_{i=1}^{p} \gamma_i u_{t-i}^2$$

X_1 to X_k are linear predictors of Y. The specification of the conditional variance resembles the conception of ENGLE [1982]. Of course, also lags of the independent and the dependent variable are includable into the just reported mean equation. But these have been excluded in the term of this short overview.

BOLLERSLEV [1986] and TAYLOR [1986] developed a more general approach also considering the possibility of an autocorrelated conditional variance (h_t). The variance equation of this widespread GARCH-approach therefore is of the following form:

7 The maximum likelihood estimation procedure basically chooses the optimal coefficients within the (conditional) mean equation by maximizing a log likelihood function term, which is mainly dependent on the error term and the error variance. This procedure now provides efficient and consistent estimates within both the mean and variance equation. OLS may serve as instrument to find good starting values for the iterative maximum likelihood estimation. The (conditional) variance equation itself is not really a regression equation in the usual sense, the chosen parameter values are found by the fact that they affect the (conditional) error variance, which appears in the log likelihood function of the mean equation. The log likelihood function is also of further importance with respect to the determination of the lag order of the GARCH-specification as it is the main element of the information criteria mentioned later on.

$$h_t = \alpha_2 + \sum_{i=1}^{p} \gamma_i u_{t-i}^2 + \sum_{j=1}^{q} \delta_j h_{t-j}$$

WEISS [1984] as well introduced a more general form of the original ARCH-model. He additionally incorporated a dependency of the conditional variance on the past squared observed values of the dependent variable of the mean equation (Y_t):

$$h_t = \alpha_2 + \sum_{i=1}^{p} \gamma_i u_{t-i}^2 + \sum_{l=1}^{s} \beta_{k+l} \cdot Y_{t-l}^2$$

Note, that WEISS [1984] also integrated squared independent variables (coincident and/or lagged) from the mean equation into the variance equation (see also WEISS [1986, p.109] and HAUSER AND KUNST [1993, p.7]). But the inclusion of independent variables into the variance equation is labelled by the term "augmentation" of the core classification which is just being introduced.

In a general-to-specific manner, which is executed in the main model set up of the investigations of this paper, the conditional variance shall be allowed to be a function of the past residuals, the past conditional variance and the past dependent variable in squares:[8]

$$h_t = \alpha_2 + \sum_{i=1}^{p} \gamma_i u_{t-i}^2 + \sum_{j=1}^{q} \delta_j h_{t-j} + \sum_{l=1}^{s} \beta_{k+l} \cdot Y_{t-l}^2$$

As explained later on, this general-to-specific approach can and will be augmented by lagged independent variables in squares and some time dummies. Also, the independent variables could also be included in a coincident (non-lagged) manner or in non-squared form, but both of these extensions are not of central interest from an analytical point of view and have not been applied here.

In order to provide a certain system of the different related approaches and specifications of the variance equation to model heteroskedasticity, a new term is being introduced here. The term incorporates the different features proposed by ENGLE [1982] (past squared residual), WEISS [1984] (past squared dependent variable) and BOLLERSLEV [1986] (past conditional variance). The family of all possible combinations or amalgams of these mentioned

[8] Note that the model is not identified if Y is white noise. If autocorrelation of Y is weak, it becomes difficult to separate the gamma and the beta terms.

approaches is now called “amalGARCH(p,q,s)”[9], where p is the lag-length of the squared residual, q the lag-length of squared dependent variance and s the lag-length of the dependent variable.

Apart from the afore-mentioned econometric advantages, there are also analytical reasons why an amalGARCH-approach is used here, since there is direct economic interest in the impact of certain events, such as the financial crisis and the “Zumwinkel-Affair”, on volatility (which is measured by the conditional variance equation explained later on). These two events are captured by two time dummies. Also, past shocks in the market, measured by the squared past percentage change of the SMI, and their impact on the current conditional variance of the stocks returns are on central relevance. Thus, the variance equation is additionally modified and augmented by the three just mentioned variables:

$$\%\Delta STOCKPRICE_t = \beta_1 \cdot \%\Delta STOCKPRICE_{t-1} + \beta_2 \cdot \%\Delta SMI_t + \beta_3 \cdot DATATHEFT_t + \beta_4 \cdot FINANCIALCRISIS_t + u_t$$

$$u_t | \Omega_t \sim \mathrm{N}(0, h_t)$$

$$\begin{aligned} h_t = \alpha + \sum_{i=1}^{q} \delta_i \cdot h_{t-i} + \sum_{j=1}^{p} \gamma_j \cdot u_{t-j}^2 + \sum_{l=1}^{s} \beta_{4+l} \cdot \%\Delta STOCKPRICE_{t-l}^2 \\ + \beta_{4+l+1} \cdot \%\Delta SMI_{t-1}^2 + \beta_{4+l+2} \cdot DATATHEFT_t + \beta_{4+l+3} \cdot FINANCIALCRISIS_t \end{aligned}$$

The applied modelling strategy is therefore called “augmented amalGARCH”. As it appears later on, the optimal specification happens to be the proposed unconventional augmented amalGARCH. In the table of figure 4, the three popular classes of models from the literature that have already been explained earlier are being listed and classified within the newly defined amalGARCH model-class. The term “augmentation” concerns the supplementation of the time dummies and the past independent variable and relates to the columns four and five in the table. The applied model is “unconventional” because it is a modification to the commonly used ARCH- and especially popular GARCH-approaches, these two conventional types only have check marks in the first two columns of figure 4.

9 The here chosen notation “amalGARCH”, was inspired by HAUSER AND KUNST [1993, p.7] who state that the original approach of WEISS [1984] allows “…amalgams of Engle-type dependence on past errors and […] as well as for explicit dependence on the squared linear predictor for [the dependent variable]…”.

	Different amalGARCH(*p,q,s*)-specifications			Possible Augmentation	
	Past Squared Residual: (*p*)	Past Conditional Variance: (*q*)	Past Squared Dependent Variable: (*s*)	(Past) Squared Independent Variables	Dummies
ENGLE [1982]: ARCH	✓				
WEISS [1984]	✓		✓	✓	
BOLLERSLEV [1986]: GARCH	✓	✓			
Augmented amalGARCH(p,q,s)	**?**	**?**	**?**	✓	✓

FIGURE 4: Popular and applied specifications within the amalGARCH-family

So, the popular ARCH-type of ENGLE [1982] would correspond to the term amalGARCH(p,0,0), the widely-applied GARCH-model by BOLLERSLEV [1986] is an amalGARCH(p,q,0) and the approach by WEISS [1984] an amalGARCH(p,0,s).

The estimation consists of two linked equations: The mean equation models the daily percentage change (return performance) of the stock value and the variance equation contains the conditional variance as a measure for the risk of the stock value. The influence on performance, in a first stage of the price of the VPB-stock and in a second stage of the price of the LLB-stock, is modelled as follows[10]:

- *Dependent variable*: The daily percentage change of the stock price (either %-change of VPB-stock price or %-change of the LLB-stock price) is used as regressand in the mean equation.

- *Control variables*: The present performance of the Swiss Market Index (%-change of SMI-value) and the past performance of bank's stock price (%-change of VPB or LLB) are used as regressors.

- *Additional impact of financial crisis*: A time dummy from October 6th (2008) until October 19th (2009) is generated to cover the impact of the financial crisis (the motivation behind the timing has already been outlined in chapter 2.1.). In the case of the mean equation, the time dummy can be interpreted as the additional effect of the crisis beyond the influence which is already captured by the bad performance of the SMI. So, this dummy tries to check if the stock value has suffered more severely (or

10 The prefix "%Δ" (in the text) and "PD_" (in estimation output tables) are applied to label the percentage change/percentage difference of a variable. The suffix "(-1)" in the estimation outputs highlights the lagged variables indicating the usage of the observed value from one trading day in the past (in time point *t*-1) compared to the dependent variable's observation in time point *t*.

less) compared to the market regarding the average returns. The detailed interpretation will be given in the next two sections.

- *Additional impact of data theft ("Zumwinkel-Affair")*: Another time dummy from February 15th (2008), when the arrest of Zumwinkel took place, until January 4th (2011), which is the end of the sample, is integrated to measure the additional impact of the "Zumwinkel-Affair", separated from the impact of the financial crisis. The incorporation of the financial crisis dummy and %-change of the SMI allows the estimated impact of the "Zumwinkel-Affair" not to be heavily biased by the financial crisis.

Of particular interest is the augmented GARCH-specification of the variance equation: The past squared residuals and the past conditional variances are supplemented by the same control variables as in the mean equation, but now in squared form. The reason for taking squares is to ensure that both past negative and past positive outbursts have the same (presumably increasing) effect on volatility measured by the conditional variance. The variance is also augmented by the time dummy variables "financial crisis" and "data theft".

The chosen time span also includes the period of recovery to the level, where the beginning of the crisis' peak has been detected in figure 2. It would be unreasonable to argue that the crisis was overcome right after the lowest trough. The decision to include some amount of recovery will surely affect and lower the estimated (presumably negative) impact of the crisis on the conditional mean of stock values, since they are highly correlated with the SMI. The consequences of the inclusion of the recovery period on the conditional variance are hard to guess in an early stage, but this decision seems to be fairly reasonable and will be explored later on.

Different specifications of the variance equation have been exercised and explicitly compared with the applied augmented amalGARCH(0,1,0)-model: An augmented amalGARCH(1,1,0)-model, where the lagged squared observations of the stock returns and of the SMI-performance have been removed from the variance equation and the typical "non-augmented" amalGARCH(1,1,0)-model, which is equivalent to the traditional term "GARCH(1,1)", are applied as benchmarks. It turns out that the chosen augmented amalGARCH(0,1,1)-

specification is not only justified by the aim of the analytical investigations but also proves to be superior to the alternative specifications (see the appendix for the details).

As noted, the variance equation will be in main focus (the determinants of the volatility of the stock prices) rather than the mean equation (the determinants of the percentage change of the stock prices), as stock returns are usually hard to model and predict, while the evaluation of the expected risk is more promising and yields more relevant information about investment decisions.

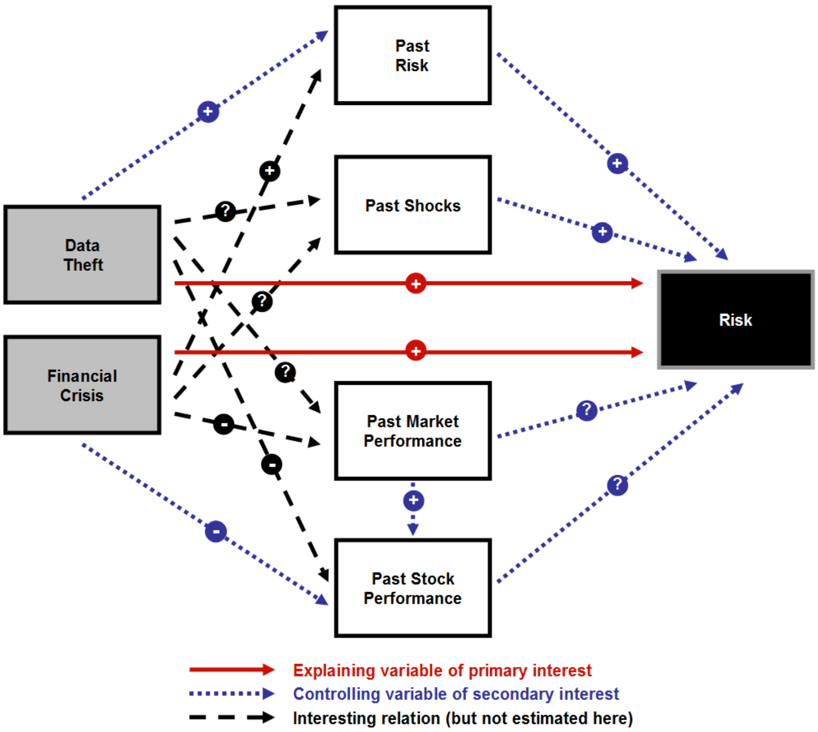

FIGURE 5: Included variables (within the variance equation) and expected signs of influence

Figure 5 summarizes all the variables, which are incorporated into the variance equation and therefore capture the influences of primary interest, namely the various determinants for the prediction of risk (volatility) of the investigated stock return: As already explained, in main focus are the effects of the data theft and of the financial crisis. A priori, it is expected that both influences of primary interest have an accumulating effect on equity risk (hence marked with a positive sign in figure 5), so it is assumed that both events have increased volatility. The observable volatility clustering suggests high positive autocorrelation of risk itself. Past shocks, captured by high values of past residuals within the mean variance, will presumably result in higher risk. Also, high absolute values of past percentage changes of the SMI and of the inspected stock value presumably have an accumulating effect on risk (but this should be estimated first before it is stuck to this claim). The interrelation of the past market performance and the financial crisis with the past stock performance is being dealt with as well within the mean equation.

