



# ANALYSIS OF A TIME-VARYING RISK PREMIUM IN THE VISEGRAD GROUP

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## **Abstract**

*The risk premium for the Visegrad countries was analyzed. The period of the considerations is between 2005 and 2015. Daily, weekly and monthly data outcomes were compared. It was found that the outcomes are quite similar for all countries. Moreover, changing to weekly or monthly data does not incorporate significantly new knowledge. Generally, daily data remain the best one to analysis. The historical period from which the stock market returns are computed was narrowed to just one calendar year (i.e., 250 stock session days). As a result, it was obtained that the risk premium varies from -70% up to 115%, whereas the average measures vary between and 1.89% and -10.46%. Generally, a negativity of a risk premium was confirmed. But, on the other hand, no leverage effect was found. Nor the significant impact of the company size. The models were based on GARCH types, i.e. AR-GARCH and GARCH in mean models were evaluated. The methods were restricted to simple GARCH(1,1) in case of the variance equations.*

**Keywords:** GARCH, leverage effect, risk premium, size premium, Visegrad countries

## **1 INTRODUCTION**

One of the basic economic and financial concepts is the notion of a risk premium. Namely, financial instruments, which are assumed to be riskier bring higher returns, in comparison to less risky ones. Stocks can serve as an example – being subject to the relatively higher risk exposure than government bonds – considered a safe investment (Jajuga & Jajuga, 2011).

The risk premium plays a key role, for example, in the popular CAPM methodology, etc. It is also an important feature in the processes of valuation,

capital cost estimation, etc. Its estimates are very useful thus.

However, the review of the literature reveals that starting from various methods and considering different time horizons significantly different results are obtained. Hence, the risk premium itself seems to be worth examination, and also its volatility. Indeed, this is the aim of this paper for a particular case of the Visegrad countries.

## **2 LITERATURE REVIEW**

On the capital market a risk premium can be defined as the difference between the expected rate of the return of stocks (i.e., assets burdened with a significant risk) and a risk-free rate. It is therefore important to determine the benchmark of

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a risk-free rate. It can be done, for example, with a help of treasury bills or yield of the 10-year treasury bonds.

It seems that the usual choice of the yield of a 10-year treasury bonds in the best one. It is the usual choice also if the considered economies are bank-based. If they are market-based, one can speculate that the short-term interest rate should be also taken under consideration. Bonds are not only guaranteed by the state, as also treasury bills, and therefore, in practice risk-free, but they are also characterized by relatively high liquidity (which cannot be said about treasury bills). Actually, the lack of liquidity also generates a specific risk by itself (Szczepankowski, 2007).

For example, Mehra and Prescott (1985) observed that the difference between the rate of return from stocks and bonds is significantly higher than it can be derived from the above arguments. This can be explained, for example, by the increasing risk-aversion of investors.

Yet, estimating a market risk premium can be done in several ways. The easiest way is to compute the difference between the average annual rate of return from the market portfolio and the average rate of return on the investment in bonds, where the average is calculated in a long horizon.

The disadvantage of this method is mainly the omission of the historical diversity of the various periods. In addition, significantly different estimates are obtained depending on whether the estimated average is the arithmetic or the geometric one. For example, for the United States arithmetic average for the period of 1926 – 2007 gives a figure of 6.9%, while the geometric mean gives 5.1%. For the period of 1978 – 2007 they are respectively 5.7% and 4.9% (Zenner, Hill, Clark, & Mago, 2008; Sfiridis, 2012).

Other methods of estimating risk premium include the usage of the dividend model, the Sharpe model, and the comparison with bonds. These methods provide, for example, for the United States a wide range of values, i.e., between 5% and 8.6% (Zenner, Hill, Clark, & Mago, 2008, 2008). For Poland, a similar studies were conducted by Dobija (2005) and Zarzecki (2008; 2009). The problem was presented in the perspective of various economies by Damodaran (2015). A variety of methodological approaches

and practical aspects were fairly presented in the review article of Kurek (2009). It was noted there that the very wide range of values can be obtained with different methodologies and constraints for different periods of time.

Another, interesting problem, closely related with the above one, is the question whether larger companies are characterized by slightly lower risk compared to the market average (Demsetz & Strahan, 1995; Fama & French, 1993; Zarzecki, 2009). Sometimes, such an assumption is made. For example, in the three-factor CAPM, proposed by Fama and French (1993). Then, a size premium is also included (Fama & French, 2012).

This issue is, however, debatable. For example, Foye, Mramor, and Pahor (2013) analyzed the new European Union members and found that the model of Fama and French (1993) has some serious disadvantages in such a context. Thus, some researchers have proposed modifications. For example, Czapkiewicz and Wójtowicz (2014) basing on the monthly data from the Warsaw Stock Exchange from the period of 2003 – 2012. On the other hand, Słoński and Kwiatkowski (2010) recognized the three-factor model as a sufficient enough to describe Polish companies. They also claimed that the size premium is important for the smallest companies.