2.3. Results and Interpretation

As already outlined in the previous section, the three regarded series feature leptokurtic patterns, the reported kurtosis is for all the three series considerably above 3. To confirm this descriptive detection of autoregressive heteroskedasticity, the sample distribution and quantiles of the returns of the VPB-stocks and LLB-stocks have been compared with the adjusted normal distribution and an ARCH-test (following ENGLE [1982]) has been executed: Both methods clearly indicate the existence of ARCH-effects (outlined in the appendix A.4.). Also, the positive serial autocorrelation of the residuals (from an "ordinary" model fitting without GARCH-specification) and the autocorrelation functions of $\%\Delta VPB$ and $\%\Delta VPB^2$ ($\%\Delta LLB$ and $\%\Delta LLB^2$) underline the existence of serially correlated variance, which is visible in the volatility clustering. The existence of autoregressive conditional heteroskedasticity makes the introduction of a variance equation (GARCH-approach) particularly lucrative, besides the fact that we are directly interested in the different influences not only on the performance but especially on the equity risk (measured by the conditional variance).

The econometric setup of the used amalGARCH(p,q,1)-model with a mean equation (with either $\%\Delta VPB_t$ or $\%\Delta LLB_t$ as dependent variable) and a variance equation (with the conditional variance h_t as dependent variable) is depicted below[11]:

$$\%\Delta VPB_t = \alpha_1 + \beta_1 \cdot \%\Delta VPB_{t-1} + \beta_2 \cdot \%\Delta SMI_t + \beta_3 \cdot DATATHEFT_t + \beta_4 \cdot FINANCIALCRISIS_t + u_t$$

$$u_t | \Omega_t \sim \text{iid N}(0, h_t)$$

$$h_t = \alpha_2 + \sum_{j=1}^{q} \delta_j \cdot h_{t-j} + \sum_{i=1}^{p} \gamma_i \cdot u_{t-i}^2 + \beta_5 \cdot \%\Delta VPB_{t-1}^2 + \beta_6 \cdot \%\Delta SMI_{t-1}^2 + \beta_7 \cdot DATATHEFT_t + \beta_8 \cdot FINANCIALCRISIS_t$$

11 The time period of the financial crisis time dummy lies entirely within the time span of the data theft dummy: The included dummy variable $FINANCIALCRISIS_t$ is therefore fully equivalent to the interaction variable $DATATHEFT_t$*$FINANCIALCRISIS_t$. This reasoning is also supported by the empirical results, which are completely the same for both specifications. In the forthcoming econometric analysis in this paper, the variable $FINANCIALCRISIS_t$ is used instead of the interaction term.

$$\%\Delta LLB_t = \alpha_1 + \beta_1 \cdot \%\Delta LLB_{t-1} + \beta_2 \cdot \%\Delta SMI_t + \beta_3 \cdot DATATHEFT_t + \beta_4 \cdot FINANCIALCRISIS_t + u_t$$
$$u_t | \Omega_t \sim \text{iid N}(0, h_t)$$
$$h_t = \alpha_2 + \sum_{j=1}^{q} \delta_j \cdot h_{t-j} + \sum_{i=1}^{p} \gamma_i \cdot u_{t-i}^2 + \beta_5 \cdot \%\Delta LLB_{t-1}^2 + \beta_6 \cdot \%\Delta SMI_{t-1}^2 + \beta_7 \cdot DATATHEFT_t + \beta_8 \cdot FINANCIALCRISIS_t$$

After adjustments, both equations include 1'256 observations. The lag lengths in the variance equation, namely of the past variances and the past squared residuals (obtained from the mean equation) have been determined with respect to different information criteria, also keeping in mind the conditions for a valid GARCH-model and the significance of the GARCH-coefficients[12].

The following passage repeats the setup of the model and already points out the main results obtained from the amalGARCH(0,1,1)-model, whose output is visible in figure 5. The influence on daily percentage change of stock prices (%Δ*VPB* and %Δ*LLB*) is captured by the mean equation:

- *Constant*: The constant was excluded since it was insignificant and led to worse information criteria. However, the main results remained insensitive to the inclusion or exclusion of the constant.

- *Control variables*: The performance of the Swiss Market Index (%-change of SMI) is highly significant meaning that general market fluctuations are closely related to the VPB-stocks, while the past performance of the bank's stock price (lagged %-change) plays only a minor role. The performance of the Swiss Market Index (%-change of SMI) is highly significant also in the case of the LLB, so the general market fluctuations are an important influence for both stocks. The past performance of the LLB's stock price (in contrast to the VPB) plays also a role: Even though the

[12] The information criteria (even though these criteria can sometimes have problems with finding a minimal extremum in the context of GARCH-models) deliver very important insights (see NEUSSER [2006, p.145]): The criteria clearly suggest a very parsimonious amalGARCH(0,1,1)-specification. Higher amalGARCH-orders (especially of past squared residuals) generate unacceptably many insignificant estimates and even negative coefficients (which is invalid). Thus, it is implausible to incorporate past observations (of variables from the mean equation) plus past squared residuals (of the mean equation) into the variance equation. The opposite approach of dropping the variables %Δ*VPB*(-1)^2 and %Δ*SMI*(-1)^2 from the variance equation (and including past squared residuals instead) is shown in the appendix. The alternative GARCH(1,1) yields very similar results with respect to the investigated variables compared to the approach outlined in this and the next section. Additionally, a typical benchmark model like the "non-augmented" GARCH(1,1)-approach, which is equivalent to a non-augmented amalGARCH(1,1,0), has been executed and compared with the two other specifications. As already pointed out, the chosen augmented GARCH(0,1) turns out to be the best specification (see the appendix).

coefficient of the lagged dependent variable is rather small, it is significant and negative.

- *Additional impact of financial crisis*: The insignificance of the time dummy indicates that there is no additional effect. Nonetheless, it would be wrong to conclude that there was no impact of the financial crisis at all, since it is reasonable to argue that the financial crisis was already captured by the bad performance of $\%\Delta SMI$ (which significantly affects the %-change of the VPB-stock and LLB-stock). Thus, the financial crisis had a negative impact on the daily returns. But this is also incorporated into the influence via the SMI. So there was no impact of the financial crisis that was bigger than the effect of the crisis on the whole stock market (ceteris paribus). Additionally, another fact contributes to the insignificance of the crisis, which even remains if the SMI-variable is removed from the estimation: Inspecting figure 1 we observe that not only the SMI fully recovers from the sharp downturn (the time span dummy was set according to this fact on purpose) but also the VPB-stock price recovers as both variables are highly correlated. Thus, the effects during the downturn and the upturn cancel out. If the duration of the crisis is shortened, so that only the downturn of the market is included until the trough on March 9th (2009), then the financial crisis dummy gets significant (this is shown in the appendix A.3.). Hence, two things can be concluded: First, the financial crisis had no additional impact on the VPB stock average returns if the recovery phase is included into the financial crisis time definition. Second, it suffered from the financial crisis during the downturn phase even more than the market. This insignificance is also the case for both stocks if the time span of the financial crisis time dummy is shortened to leave out the recovery period but only for the LLB-stock, if the SMI-variable is dropped within the estimation using the shorter period definition (for detailed results see the appendix A.3.). Thus, the insignificance tells us two things: First, the financial crisis had no impact on the LLB-stock average returns that was more severe compared to the market not in the downward phase and not if the recovery period is included into the time definition of the financial crisis. Second, the LLB-stock only suffered from the financial crisis during the downturn phase (very similar to the market performance).

- *Impact of data theft*: This time dummy captures the impact of the “Zumwinkel-Affair”, separated from the impact of the financial crisis and the ordinary market fluctuations, on daily returns (%ΔVPB and %ΔLLB). No significant (additional) effect can be discovered consulting the estimation results of the mean equation.

As already noted, it is also of central relevance to inspect the effect of the involved variables on the conditional variance of the stock prices. The influence on volatility (as a measure for risk) is modeled by the variance equation with the conditional variance as the explained variable:

- All the estimated coefficients of the included variable are statistically significant and with expected positive signs, meaning that they all have a traceable accumulating effect on risk.

- The constant and the past conditional variance as explanatory variables within the variance equation are both highly significant. So, there is a generally existent average risk (not explained by the market risk or the other considered variables).

- The squared control variables (%ΔVPB^2_{t-1} and %$\Delta SMI(-1)^2$) are also significant but contribute to a lower extent than the other included variables to the conditional variance. The squared control variables %$\Delta LLB(-1)^2$ and %$\Delta SMI(-1)^2$ are also significant in the LLB equation but have a lower impact on the conditional variance.

- Most interestingly, the two dummy variables are highly significant and intensify the variance: Hence, it can be concluded that the financial crisis had a very strong effect on the volatility during the period when the crisis took place. Additionally, the data theft/"Zumwinkel-Affair" also intensified the volatility/risk of the daily VPB-stock returns to a high extent. The data theft also intensified the volatility/risk of the daily LLB-stock returns, but the effect was weaker (the magnitude of the effect can also be seen in the plotted conditional variance of figure 9). Both the effects of the Zumwinkel-Affair and of the financial crisis are considerably lower compared to the effect on the conditional variance of %ΔVPB (see regression results in figure 6). The strength of the two events measured by the dummies on the magnitude of the volatility can be seen by comparing the considerable size of the coefficient with the constant of the variance equation that measures the average risk.

	Dependent Variable	
	$\%\Delta VPB_t$	$\%\Delta LLB_t$
Mean Equation		
$\%\Delta VPB_{t-1}$	-0.0102	
$\%\Delta LLB_{t-1}$		-0.0869***
$\%\Delta SMI_t$	0.5941***	0.4170***
Financial Crisis	-0.0196	0.0784
Data Theft	-0.0179	-0.0106
Variance Equation		
Constant	0.3073***	0.4217***
$ARCH(1): \hat{u}_{t-1}^2$		
$GARCH(1): h_{t-1}$	0.6452***	0.5331***
$\%\Delta VPB_{t-1}^2$	0.1085***	
$\%\Delta LLB_{t-1}^2$		0.1639***
$\%\Delta SMI_{t-1}^2$	0.1699***	0.2450***
Financial Crisis	1.9821***	1.2248***
Data Theft	0.4550***	0.1617**
Measures of Fit		
R^2	0.1255	0.0774
Adjusted R^2	0.1192	0.0707

FIGURE 6: Estimation output of applied amalGARCH(0,1,1)-model

The augmented amalGARCH(0,1,1)-model therefore suggests that there is a certain path dependency (serial correlation) of volatility of the examined dependent variable $\%\Delta VPB$, but there is no autocorrelation of the variable $\%\Delta VPB$ itself. This means that even though the stock return itself cannot be well predicted by its own observable past (which conforms to the often quoted market efficiency hypothesis), the risk, measured by the conditional variance, can be predicted to a certain extent using the past observed variables within the variance equation[13]. Interestingly, it turns out that there is a certain path dependency (serial correlation) of the volatility of the examined dependent variable $\%\Delta LLB$ and that there is, in contrast to $\%\Delta VPB$, also significant autocorrelation of the variable $\%\Delta LLB$ itself: The lagged dependent variable $\%\Delta LLB_{t-1}$ is significant and the negative autocorrelation exhibits a significant Ljung-Box-Q-statistic, with a p-value of 0.028, for the first lag (and only for the first lag). The Q-statistic tests the null hypothesis that there is no autocorrelation up to the regarded order (see LJUNG AND BOX [1978]). This means that the stock return itself can be predicted to a certain extent by its own observable past, which is not in line with the already outlined market

[13] If the stock prices follow a random walk, then the current stock price in time point t will always be the best forecast for the stock price in t+1 since $p_{t+1} = \delta p_t + \varepsilon_{t+1}$ (in the case of a random walk: $\delta = 1$, ε_t follows a white noise process). So, if we are interested in the return Δp_t (or in our case the percentage return) we can deduce the expected return from the just quoted equation: $\Delta p_{t+1} = p_{t+1} - p_t = \varepsilon_{t+1}$. The expected return $E_t[\Delta p_{t+1}] = E_t[\varepsilon_{t+1}] = 0$ is purely stochastic (white noise) and therefore not predictable in a meaningful way. Therefore, the best prediction of the stock prices tomorrow would be the stock price today.

efficiency hypothesis. Also the risk, measured by the conditional variance, can be predicted using the past observed variables within the variance equation.

The main findings of the estimation equations for both banks, as shown in figure 6, are not sensitive to the assumption on the conditional distribution of the residual. As an alternative to the chosen normal distribution, also student's t-distribution, which is sometimes preferred in the context of finance data, has been applied. The main findings about the significance, magnitude and sign of the coefficients, which have just been stated and which are outlined again at the end of this chapter, remain unchanged.

The table in figure 7 summarizes and classifies the applied augmented amalGARCH(0,1,1)-model and relates this (in this application superior) approach to the popular models that have been proposed in the literature:

	Different amalGARCH(p,q,s)-specifications			Applied Augmentation	
	Past Squared Residual: (p)	Past Conditional Variance: (q)	Past Squared Dependent Variable: (s)	Past Squared Independent Variables	Time Dummies: Data Theft, Financial Crisis
ENGLE [1982]: ARCH	✓				
WEISS [1984]	✓		✓	✓	
BOLLERSLEV [1986]: GARCH	✓	✓			
Augmented amalGARCH(0,1,1)		✓	✓	✓	✓
Invalid Results	☠	✓	☠	☠	✓

FIGURE 7: Applied augmented amalGARCH(0,1,1) and other models within the amalGARCH-group

The popular models included in the previous table can be integrated into the proposed amalGARCH-notation: The ARCH-model by ENGLE [1982] would be termed as amalGARCH(p,0,0), the specification of WEISS [1984] as amalGARCH(p,0,s) and the very popular GARCH-model by BOLLERSLEV [1986] as amalGARCH(p,q,0). The chosen model specification corresponds to an amalGARCH(0,1,1) that was additionally augmented by a squared past independent variable ($\%\Delta SMI_{t-1}^2$) and the two time dummies capturing the financial crisis and the Zumwinkel-Affair. Applying all the possible components yielded invalid results (see footnote 12 and appendix A.1.).

After the incorporation of the variance equation complementing the "ordinary" mean equation that accounts for the autoregressive heteroskedasticity (through the just outlined GARCH-approach) we observe that the squared residuals of the improved model are not autocorrelated anymore (they were autocorrelated in the model setup without the variance equation.

Correlogram of squared residuals ($\hat{u}_t^2$)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.005	0.005	0.0258	0.872
		2	-0.005	-0.005	0.0634	0.969
		3	-0.014	-0.013	0.2934	0.961
		4	0.005	0.005	0.3196	0.989
		5	0.010	0.010	0.4559	0.994
		6	-0.037	-0.038	2.2232	0.898
		7	-0.019	-0.019	2.6997	0.911
		8	0.000	0.000	2.6997	0.952
		9	0.005	0.003	2.7277	0.974
		10	0.014	0.013	2.9626	0.982

Correlogram of squared residuals ($\hat{u}_t^2$)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.031	0.031	1.1891	0.276
		2	-0.020	-0.021	1.7011	0.427
		3	-0.031	-0.030	2.9305	0.402
		4	0.019	0.020	3.3643	0.499
		5	0.053	0.050	6.8522	0.232
		6	0.045	0.041	9.3559	0.155
		7	0.014	0.014	9.5958	0.213
		8	-0.063	-0.060	14.635	0.067
		9	-0.021	-0.017	15.209	0.085
		10	-0.009	-0.014	15.322	0.121

FIGURE 8: Correlogram of squared residuals of the GARCH-model
(%ΔVPB left side, %ΔLLB right side)

The (weak) significance at lag of 8 with a p-value of 0.067 has no economically intuitive interpretation and may be considered as an outlier. Such an outlier can be expected with the chance of 1 to 20, even if the series not auto-correlated at all (see CHATFIELD [2004, p.24]).

Plotting the graph with the estimated conditional standard deviations for %Δ*VPB*, one can clearly observe the higher level of volatility beginning with the “Zumwinkel-Affair” and the even higher risk during the financial crisis.

The conditional standard deviation plot also reflects the already mentioned strong volatility clustering, meaning that risk is time-dependent (heteroskedasticity of both stocks). Plotting the graph with the estimated conditional standard deviations for %Δ*LLB*, it can be observed that volatility is slightly rising with the beginning of the “Zumwinkel-Affair”, but considerably less compared to the conditional variance graph of %Δ*VPB*. This observation underlines the earlier findings from the estimation outputs: The financial crisis clearly had a cumulating impact on risk.

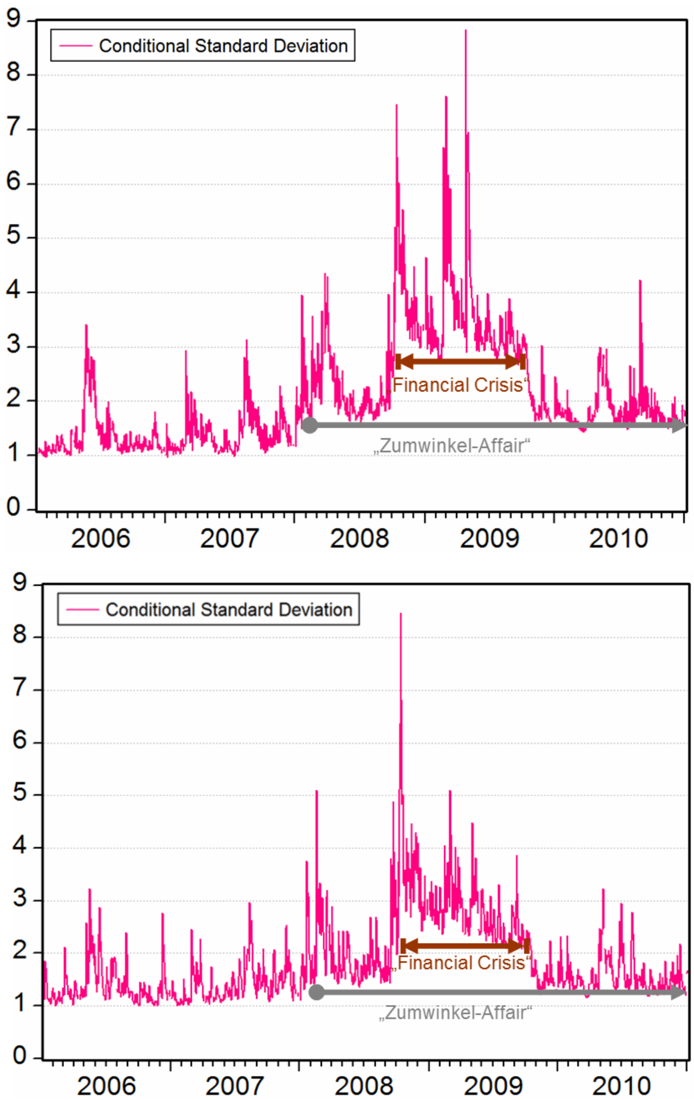

FIGURE 9: Estimated conditional standard deviation (%ΔVPB upper graph, %ΔLLB lower graph)

As an alternative, a GARCH(1,1) approach, which excludes the two variables $\%\Delta VPB(\text{-}1)^2$ or $\%\Delta LLB(\text{-}1)^2$ and $\%\Delta SMI(\text{-}1)^2$ from the variance equation but includes one past squared residual, has been estimated as well. The computed output results applying the GARCH(1,1)-model are analogous to the augmented amalGARCH(0,1,1)-model from figure 6 if we compare the estimates of the mean equation and the high significance of the two dummy variables in the variance equation (for further details and results see the appendix A.1.).

The also popular GARCH-M specification (proposed by ENGLE, LILIEN AND ROBINS [1987]), which allows the conditional mean to depend directly on its own conditional variance, has also been estimated: The coefficient estimates of the independent variables in variance and mean equation were only slightly changed and the significance conclusions remained unchanged, while the GARCH-M-component in the mean equation appeared to be insignificant. The analytical interpretation of this result could be that the stock prices are not directly dependent on risk in this case. The economic reasoning of a potential significance of the GARCH-M-component lies in the "value at risk"-argument: A (usually rather risk-avers) investor would desire better returns in order to compensate for higher risk, following usual finance theory such as Capital Asset Pricing Models.

So, it can be stated here that, in this context, the chosen unconventional modelling of the dependence of the conditional variance (on past observations instead of past residuals) beats the conventional forms after ENGLE [1982], BOLLERSLEV [1986] and also the less known specification by WEISS [1984], which also includes past observations but excludes lagged conditional variances. These conclusions rely on the consultation of the information criteria of AKAIKE [1974] and SCHWARZ [1978] and also hold if the augmentation (financial crisis and data theft dummies) is skipped from the variance equation.[14]

It is important to refer to other specifications that have been executed for the estimation frame for both stocks in order to obtain a more general base to draw the central conclusions. These modifications shall be outlined in the following:

- *SPI (financial institutes) instead of SMI to capture market fluctuations*: As an alternative indicator for the market fluctuations a sub-index has also been used. This sub-index "SPI (financial institutes)" captures all financial institutes that are present at the Swiss Stock Exchange. However, the usage of this alternative indicator does not yield any changes worth mentioning. This result is not very surprising as visual and descriptive statistics suggest that both series SMI and SPI (financial institutes) are highly correlated.

- *TED Spread as alternative indicator for the financial crisis*: The TED spread is the calculated difference between the interest rates of the 3-months dollar-LIBOR (interbank loans) and the interest rates of 3-months U.S. treasury bills. It captures the observed credit risk and is therefore a good indicator for the trust in the financial market. As it turns out, the inclusion of the TED spread does not affect the sign or the

[14] It can be argued that it might not beneficial to gauge if a difference in information criterion's values between two (nested or non-nested) models is significant, as this decision is already implicitly included in the criterion's choice. This is discussed in KUNST [2003]. Also, the fact that these information criteria somehow already incorporate a "likelihood ratio test choice" is mentioned in BURNHAM AND ANDERSON [2004] and STOICA, SELÉN AND LI [2004].

significance of the dummy capturing the Zumwinkel-Affair. More detailed results are outlined in the appendix (A.2.).

- *Different lengths of the financial crisis dummy*: Along with the originally chosen time span used for the financial crisis time dummy other identifications of the relevant time span have been executed. The crucial finding that the Zumwinkel-Affair had a significant (accumulating) effect on the risk of the banks' stock values is insensitive to the different lengths of the time span of the financial crisis dummy. The detailed results will be discussed in the appendix (A.3.).

- *Three time dummies*: Another alternation of the chosen setting is to have three time dummies for a better separation of short-run and long-run effects of the data theft. Hence, three dummies are introduced. The first one is from the beginning of the original data theft dummy in February 2008 (arrest of Zumwinkel) until the beginning of the original financial crisis dummy starting with the collapse of Lehman Brothers in October 2008. The second has the same time span as the original financial crisis dummy (October 2008 until October 2009) and the third one lasts from the end of the second time dummy until the end of the sample (beginning of 2011). It turns out that for both banks all the three dummies are insignificant in the mean equation, as could have been expected following the reasoning regarding the data theft and the financial crisis dummies discussed earlier. But the first two time dummies show high significance in the variance equation considering both banks. Also in this setting, it can be deduced that both events data theft and financial crisis have boosted volatility/risk of both banks' stock prices. Interestingly, the third dummy is only significant in the variance equation of the VPB.[15] So, while affecting both banks, the impact of the data theft seems to have vanished more rapidly for the LLB compared to the VPB.

One can conclude for both stock return series that the most important findings, such as the highly significant effect of the Zumwinkel-Affair on risk, do not change across the various alternative specifications.[16] Also the estimation including the variables in differenced

[15] Wald-tests show that for VPB the difference between the third and the first time dummy in the variance equation is not significant (p-value of 0.1123), while the null of equality of these two dummies can be rejected in the case of LLB (p-value of 0.0324). The charts with the conditional variances over time are very similar to those in Figure 9.

[16] This also holds for the inclusion of the stock returns of the LLB into the VPB-model and vice versa: The main results are not altered. The same remark applies if the financial crisis dummy is dropped. Also the

logarithms instead of percentage changes delivers similar results, with the same conclusions, especially regarding the effects of primary interest.

As a crosscheck, the same estimations are also carried out for the Swiss banks Sarasin and Vontobel and compared with the results for Liechtenstein's banks. Of central concern is the crosscheck whether the magnifying effect of the data theft and the revelation of tax evaders (and also the following international pressure on Liechtenstein, the investors' insecurity and the following transformation process within the financial services sector in Liechtenstein) also had an effect for the Swiss banks. It turns out that no effect of the Zumwinkel-Affair on the Swiss stocks' risk can be found: The coefficients are extremely small and not significant. Hence, the Zumwinkel Affair seems to have magnified the volatility of stock values of Liechtenstein's banks but not of the Swiss banks, which is intuitive and additionally supports the chosen model. In Appendix A.6., more specific interpretations of the estimations including the Swiss stock values are explained.

inclusion of the interaction term *DATATHEFT*%ΔSMI* does not affect the main results and the coefficient of the interaction term is not significant for both stock values' mean and variance equations.

3. Conclusions

During a time of very good performance in the middle of the first decade of this century the financial sector in Liechtenstein was flourishing, also in line with a general national and international economic expansion phase. But with the peak in 2007 and the ongoing start of the American sub-prime crisis the banking sector has faced rising pressure. The following financial crisis and the depicted "Zumwinkel-Affair" (affecting Liechtenstein's economy as a whole) was a huge challenge, maybe the most turbulent time in Liechtenstein's recent economic history and came along with a deep transformation process of its whole financial sector.

The main analytical findings of this empirical paper, which applied an augmented amalGARCH(0,1,1)-model, can be summed up as follows:

- *Accumulating effect of "Zumwinkel-Affair" on risk*: While the data theft dummy showed no significant impact on the average return performance of the two stock values' daily percentage changes, there is striking evidence that the data theft and the affair had a deep impact on risk. The impact of the data theft time dummy on risk is significant for both stocks' conditional variance. However, the impact is considerably higher for the VPB-shares than for the LLB-shares. This main finding answering the main object of investigation was independent of alternative model specifications. These modified specifications are discussed in the main text and in particular in the appendix and consist of different specified GARCH-models, the inclusion of the TED spread (serving as proxy for market risk), the replacement of the SMI with the SPI (financial institutes) and differently chosen lengths of the financial crisis dummy. The magnifying effect of the data theft on risk is also insensitive to different assumptions on the conditional distribution of the residual. Yet, this impact seems to have vanished more rapidly in the case of LLB (compared to VPB). Also, along with a crosscheck, it has been found that these findings regarding the data theft do not hold for the inspected Swiss banks Sarasin and Vontobel. There is no accumulating impact of the Zumwinkel Affair on the volatility of their stock prices detectable.

- *Financial crisis had an effect on risk*: Volatility (measured by the conditional variance) was directly affected by the financial crisis, which is indicated by the significant dummy. This holds for both stock return series. In addition, the significant effect of the financial crisis dummy and "Zumwinkel-Affair" dummy are both not really sensitive to changes in the chosen time period of the financial crisis time dummy considering the impact on risk.

- *Strong volatility clustering is present for both stocks*: The conditional risk is clearly time-dependent and the prediction of the risk is also subject to the estimated past risk. This has been shown in different tests indicating heteroskedasticity, by the significant lagged variables within the estimation of the variance equation and by the conditional variance graph and the strong autocorrelation of the generated conditional variance series.

- *Past (negative or positive) shocks boost volatility*: Both stocks' conditional variances are very sensitive to past shocks, which is expressed by the highly significant positive coefficients of the lagged squared observations of the percentage change of the SMI and the percentage change of the stock prices in the variance equation. This finding holds for both inspected stocks and is of course related to the statement about the volatility clustering made before.

- *Closely related to the market*: Both the performance and the volatility of the two stocks are closely linked to the general market fluctuations, the influence of the SMI is significant in the mean and in the variance equation.

- *No effect of Zumwinkel Affair and financial crisis on daily returns*: Surprisingly, the Zumwinkel Affair does not seem to have a strong effect on the stock returns of both banks (at least not when it comes to their daily percentage changes). Also the financial crisis had no additional total effect on the expected daily return as the financial crisis dummy is not significant in the mean equation due to the cancelling out effect already explained.[17] The financial crisis features a significant negative impact

[17] The following comment was already outlined earlier, but should be made here to summarize a few important points within the context of the financial crisis time dummy: The insignificance of its coefficient is not extremely surprising, as the recovery period was also covered by the time dummy, leading to a cancel out effect in total as the stock values are highly correlated with the SMI (which was used to define the financial crisis time span including downturn and recovery). This is well acceptable since the main emphasis is on the variance equation as we are particularly interested in the determinants of volatility. Moreover, the originally chosen time period for the financial crisis seems very plausible: The inclusion of some recovery into the chosen time period seems fairly reasonable as the financial crisis was surely not overcome by the reaching

during the downturn period (fall 2008 until spring 2009) and a significant positive effect during the recovery period on the daily stock returns. It should be stated again, that the included financial crisis dummy captures only the additional effect of the crisis beyond the connection of the SMI and the banks' stock prices. The financial crisis therefore had an effect in the downward period on both stocks' daily return beyond the impact already covered by the bad SMI-performance: During that period, the VPB stock suffered even more from the crisis than the market and more than the LLB stock (which also suffered but not more severely than the market). Note that both the Zumwinkel Affair and the financial crisis dummy are highly significant within the variance equation, which was stated earlier.

- *Market efficiency*: While the daily VPB-stock returns feature no significant autocorrelation, we can observe serial correlation of the LLB-stock returns (also expressed through the significant lagged dependent variable in the mean equation). However, the latter finding is not in line with the efficient market hypothesis, which states that a stock price return cannot at all be predicted using past observations, since all observable information has already been processed by the market and transferred into the stock prices.

In the course of this econometric project it has been shown that insecurity concerning the examined stock prices rose within the analysed time period, expressed by increasing risk (besides a strong volatility clustering). The effect of the "Zumwinkel-Affair" played an important role in this process. Within the chosen model, this effect could be successfully separated from the market insecurity and other effects such as the financial crisis. It is not easy to judge how immediately this insecurity came from the data theft itself, but it is very reasonable to argue that it occurred from a combination of the already mentioned factors, such as the high political pressure, capital outflow, political reforms, and the transformation process within the financial sector (in this context it is important to keep in mind the comments made in the introduction[18]). Even though the causal relationships between these

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of the lowest trough of the Swiss Market Index in March 2009. During the recovery period afterwards, the market was still affected by high insecurity and volatility, which are of main interest here.

18 It is very important to clarify that the aim of this paper is not to judge which was the main driving force behind the consequences of the data theft: The international pressure on Liechtenstein, the investors' insecurity, the capital outflows, or the tax information exchange agreements (and the causal relations between these factors). The emphasis is entirely on the empirical investigation whether the data theft had an impact on the stock price risk/performance and not what the driving forces behind this impact were, not to mention the question if any of these negative consequences were avoidable at all (or even reversible). This

factors would be very interesting to investigate, it is almost impossible to analyse this question only in an econometric/statistical frame. To give answers other analytical tools should also be used. However, such considerations are not of central importance in this scientific context. The mentioned factors all contribute in a combined form to a common influence resulting in the effects shown in the econometric analysis. Along with the other included variables, the two introduced time dummies manage to capture the volatility clusters very well.

It would be very interesting to incorporate other sources of influence on the performance and the risk of the investigated stock series. However, as the model takes advantage of the daily availability of stock data, which enables a better capture of short-run dynamics, it is complicating to find other potentially influential data that are also available at such a high frequency.

Apart from the analytical conclusions arising from these empirical investigations there are also other (econometrically) important features of the applied setup: There exists convincing evidence that the chosen augmented amalGARCH(0,1,1)-model[19] is superior in this application to the popular, ordinary and "non-augmented" GARCH(1,1)-approach, which would be equivalent to the term amalGARCH(1,1,0), without any additional explanatory/control variables in the variance equation. It is also superior to the augmented GARCH(1,1)-specification without the additional squared lagged variables, albeit with similar coefficient estimates considering the two variables of interest (namely the two time dummies). As shown, the proposed setting within this contribution therefore outperforms here the widely-applied specifications after ENGLE [1982] and BOLLERSLEV [1986] that both do not include past observations in the variance equation and also the less known specification after WEISS [1984] which does include them but does not incorporate past conditional variances. This econometric finding could not have been expected in the first place, since it is an exceptional case, but supports the chosen approach beyond its analytical advantages. Additionally, the applied specification enables a better understanding, via which channels past

specific question "which one was the main impact?" might be easier to answer in a few years, maybe also leading to the conclusion that some factors, while with a negative impact in the short-run, might exhibit a positive effect in the long-run on the banks' performance and the stock prices (factors such as the transformation process or the tax information exchange agreements).

19 As already mentioned, the chosen "unconventional" and augmented amalGARCH (0,1,1)-model contains squared past observations of the SMI-value's daily percentage change and the bank's stock returns plus the two time dummies for the "Zumwinkel-Affair" and the financial crisis in the variance equation, while the squared lagged residuals originating from the mean equation are dropped.

shocks translate into rising volatility of the stock prices, compared to the widely applied settings by the prementioned authors only incorporating conventional components into the variance equation (the past conditional variances and undefined past shocks via the past squared residuals). The interesting past shocks are made visible in the proposed augmented amalGARCH(0,1,1)-setting by introducing additional explanatory variables such as the past squared returns of the particular stock value and the squared percentage changes of the whole market index and also potential shocks on either or both of them.

Also, in the course of this project, a new term classifying popular specifications of the modelling of the conditional variance within one group could be introduced. This term, amalGARCH(p,q,s), includes possible amalgams of the approaches of ENGLE [1982], WEISS [1984] and BOLLERSLEV [1986]/TAYLOR [1986]

Appendix

A.1. Alternative GARCH-Approaches within Main Model

As already mentioned and explained in sections 2.2. and 2.3., a different GARCH-approach has been applied as an alternative to the applied augmented amalGARCH(0,1,1)-specification with lagged squared observations of the stock prices and of the SMI ($\%\Delta VPB(-1)^2$ or $\%\Delta LLB(-1)^2$ and $\%\Delta SMI(-1)^2$). Also, ARCH-models after ENGLE [1982] (amalGARCH(p,0,0) that only includes past residuals) have been estimated but then skipped as they were inferior to the GARCH-specifications after BOLLERSLEV [1986]).

The relevant results appear insensitive to the distinction between the augmented amalGARCH(0,1,1) or the augmented GARCH(1,1) specification without lagged squared observations: The evaluation of the effects of the "Zumwinkel-Affair" and the financial crisis on performance and risk, which was the main objective of investigation in this paper, remains unaltered. The statement made in footnote 12 can be repeated here, as its holds for the estimation process of $\%\Delta VPB$ and $\%\Delta LLB$: It seems that it is problematic in this case to include past observations (of variables from the mean equation) and past squared residuals (of the mean equation) into the variance equation. Higher GARCH-orders in the original augmented variance equation (especially of past squared residuals) generate unacceptable many insignificant estimates and even negative coefficients (which is invalid here). Dropping the lagged variables from the variance equation removes these problems. But figure 10 and 12, where percentage differences of variables if prefixed with "PD_", show that the two alternative approaches generate analogous results.

The significance structure of the variables within the mean and the variance equation and the estimated coefficients remains nearly unchanged (same signs and comparable magnitude).

Dependent Variable: PD_VPB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 01/27/11 Time: 04:50
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 42 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*GARCH(-1) + C(7)*PD_VPB(-1)^2 + C(8)
*PD_SMI(-1)^2 + C(9)*FINANCIALCRISIS + C(10)*DATATHEFT

	Coefficient	Std. Error	z-Statistic	Prob.
PD_VPB(-1)	-0.010239	0.031656	-0.323430	0.7464
PD_SMI	0.594137	0.042882	13.85515	0.0000
FINANCIALCRISIS	-0.019577	0.261002	-0.075007	0.9402
DATATHEFT	-0.017935	0.091245	-0.196553	0.8442
Variance Equation				
C	0.307309	0.084682	3.628972	0.0003
GARCH(-1)	0.645165	0.064753	9.963490	0.0000
PD_VPB(-1)^2	0.108462	0.022197	4.886225	0.0000
PD_SMI(-1)^2	0.169894	0.041518	4.092028	0.0000
FINANCIALCRISIS	1.982111	0.497751	3.982132	0.0001
DATATHEFT	0.454955	0.121831	3.734311	0.0002

R-squared	0.125485	Mean dependent var	-0.022798
Adjusted R-squared	0.119169	S.D. dependent var	2.460821
S.E. of regression	2.309545	Akaike info criterion	4.147858
Sum squared resid	6646.159	Schwarz criterion	4.188747
Log likelihood	-2594.855	Durbin-Watson stat	1.926045

Dependent Variable: PD_VPB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 01/27/11 Time: 05:29
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 27 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1) + C(8)
*FINANCIALCRISIS + C(9)*DATATHEFT

	Coefficient	Std. Error	z-Statistic	Prob.
PD_VPB(-1)	-0.010846	0.029363	-0.369357	0.7119
PD_SMI	0.565213	0.037601	15.03192	0.0000
FINANCIALCRISIS	0.193831	0.248199	0.780952	0.4348
DATATHEFT	-0.042140	0.093559	-0.450414	0.6524
Variance Equation				
C	0.367928	0.094571	3.890492	0.0001
RESID(-1)^2	0.157713	0.028247	5.583388	0.0000
GARCH(-1)	0.658494	0.061456	10.71481	0.0000
FINANCIALCRISIS	1.884990	0.492926	3.824081	0.0001
DATATHEFT	0.478630	0.125134	3.824944	0.0001

R-squared	0.122376	Mean dependent var	-0.022798
Adjusted R-squared	0.116745	S.D. dependent var	2.460821
S.E. of regression	2.312719	Akaike info criterion	4.169544
Sum squared resid	6669.791	Schwarz criterion	4.206344
Log likelihood	-2609.474	Durbin-Watson stat	1.918032

FIGURE 10: Estimation outputs of the augmented GARCH(0,1)-model and alternative GARCH(1,1)-model (%ΔVPB)

Also the patterns of the estimated conditional standard deviation shown in figure 11 and gained from the variance equation are comparable for the two approaches:

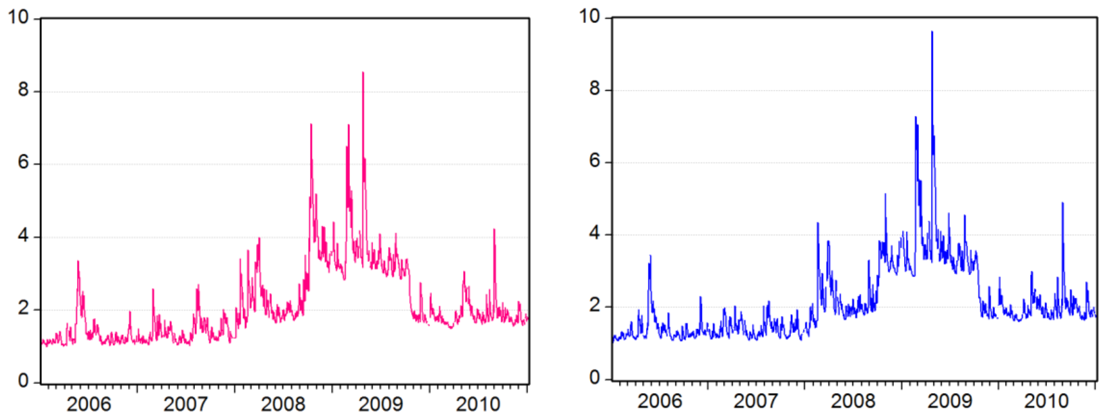


FIGURE 11: Conditional standard deviation (%ΔVPB) applying a GARCH(0,1)-model with squared past observations (left graph) and a GARCH(1,1)-model without squared past observations (right graph)

Both estimated conditional standard deviations show similarly timed volatility outbursts, especially during the financial crisis (end of 2008 until end of 2009) and in the beginning of the "Zumwinkel-Affair" (in the beginning of 2008). Both graphs feature a strong and similar volatility clustering.

Dependent Variable: PD_LLB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 01/27/11 Time: 05:25
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 17 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*GARCH(-1) + C(7)*PD_LLB(-1)^2 + C(8)*PD_SMI(-1)^2 + C(9)*FINANCIALCRISIS + C(10)*DATATHEFT

	Coefficient	Std. Error	z-Statistic	Prob.
PD_LLB(-1)	-0.086890	0.032827	-2.646936	0.0081
PD_SMI	0.416952	0.039077	10.67009	0.0000
FINANCIALCRISIS	0.078399	0.188691	0.415490	0.6778
DATATHEFT	-0.010578	0.074336	-0.142297	0.8868
Variance Equation				
C	0.421693	0.092447	4.561443	0.0000
GARCH(-1)	0.533147	0.060467	8.817209	0.0000
PD_LLB(-1)^2	0.163867	0.022305	7.346628	0.0000
PD_SMI(-1)^2	0.244959	0.050403	4.859966	0.0000
FINANCIALCRISIS	1.224834	0.383799	3.191338	0.0014
DATATHEFT	0.161700	0.076432	2.115617	0.0344

R-squared	0.077355	Mean dependent var	0.014775
Adjusted R-squared	0.070691	S.D. dependent var	2.047996
S.E. of regression	1.974282	Akaike info criterion	3.949250
Sum squared resid	4856.648	Schwarz criterion	3.990139
Log likelihood	-2470.129	Durbin-Watson stat	2.001918

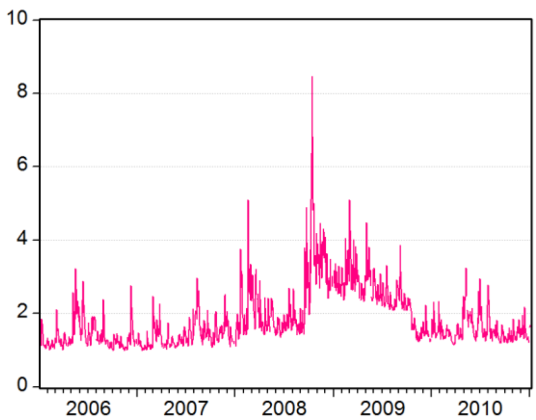
Dependent Variable: PD_LLB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 01/27/11 Time: 05:28
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 19 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1) + C(8)*FINANCIALCRISIS + C(9)*DATATHEFT

	Coefficient	Std. Error	z-Statistic	Prob.
PD_LLB(-1)	-0.081035	0.030009	-2.700302	0.0069
PD_SMI	0.428196	0.031033	13.79792	0.0000
FINANCIALCRISIS	0.037523	0.185392	0.202399	0.8396
DATATHEFT	0.004081	0.071469	0.057102	0.9545
Variance Equation				
C	0.570370	0.098710	5.778220	0.0000
RESID(-1)^2	0.225942	0.024068	9.387582	0.0000
GARCH(-1)	0.531451	0.053820	9.874635	0.0000
FINANCIALCRISIS	1.548949	0.388522	3.986768	0.0001
DATATHEFT	0.182107	0.076537	2.379317	0.0173

R-squared	0.077565	Mean dependent var	0.014775
Adjusted R-squared	0.071647	S.D. dependent var	2.047996
S.E. of regression	1.973266	Akaike info criterion	3.969404
Sum squared resid	4855.544	Schwarz criterion	4.006205
Log likelihood	-2483.786	Durbin-Watson stat	2.014471

FIGURE 12: Estimation outputs of the augmented GARCH (0,1)-model and alternative GARCH(1,1)-model (%ΔLLB)

The former findings from inspecting the amalGARCH(1,1,0)-regression of %Δ*VPB* also hold for the regression of %Δ*LLB*. The significance of the variables is unchanged with same signs and comparable magnitude of the coefficients. Also the pattern of the estimated conditional standard deviations shown in figure 13 and gained from the variance equation is comparable for the two model approaches:



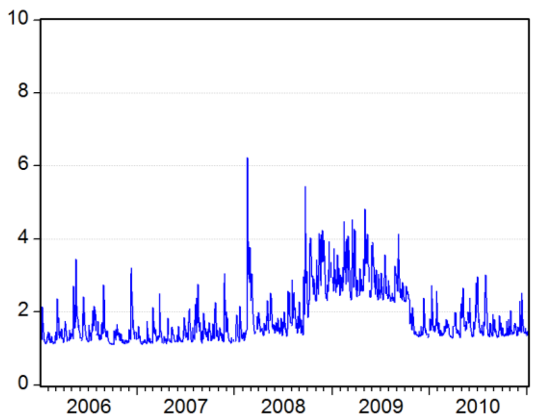


FIGURE 13: Conditional standard deviation (%ΔLLB) applying a GARCH(0,1)-model with squared past observations (left graph) and a GARCH(1,1)-model without squared past observations (right graph)

As already stated in the main section of this text, also an ordinary popular benchmark model has been estimated: The “non-augmented” pure GARCH(1,1), which is equivalent to non-augmented amalGARCH(1,1,0), whose output is listed in figure 14.

Dependent Variable: PD_VPB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 02/06/11 Time: 03:38
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 31 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
PD_VPB(-1)	-0.008312	0.027461	-0.302686	0.7621
PD_SMI	0.561171	0.039259	14.29402	0.0000
FINANCIALCRISIS	0.132898	0.176759	0.751863	0.4521
DATATHEFT	-0.022319	0.081462	-0.273986	0.7841
Variance Equation				
C	0.047823	0.012418	3.851020	0.0001
RESID(-1)^2	0.093660	0.009938	9.424133	0.0000
GARCH(-1)	0.904649	0.007291	124.0696	0.0000

R-squared	0.122964	Mean dependent var	-0.022798
Adjusted R-squared	0.118751	S.D. dependent var	2.460821
S.E. of regression	2.310092	Akaike info criterion	4.194759
Sum squared resid	6665.321	Schwarz criterion	4.223381
Log likelihood	-2627.309	Durbin-Watson stat	1.924071

Dependent Variable: PD_LLB
Method: ML - ARCH (Marquardt) - Normal distribution
Date: 02/06/11 Time: 03:28
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments
Convergence achieved after 16 iterations
Variance backcast: ON
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
PD_LLB(-1)	-0.079928	0.028993	-2.756821	0.0058
PD_SMI	0.440562	0.029036	15.17321	0.0000
FINANCIALCRISIS	0.013665	0.130250	0.104917	0.9164
DATATHEFT	0.009709	0.067526	0.143782	0.8857
Variance Equation				
C	0.265468	0.039524	6.716619	0.0000
RESID(-1)^2	0.190966	0.017740	10.76456	0.0000
GARCH(-1)	0.749135	0.021126	35.46105	0.0000

R-squared	0.077360	Mean dependent var	0.014775
Adjusted R-squared	0.072928	S.D. dependent var	2.047996
S.E. of regression	1.971904	Akaike info criterion	4.000645
Sum squared resid	4856.621	Schwarz criterion	4.029267
Log likelihood	-2505.405	Durbin-Watson stat	2.017996

FIGURE 14: Estimation output of a pure GARCH (1,1)-approach as benchmark model applied for %ΔLLB (right table) and %ΔVPB (left table)

The highly significant coefficients of the explanatory/control variables and the better information criteria (as shown in figure 10, 12, 14 and 16) indicate that the chosen augmented amalGARCH(0,1,1)-model is an improvement to the more parsimonious specifications.

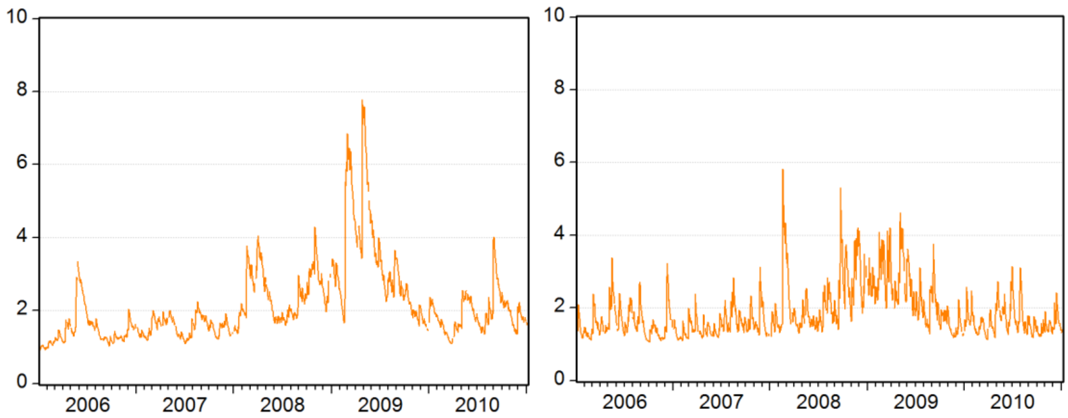


FIGURE 15: Conditional standard deviation applying a “non-augmented” GARCH(1,1)-model for %ΔVPB (left graph) and %ΔLLB (right graph)

Figure 15 shows the estimated conditional standard deviations of the stock returns of the two banks applying the ordinary GARCH(1,1)-benchmark model. In both graphs the beginning of the “Zumwinkel-Affair” in the first half of 2008 and the financial crisis (especially during 2009) are visible through higher volatility.

Figure 16 exhibits an overview of the described competing models with the different specification of the variance equation. It features the various GARCH-specifications, which have just been outlined. It is visible that the coefficient estimates of the important variables are not very different considering the sign, significance and magnitude of the coefficients.

	Dependent Variable					
	$\%\Delta VPB_t$			$\%\Delta LLB_t$		
(Conditional) Mean Equation						
$\%\Delta VPB_{t-1}$	-0.0102	-0.0108	-0.0083			
$\%\Delta LLB_{t-1}$				-0.0869***	-0.0810***	-0.0799***
$\%\Delta SMI_t$	0.5941***	0.5652***	0.5612***	0.4170***	0.4282***	0.4406***
Financial Crisis	-0.0196	0.1938	0.1329	0.0784	0.0375	0.0137
Data Theft	-0.0179	-0.0421	-0.0223	-0.0106	0.0041	0.0097
(Conditional) Variance Equation						
Constant	0.3073***	0.3679***	0.0478***	0.4217***	0.5704***	0.2655***
$ARCH(1)^{1)} : \hat{u}_{t-1}^2$		0.1577***	0.0937***		0.2259***	0.1910***
$GARCH(1)^{2)} : h_{t-1}$	0.6452***	0.6585***	0.9046***	0.5331***	0.5315***	0.7491***
$\%\Delta VPB_{t-1}^2$	0.1085***					
$\%\Delta LLB_{t-1}^2$				0.1639***		
$\%\Delta SMI_{t-1}^2$	0.1699***			0.2450***		
Financial Crisis	1.9821***	1.8850***		1.2248***	1.5489***	
Data Theft	0.4550***	0.4786***		0.1617**	0.1821**	
Measures of Fit						
R^2	0.1255	0.1224	0.1230	0.0774	0.0776	0.0774
Adjusted R^2	0.1192	0.1167	0.1188	0.0707	0.0716	0.0729
Akaike Info Criterion	4.1479	4.1695	4.1948	3.9493	3.9694	4.0006
Schwarz Info Criterion	4.1887	4.2063	4.2234	3.9901	4.0062	4.0293

[1)] Past squared residual from the mean equation (past shocks).
[2)] Lagged conditional variance (serial time dependency of risk).
The magnitude of the relevant p-values are marked with stars and therefore reflects the significance of the respective parameter (*: p-value ≤ 0.10 and > 0.05, **: p-value ≤ 0.05 and > 0.01, ***: p-value ≤ 0.01). The p-value denotes the lowest significance level at which the null hypothesis (of insignificance in this case) could be rejected regarding the regressor's t-value (which is here the estimated coefficient of the regressor divided by the estimated standard error of the coefficient).
See sections 2.2. and 2.3. for the theoretical equation setup and estimation results of the main GARCH-models.

FIGURE 16: Competing models with different specifications of the variance equation

It also turns out that the applied setting, the augmented amalGARCH(0,1,1,) outperforms the other two benchmarking approaches in this application. Note that footnote 14 applies here, as well.

A.2. Inclusion of TED Spread

As an alternative proxy for the financial crisis (apart from the financial crisis time dummy), one could also include the TED spread. The TED ("treasury bill euro difference dollar") spread is the calculated difference between the interest rates of the 3-months dollar-LIBOR (interbank loans) and the interest rates of 3-months U.S. treasury bills. The spread is expressed in base points: So if, for example, the LIBOR's interest rate is one percentage point higher (e.g. 6%) than the treasuries' interest rate (e.g. 5%), then the TED spread is 100. The TED spread captures the observed credit risk and is therefore a good indicator for the trust in the financial market. As it turns out, the inclusion of the TED spread does not affect the sign or the significance of the dummy capturing the Zumwinkel-Affair.

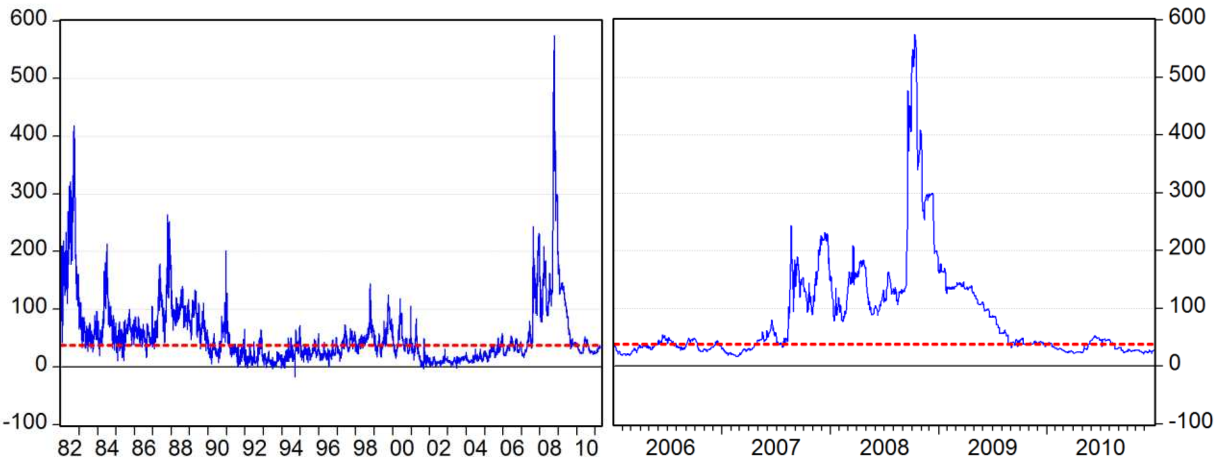


FIGURE 17: The TED spread (blue line) and its historical median (red dotted line)

Figure 17 shows the TED spread since 1982 (left graph) and in more detail covering the investigated time period (right graph). Different recessions or shocks are visibly expressed by the TED spread time plot: The second oil shock around 1981/1982, the Black Monday in 1987, the Iraq War in 1990, the Asian Crisis by the end of the 90th century and the turbulences in 2001. But most importantly, the outburst reflects the financial crisis very strikingly.

Carrying out the estimations including the daily percentage change of the TED spread, it can be observed table of figure 18 that the clear significant effects of the financial crisis and the Zumwinkel Affair within the variance equation remain untouched.[20] If the output tables showing the main models in section 2.2. and 2.3. are consulted, it is evident that also the other important variables are unaffected inspecting the sign and significance of their coefficients. But it should be noted that the percentage change of the TED spread is significant within the mean equation of the LLB-stocks and slightly significant within the variance equation of the VPB-stocks. At first sight, it is not easy to identify particular reasons why the TED spread seems to have an impact on the return of the LLB-stock in mean and on the risk of the VPB-

[20] The sample had to be slightly adjusted as the trading days in the US sometimes differ from the trading days in Switzerland. Also, daily percentage changes of the TED spread have been calculated and used in the estimations because of analytical reasons and since various tests indicate that the TED spread contains a unit root and therefore follows a random walk.

stock, but not directly on the level of the returns of VPB and not on risk of LLB. This will not be examined here in further detail but would sure be worth being investigated in future research.

	Dependent Variable					
	$\%\Delta VPB_t$			$\%\Delta LLB_t$		
(Conditional) Mean Equation						
$\%\Delta VPB_{t-1}$	0.0044	-0.0065	-0.0056			
$\%\Delta LLB_{t-1}$				-0.0894***	-0.0868***	-0.0869***
$\%\Delta SMI_t$	0.5684***	0.5680***	0.5683***	0.3984***	0.4087***	0.4072***
Financial Crisis		-0.0014	0.0183		0.0396	0.0839
$\%\Delta TED\ Spread_t$	-0.0023	-0.0036	-0.0041	-0.0110**	-0.0125**	-0.0152***
$Financial\ Crisis * \%\Delta TED\ Spread_t$			0.0146			0.0606
Data Theft	-0.0067	-0.0061	-0.0067	0.0047	-0.0181	-0.0179
(Conditional) Variance Equation						
Constant	0.0718***	0.2497***	0.2917***	0.2215***	0.3936***	0.3975***
$GARCH(1)^{1)} : h_{t-1}$	0.8440***	0.6946***	0.6515***	0.6934***	0.5918***	0.5903***
$\%\Delta VPB_{t-1}^2$	0.0897***	0.0986***	0.1100***			
$\%\Delta LLB_{t-1}^2$				0.1329***	0.1265***	0.1267***
$\%\Delta SMI_{t-1}^2$	0.0754***	0.1353***	0.1532***	0.1765***	0.1827***	0.1806***
Financial Crisis		1.7046***	1.8318***		1.1303***	1.0585***
$\%\Delta TED\ Spread_t$	0.0105*	0.0181**	0.0185**	-0.0008	0.0049	0.0050
$Financial\ Crisis * \%\Delta TED\ Spread_t$			-0.1799			-0.0368
Data Theft	0.1737***	0.3677***	0.4299***	0.1842***	0.1623**	0.1631**
Measures of Fit						
R^2	0.1163	0.1156	0.1161	0.0717	0.0716	0.0792
Adjusted R^2	0.1097	0.1075	0.1065	0.0648	0.0631	0.0693
Akaike Info Criterion	4.1500	4.1279	4.1302	3.9451	3.9300	3.9293
Schwarz Info Criterion	4.1920	4.1784	4.1890	3.9871	3.9804	3.9881

[1)] Lagged conditional variance (serial time dependency of risk)
The magnitude of the relevant p-values are marked with stars and therefore reflects the significance of the respective parameter (*: p-value ≤ 0.10 and > 0.05, **: p-value ≤ 0.05 and > 0.01, ***: p-value ≤ 0.01). The p-value denotes the lowest significance level at which the null hypothesis (of insignificance in this case) could be rejected regarding the regressor’s t-value (which is here the estimated coefficient of the regressor divided by the estimated standard error of the coefficient).
See sections 2.2. and 2.3. for the theoretical equation setup and estimation results of the main GARCH-models.

FIGURE 18: Competing models including the TED spread’s percentage change

A.3. Evaluation of Alternative Time Spans of the Financial Crisis

As already stated in the main text, it is useful to allow for different lengths of the chosen time period of the financial crisis captured by the financial time dummy. In chapter 2.1., the motivation for the original choice of the time span of the two time dummies is already outlined. Along with the original time span (labelled with "Financial Crisis") from October 6th (2008) to October 16th (2009) with the SMI as reference two other time spans have been applied: As second time span covered, a shorter period is applied and just covers the sharp decline from October 6th (2008) until March 9th (2008), again with the SMI as reference for the downturn. A longer period, which now relies on the TED spread[21] as reference, has also been considered. Apart from the visual detection of the visible beginning of the financial crisis by inspecting the TED chart, the median of the TED spread serves as a useful threshold for a more precise detection of the timing of the financial crisis (see figure 17). The TED spread exceeds the median of 38 on April 25th (2007) and does not score below 38 until August 24th (2009). This time span has been chosen to set the length for the longest period of the financial crisis time dummy (labelled in figure 19 as "Financial Crisis (long)"). The three different time periods chosen are marked in the following figure.

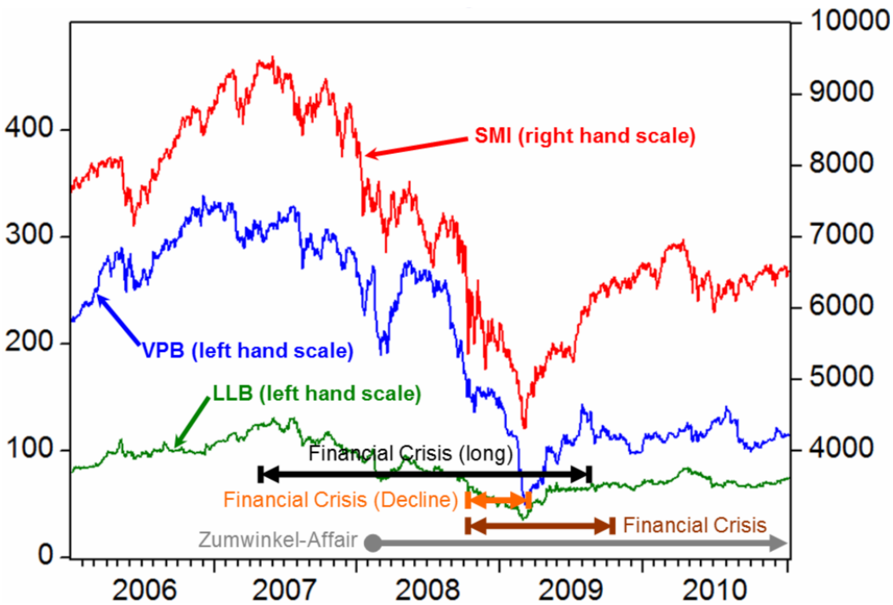


FIGURE 19: Different specifications of the financial crisis time dummy's length

All the relevant estimation results are listed in the output table of figure 20 and are summarized in the following. The crucial finding that the Zumwinkel-Affair had a significant

21 The explanation and the plotted time series of the TED spread can be found in section A.2. of the appendix.

(accumulating) effect on the risk of the banks' stock values is insensitive to the different lengths of the time span of the financial crisis dummy. The effect of the financial crisis on risk vanishes in the longest time period specification of the financial crisis time dummy. This is the case within the variance equation of both stock values.

	Dependent Variable					
	$\%\Delta VPB_t$			$\%\Delta LLB_t$		
(Conditional) Mean Equation						
$\%\Delta VPB_{t-1}$	-0.0102	-0.0022	0.0031			
$\%\Delta LLB_{t-1}$				-0.0869***	-0.0895***	-0.0904***
$\%\Delta SMI_t$	0.5941***	0.5849***	0.5931***	0.4170***	0.3985***	0.4028***
Financial Crisis	-0.0196			0.0784		
Financial Crisis (Short)		-0.8684**			-0.5173	
Financial Crisis (Long)			-0.0392			-0.0246
Data Theft	-0.0179	0.0310	-0.0106	-0.0106	0.0461	0.0262
(Conditional) Variance Equation						
Constant	0.3073***	0.0585***	0.0692***	0.4217***	0.3342***	0.2607***
$GARCH(1)^{1)}: h_{t-1}$	0.6452***	0.8836***	0.8569***	0.5331***	0.5826***	0.6218***
$\%\Delta VPB_{t-1}^2$	0.1085***	0.0633***	0.0810***			
$\%\Delta LLB_{t-1}^2$				0.1639***	0.1714***	0.1696***
$\%\Delta SMI_{t-1}^2$	0.1699***	0.0588***	0.0604***	0.2450***	0.2360***	0.2215***
Financial Crisis	1.9821***			1.2248***		
Financial Crisis (Short)		0.2207**			1.2306*	
Financial Crisis (Long)			0.0332			0.0960
Data Theft	0.4550***	0.1091***	0.1565***	0.1617**	0.2413***	0.2096***
Measures of Fit						
R^2	0.1255	0.1365	0.1267	0.0774	0.0818	0.0771
Adjusted R^2	0.1192	0.1303	0.1204	0.0707	0.0752	0.0704
Akaike Info Criterion	4.1479	4.1644	4.1712	3.9493	3.9595	3.9663
Schwarz Info Criterion	4.1887	4.2053	4.2121	3.9901	4.0004	4.0072

1) Lagged conditional variance (serial time dependency of risk).
The magnitude of the relevant p-values are marked with stars and therefore reflects the significance of the respective parameter (*: p-value ≤ 0.10 and > 0.05, **: p-value ≤ 0.05 and > 0.01, ***: p-value ≤ 0.01). The p-value denotes the lowest significance level at which the null hypothesis (of insignificance in this case) could be rejected regarding the regressor's t-value (which is here the estimated coefficient of the regressor divided by the estimated standard error of the coefficient).
See sections 2.2. and 2.3. for the theoretical equation setup and estimation results of the main GARCH-models.

FIGURE 20: Competing models with different time periods of the financial crisis dummy

There is an additional observation that only for the shortest period (the downturn phase without recovery) the financial crisis dummy shows significance in the mean equation of the VPB-stocks, while it shows no significance within the mean equation of the LLB-stock for all various lengths of the financial crisis dummy. If the SMI is removed from the mean equation then the financial crisis dummy becomes also significant in the equation with the LLB-stock as dependent variable. So, the financial crisis had no impact on the LLB- and no impact on the VPB-stock average returns that was worse compared to the impact on the market (not in the downward phase and not if the recovery period is included into the time definition of the financial crisis). Second, they only suffered from the financial crisis during the downturn phase. The LLB-stock was hit to a very similar extent as the market, the VPB-stock performed even worse than the market.

It should be stressed again that the SMI-variable also contains the impact of the financial crisis on the whole market to which the banks' stocks are heavily linked and correlated. The financial crisis dummy in the mean equation therefore measures whether the impact was stronger or less strong compared to the market.

The originally chosen time period appears to be the most appropriate as the emphasis should be on the most suitable time period concerning the variance equation which is of main interest in this contribution's analysis. Also, the information criteria are optimized in that setting regarding the length of the financial crisis time dummy (note that the sample is always the same). The longest period seems too long in this context. The recovery should also be included as it was still a very insecure period affecting returns and especially volatility on the financial markets[22].

A.4. Detection of ARCH-Effects of the Investigated Time Series

As already argued in the main text, both investigated series ($\%\Delta VPB$ and $\%\Delta LLB$) seem to feature autoregressive heteroskedasticity. In the following, these findings of the descriptive analysis shall be underlined in a more elaborate manner. First, the series of the VPB-stock is investigated: In the left graph of figure 21 we can recognize that the occurrence of extreme values is more likely compared to the normal quantile ("heavy tail property"), while the right graph shows the higher kurtosis of the series compared to the normal distribution.

22 The high level of stock prices in 2007 can be seen as "overshooting" rather than being a good "average benchmark".

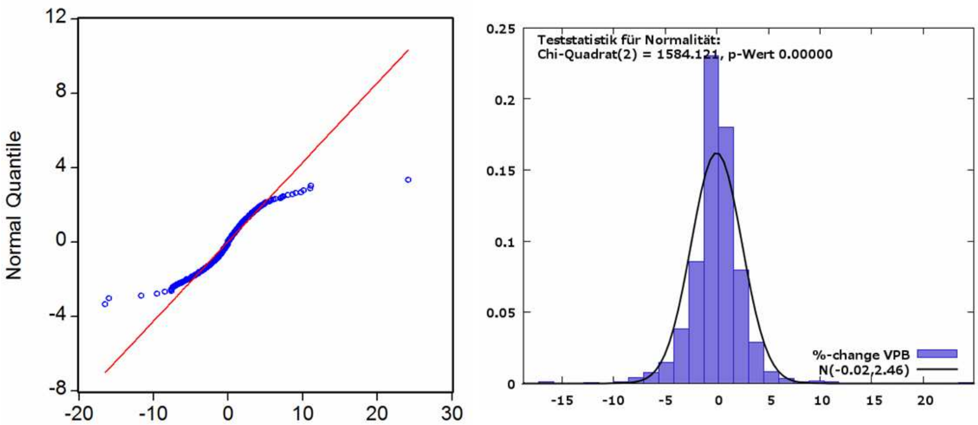


FIGURE 21: Comparison of sample distribution/quantile with normal distribution/quantile (%ΔVPB)

The setup of the estimation has already been introduced (in section 2.1.). Carrying out the estimation of the mean equation (in a first step without GARCH-modelling) delivers already in an early stage important conclusions that highlight the econometric suitability of the inclusion of a GARCH-structure: The regression of the daily percentage difference of the VPB-stock prices (denoted as PD_VPB) yields autocorrelated squared residuals. On the other hand, the non-squared residuals show no clearly significant serial correlation. Also the autocorrelation function of the series $\%\Delta VPB$ itself unveils no autocorrelation, while the autocorrelation function of $\%\Delta VPB^2$ shows significant autocorrelation and therefore heteroskedastic characteristics. Positive serial dependency of the residuals‘ second moments indicates that the variance is not constant over time (heteroskedasticity, volatility clustering). Results are shown in the following figure.

Dependent Variable: PD_VPB
Method: Least Squares
Date: 01/27/11 Time: 04:56
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PD_VPB(-1)	0.043607	0.026374	1.653386	0.0985
PD_SMI	0.652914	0.048323	13.51158	0.0000
FINANCIALCRISIS	-0.019899	0.178008	-0.111785	0.9110
DATATHEFT	-0.061710	0.106261	-0.580735	0.5615

R-squared	0.129675	Mean dependent var	-0.022798
Adjusted R-squared	0.127590	S.D. dependent var	2.460821
S.E. of regression	2.298478	Akaike info criterion	4.505551
Sum squared resid	6614.315	Schwarz criterion	4.521906
Log likelihood	-2825.486	Durbin-Watson stat	2.042928

Correlogram of squared residuals ($\hat{u}_t^2$)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.134	0.134	22.751	0.000
		2	0.085	0.068	31.922	0.000
		3	0.130	0.113	53.382	0.000
		4	0.133	0.101	75.560	0.000
		5	0.208	0.173	130.04	0.000
		6	0.030	-0.038	131.16	0.000
		7	0.048	0.004	134.04	0.000
		8	0.081	0.026	142.35	0.000
		9	0.076	0.028	149.69	0.000
		10	0.101	0.052	162.52	0.000

FIGURE 22: Results of “ordinary” estimation (without GARCH-specification)
and correlogram of squared residuals

To verify the presence of autoregressive heteroskedasticity in a more formal way, an ARCH-test as proposed by ENGLE [1982] is carried out. Both the Lagrange Multiplier (LM) test and the F-test are computed using an auxiliary regression of the "ordinary" model's squared residual against squared lagged[23] residuals plus a constant.

Dependent Variable: PD_VPB
Method: Least Squares
Date: 01/27/11 Time: 04:56
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PD_VPB(-1)	0.043607	0.026374	1.653386	0.0985
PD_SMI	0.652914	0.048323	13.51158	0.0000
FINANCIALCRISIS	-0.019899	0.178008	-0.111785	0.9110
DATATHEFT	-0.061710	0.106261	-0.580735	0.5615

R-squared	0.129675	Mean dependent var	-0.022798
Adjusted R-squared	0.127590	S.D. dependent var	2.460821
S.E. of regression	2.298478	Akaike info criterion	4.505551
Sum squared resid	6614.315	Schwarz criterion	4.521906
Log likelihood	-2825.486	Durbin-Watson stat	2.042928

ARCH Test:

F-statistic	19.78249	Probability	0.000000
Obs*R-squared	92.07405	Probability	0.000000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 01/12/11 Time: 17:46
Sample (adjusted): 1/12/2006 1/04/2011
Included observations: 1251 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.808677	0.601979	4.665742	0.0000
RESID^2(-1)	0.088483	0.027914	3.169867	0.0016
RESID^2(-2)	0.031312	0.027928	1.121157	0.2624
RESID^2(-3)	0.092864	0.027818	3.338267	0.0009
RESID^2(-4)	0.082709	0.027928	2.961512	0.0031
RESID^2(-5)	0.172990	0.027914	6.197282	0.0000

R-squared	0.073600	Mean dependent var	5.283407
Adjusted R-squared	0.069880	S.D. dependent var	19.81501
S.E. of regression	19.11013	Akaike info criterion	8.743099
Sum squared resid	454670.5	Schwarz criterion	8.767712
Log likelihood	-5462.808	F-statistic	19.78249
Durbin-Watson stat	1.986909	Prob(F-statistic)	0.000000

FIGURE 23: Results of „ordinary" estimation (without GARCH-specification) and ARCH-test

While Engle's LM-statistic is calculated by multiplying the estimated R^2 with the number of observations, the F-test checks the joint significance of the squared lagged residuals. Both statistics reject the null of non-existence of ARCH-effects clearly, as indicated by the p-values (both 0.0000) reported in figure 23. Thus, the obtained results of the ARCH-test are entirely in line with the prior findings from section 2.1. and strongly notify the existence of ARCH-effects.

Now, if the LLB stocks' sample distribution is as well compared with the adjusted normal distributions and quantiles, as done with the VPB-stocks, we can again deduce that the occurrence of extreme values is more likely compared to the normal quantile and that the kurtosis of the series is higher compared to the normal distribution:

[23] The lag length has been chosen as subject to the AKAIKE [1974] and the SCHWARZ [1978] information criteria, but it was found that the clear test results were insensitive to varying lag lengths anyway.

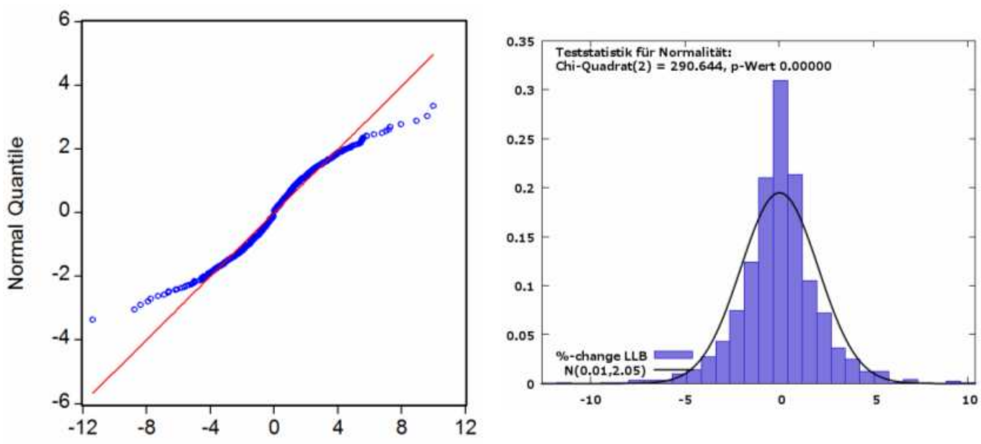


FIGURE 24: Comparison of sample distribution/quantile with normal distribution/quantile (%ΔLLB

The estimation without GARCH-modelling yields autocorrelated squared residuals. The reported results are shown below:

Dependent Variable: PD_LLB
Method: Least Squares
Date: 01/27/11 Time: 05:19
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PD_LLB(-1)	-0.055013	0.027140	-2.027017	0.0429
PD_SMI	0.416425	0.041392	10.06045	0.0000
FINANCIALCRISIS	0.080021	0.152443	0.524923	0.5997
DATATHEFT	-0.041855	0.090990	-0.459994	0.6456

R-squared	0.078506	Mean dependent var	0.014775
Adjusted R-squared	0.076298	S.D. dependent var	2.047996
S.E. of regression	1.968317	Akaike info criterion	4.195415
Sum squared resid	4850.590	Schwarz criterion	4.211770
Log likelihood	-2630.720	Durbin-Watson stat	2.063262

Correlogram of squared residuals ($\hat{u}_t^2$)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.225	0.225	63.565	0.000
		2	0.110	0.063	78.890	0.000
		3	0.101	0.067	91.670	0.000
		4	0.120	0.084	109.92	0.000
		5	0.149	0.103	138.09	0.000
		6	0.128	0.064	158.69	0.000
		7	0.185	0.131	201.95	0.000
		8	0.015	-0.083	202.23	0.000
		9	0.099	0.072	214.74	0.000
		10	0.073	0.002	221.42	0.000

FIGURE 25: Results of "ordinary" estimation (without GARCH-specification)
and correlogram of squared residuals

Also the autocorrelation function of $\%\Delta LLB^2$ shows a significant degree of autocorrelation and therefore a strong heteroskedastic pattern. Hence, the variance is not constant over time (heteroskedasticity and volatility clustering). Again, an ARCH-test as proposed by ENGLE [1982] is carried out. The reported results of the ARCH-test, as shown in figure 26, strongly indicate the existence of ARCH-effects since the null of insignificance of the lagged squared residuals[24] can be clearly rejected executing both the LM- and the F-test[25]:

---

[24] Again, footnote 23 applies.
[25] The test procedure has already been explained in further detail before.

Dependent Variable: PD_LLB
Method: Least Squares
Date: 01/27/11 Time: 05:19
Sample (adjusted): 1/05/2006 1/04/2011
Included observations: 1256 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PD_LLB(-1)	-0.055013	0.027140	-2.027017	0.0429
PD_SMI	0.416425	0.041392	10.06045	0.0000
FINANCIALCRISIS	0.080021	0.152443	0.524923	0.5997
DATATHEFT	-0.041855	0.090990	-0.459994	0.6456

R-squared	0.078506	Mean dependent var	0.014775
Adjusted R-squared	0.076298	S.D. dependent var	2.047996
S.E. of regression	1.968317	Akaike info criterion	4.195415
Sum squared resid	4850.590	Schwarz criterion	4.211770
Log likelihood	-2630.720	Durbin-Watson stat	2.063262

ARCH Test:

F-statistic	17.49565	Probability	0.000000
Obs*R-squared	126.6722	Probability	0.000000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 01/13/11 Time: 19:16
Sample (adjusted): 1/17/2006 1/04/2011
Included observations: 1248 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.893423	0.316564	5.981176	0.0000
RESID^2(-1)	0.188414	0.028310	6.655276	0.0000
RESID^2(-2)	0.026926	0.028512	0.944367	0.3452
RESID^2(-3)	0.041435	0.028497	1.454037	0.1462
RESID^2(-4)	0.060222	0.028409	2.119808	0.0342
RESID^2(-5)	0.089206	0.028406	3.140347	0.0017
RESID^2(-6)	0.042265	0.028471	1.484501	0.1379
RESID^2(-7)	0.145438	0.028483	5.106122	0.0000
RESID^2(-8)	-0.083109	0.028285	-2.938254	0.0034

R-squared	0.101500	Mean dependent var	3.872228
Adjusted R-squared	0.095699	S.D. dependent var	8.891254
S.E. of regression	8.455117	Akaike info criterion	7.114606
Sum squared resid	88574.87	Schwarz criterion	7.151596
Log likelihood	-4430.514	F-statistic	17.49565
Durbin-Watson stat	1.987927	Prob(F-statistic)	0.000000

FIGURE 26: Results of „ordinary" estimation (without GARCH-specification) and ARCH-test

Hence, it truly makes sense to apply some GARCH-model to properly account for the existence of autoregressive heteroskedasticity, which is (from an econometric point of view) not especially surprising in the context of financial time series. But as already explained, the analytic advantages of modelling the conditional variance also justify the use of a GARCH-model, since we are directly interested in influences not only on the average performance but especially on the risk (measured by the conditional variance).

A.5. Additional Facts to Liechtenstein's Financial Sector and Zumwinkel-Affair

The "Liechtenstein Global Trust" (LGT) was founded in 1920. It is owned by the princely family of Liechtenstein. LGT has 1'985 employees (2010) worldwide. The "Liechtensteinische Landesbank AG" (LLB) is the oldest bank in Liechtenstein (founded in 1861) and employs 1'068 people (2010). The state of Liechtenstein holds the majority of LLB's shares. The "Verwaltungs- und Privatbank AG" (VPB) was founded in 1956, is privately owned and has 766 employees (2010).

Not only the financial sector, but also the industrial export sector[26] was strongly affected by the world recession, which combined with bad performance within the financial sector led to

[26] Even though Liechtenstein's industry sector has a very high share of the national gross value added (2008: 36%) and of total employment (2008: 46%) - both are considerably higher than in its surrounding countries such as Switzerland, Germany or Austria (where industrial employment usually is around 25%) - it is internationally mostly recognized for its financial sector. The financial sector in turn also has a comparable high share of the national gross value added (2008: 33%) and of total employment (2008: 16%). The total nominal national value added measured by the GDP was 5'495 million Swiss Francs (in 2008). The total

a dramatically high real annual decrease of Liechtenstein's GDP (-2,7% in 2008, -11,0% in 2009), which was even worse than in the first oil crisis of the mid-70s. These findings rely on estimates of the Konjunkturforschungsstelle Liechtenstein (2010, see SCHLAG [2012]), official national accounts (1998-2009, see OFFICE OF STATISTICS [2011]) and estimated figures by the author of this paper (1972-1997)[27]. Following the estimations of the Konjunkturforschungsstelle Liechtenstein (KOFL), the year 2010 was the economic turning point featuring positive real GDP-growth (+7,7%) again.

An additional and good current example for the still ongoing international pressure on Liechtenstein, especially by Germany, were the negotiations between Deutsche Bank AG and LGT Bank AG about the sale of the BHF-Bank that belongs to Deutsche Bank. The Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht) subsequently delayed and as a consequence blocked the negotiations between the two banks. Therefore, the sale did not take place: An event which can be seen as being a direct consequence of the Zumwinkel-Affair (see FINANCIAL TIMES DEUTSCHLAND [2011]) and reflects possible restraints towards banks from Liechtenstein. As a consequence, the LGT closed its branches in Germany, which led to depreciations of around 50 million Swiss Francs and diminished the profits in 2011 from 120 to 70 million Swiss Francs (see HANDELSBLATT [2012]). As additional burden, the public prosecution department of Bochum (Germany) fined the LGT with a monetary penalty of 50 million Euros, which was accepted and paid in 2010 (see NEUE ZÜRCHER ZEITUNG [2010]).

A.6. Comparison with Swiss Banks

As an additional application of the chosen augmented amalGARCH(0,1,1), it has also been inspected whether the results regarding the Zumwinkel Affair, which have been observed for the two inspected banks from Liechtenstein, the Verwaltungs- und Privatbank AG (VPB) and the Liechtensteinische Landesbank AG (LLB), also hold for banks in Switzerland. There are three banks with a comparable size to the VPB and the LLB that are quoted at the Swiss Stock Exchange: The "Bank Sarasin AG", the "Vontobel Holding AG" and the "Julius Bär Gruppe AG". Unfortunately, Julius Bär was split into two separate corporations in March 2009, which

employment in Liechtenstein was 33'265 (2008), so GDP/employee was around 160'000 Swiss Francs. For further detailed statistics see OFFICE OF STATISTICS [2010].

[27] A preliminary version of this historic GDP-time series has been presented in BRUNHART, KELLERMANN AND SCHLAG [2012], the final series can be obtained by request (andreas.brunhart@kofl.li).

led to a structural break in the stock prices, since both corporations now had their own stocks. Hence, only the stocks of Sarasin and Vontobel are used here. The stock prices of these two banks and the SMI-index are depicted in figure 27.

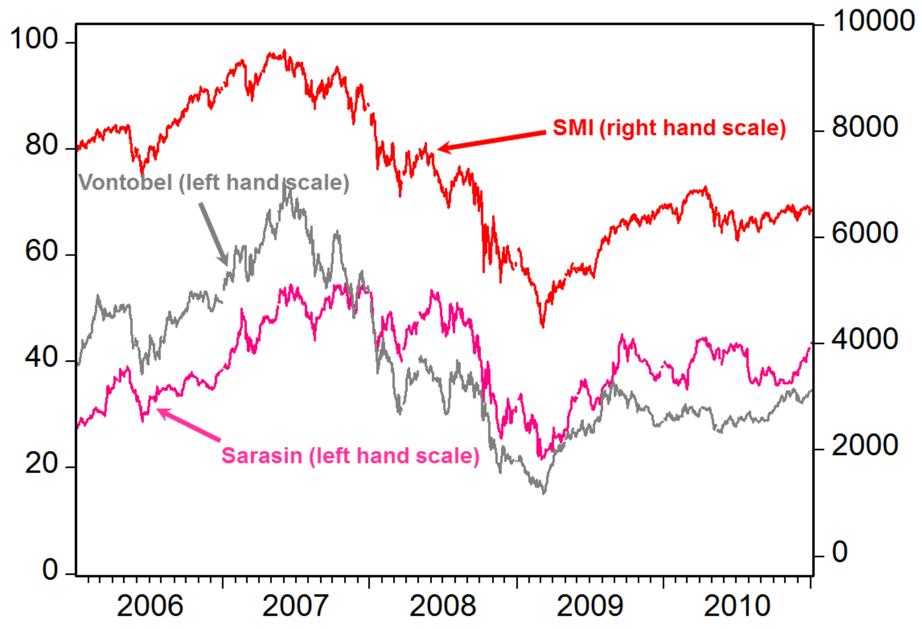


FIGURE 27: Stock prices of inspected banks and SMI-index

The output tables of the comparative estimations applying returns of stock price values of Swiss banks, which are outlined towards the end of chapter 2.3., are visible in figure 28. There was no detectable impact of the sapid Zumwinkel-Affair on the Swiss banks' average stock returns, a similar finding compared to the banks in Liechtenstein. More interestingly, there was also no magnifying impact on the risk of the stocks by this prementioned affair that followed the data theft: For both banks, the coefficient of the data theft time dummy in the variance equation is extremely small and not significant in almost all the settings.[28] This finding is a sharp contrast to the observations made for the two banks from Liechtenstein in this context. The chosen modelling setting, the augmented amalGARCH, and the conclusions drawn from it are therefore supported, as the crucial findings are in line with economic and logical a-priori considerations and not just an artefact of the chosen econometric modelling specifications. The fact that the data theft and the revelation of tax evaders (and also the following international pressure on Liechtenstein, the investors' insecurity and the following transformation process within the financial services sector in Liechtenstein) seem to have

[28] The significance of the coefficient of the data theft dummy in the variance equation only appears for Sarasin and only if a normal distribution is assumed. The assumption of a normal distribution is, according to information criteria, inferior to the student's t distribution after BOLLERSLEV [1987] and the generalized error distribution after NELSON [1991], though. But also for Sarasin under the assumption of a normal distribution applies: The magnitude of the coefficient is extremely small and features a negative sign.

magnified the volatility of stock values of Liechtenstein's banks but not of the Swiss banks is intuitive.

	Dependent Variable					
	$\%\Delta VONTOBEL$			$\%\Delta SARASIN_t$		
Assumed Distribution	Normal	Student's t	GED	Normal	Student's t	GED
(Conditional) Mean Equation						
$\%\Delta SARASIN_{t-1}$				0.1169***	0.0545**	0.0600***
$\%\Delta VONTOBEL_{t-1}$	0.0494*	0.04747*	0.0462*			
$\%\Delta SMI_t$	0.0097***	0.0093***	0.0092***	0.0068***	0.0061***	0.0062***
Financial Crisis	0.0004	0.0006	0.0007	0.0017	0.0004	-0.0003
Data Theft	0.0002	0.0001	0.0001	-0.0001	-0.0002	-0.0002
(Conditional) Variance Equation						
Constant	1.8E-5***	1.4E-5***	1.3E-5***	3.0E-5***	4.0E-05***	3.1E-05***
$GARCH(1)^{2)} : h_{t-1}$	0.8004***	0.8378***	0.8438***	0.7591***	0.6715***	0.7041***
$\%\Delta SARASIN^{2}_{t-1}$				0.0890***	0.1572***	0.1054***
$\%\Delta VONTOBEL^{2}_{t-1}$	0.0543***	0.0540***	0.0503***			
$\%\Delta SMI^{2}_{t-1}$	1.0E-5***	5.9E-6*	6.4E-6**	1.2E-5***	2.5E-5***	1.7E-5***
Financial Crisis	2.8E-5	2.6E-5*	2.3E-5*	2.2E-5*	0.0001**	5.7E-5*
Data Theft	-5.1E-7	2.0E-7	-3.2E-7	-1.1E-5***	-1.1E-5	-1.1E-5
Measures of Fit						
R^2	0.3004	0.3020	0.3020	0.2125	0.2080	0.2091
Adjusted R^2	0.2954	0.2963	0.2964	0.2068	0.2022	0.2027
Akaike Info Criterion	-5.3466	-5.3615	-5.3638	-5.2973	-5.4449	-5.4441
Schwarz Info Criterion	-5.3058	-5.3165	-5.3189	-5.2564	-5.4041	-5.3991

1) Past squared residual from the mean equation (past shocks).
2) Lagged conditional variance (serial time dependency of risk).
The magnitude of the relevant p-values are marked with stars and therefore reflects the significance of the respective parameter (*: p-value ≤ 0.10 and > 0.05, **: p-value ≤ 0.05 and > 0.01, ***: p-value ≤ 0.01). The p-value denotes the lowest significance level at which the null hypothesis (of insignificance in this case) could be rejected regarding the regressor's t-value (which is here the estimated coefficient of the regressor divided by the estimated standard error of the coefficient).
See sections 2.2. and 2.3. for the theoretical equation setup and estimation results of the main GARCH-models.

FIGURE 28: Estimation output of the augmented amalGARCH-model for Swiss banks

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