However, Sekuła (2013) basing on data from the period of 2002 – 2010 questioned the relationship between the market capitalization of companies and the rates of return. Moreover, it was noted that the size premium effect is reversed, i.e., companies with medium and large capitalization generate higher returns than companies with low capitalization.

Similarly, doubts on the existence of the size premium appeared during the analysis of data from developed markets (Horowitz, Loughran, and Savin, 2000). Van Dijk (2011) conducted a fairly extensive comparative analysis and came to the conclusion that the premium for the size fades since 1980s. Similarly, its presence on the markets was disputed by Paschall (1999). For the markets of the Central and Eastern Europe doubts were presented also by Konieczka and Zaremba (2014).

Also, some interesting researches for the other Visegrad countries were done, for example, by

Gersl and Lesanovska (2014), Vonnak (2010), Boubakri and Guillaumin (2011) and Poshakwale and Murinde (2001a; 2001b).

### 3 METHODOLOGY

One of the econometric models used in the modelling of the volatility of time series is GARCH model. This model was proposed by Bollerslev (1986) as a generalization of earlier ARCH model of Engle (1982). The simplest (and simultaneously the best for various applications) is GARCH(1,1).

Formally, it is said that the variable  $x_t$  follows GARCH (1,1), if:

$$x_t = a_0 + a_1 \cdot y_1 + a_2 \cdot y_2 + \dots + a_k \cdot y_k + e_t,$$

$$e_t = z_t \sqrt{h_t},$$

$$h_t = c_0 + c_1 \cdot (u_{t-1})^2 + d_1 \cdot h_{t-1},$$

where  $y_1, \dots, y_k$  are explanatory variables and  $u$  is the residual term. The variable  $t$  is a time index. It is assumed that the variable  $z_t$  follows the standard normal distribution (with mean 0 and variance 1), i.e.,  $N(0,1)$  process.

It is said that the variable  $x_t$  follows ARMA(m,n)-GARCH(p,q) process, if

$$x_t = a_0 + a_1 \cdot x_{t-1} + \dots + a_m \cdot x_{t-m} + b_1 \cdot e_{t-1} + \dots + b_n \cdot e_{t-n} + e_t,$$

where:

$$e_t = u_t \sqrt{h_t}$$

$$u_t \sim N(0,1)$$

$$h_t = c_0 + c_1 \cdot (e_{t-1})^2 + \dots + c_p \cdot (e_{t-p})^2 + d_1 \cdot h_{t-1} + \dots + d_q \cdot h_{t-q}$$

More on GARCH models can be found for example in the book of Xekalaki and Degiannakis (2010) or Tsay (2010). In this paper, following the methods of Heryan (2014) and Sekuła (2011), the risk premium is substituted as the variable  $x_t$ .

Notice, that  $h_t$  is a variance, which cannot be negative. Therefore, estimated parameters  $c_0, c_1, \dots, c_p, d_1, \dots, d_q$  should be positive. Sometimes, it happens that numerical outcomes are negative.

However, the risk premium is also often estimated using GARCH-M (Doman & Doman, 2009; Asness, 2000). Then, of course, its conceptual meaning is understood slightly different.

It is said that the variable  $x_t$  follows AR(m)-GARCH-M(p,q) process, if

$$x_t = a_0 + a_1 \cdot x_{t-1} + \dots + a_m \cdot x_{t-m} + b \cdot h_t + e_t,$$

where:

$$e_t = u_t \sqrt{h_t}$$

$$u_t \sim N(0,1)$$

$$h_t = c_0 + c_1 \cdot (e_{t-1})^2 + \dots + c_p \cdot (e_{t-p})^2 + d_1 \cdot h_{t-1} + \dots + d_q \cdot h_{t-q}$$

In such a case, the parameter  $b$  itself is interpreted just as the risk premium (Doman & Doman, 2009). Indeed, high volatility should be compensated by a higher rate of return. Hence, this parameter should be positive (Glosten, Jagannathan, & Runkle, 1993). However, it is sometimes found that there is a negative correlation between the rate of return from stocks and their volatility over time. In other words, high volatility is present during price declines, while price increases follow rather stable processes. Such a phenomenon has been observed in certain situations and named the leverage effect (Ait-Sahalia, Fan, & Li, 2013).

GARCH models are very useful in finance and economics, especially in the analysis of high-frequency time series (Alexander, 2001; Fiszeder, 2009). Rarely, GARCH(p,q) with  $p > 1$  and  $q > 1$  is needed, because greater complication of the model does not provide a relatively better outcome estimation (Matei, 2009; Hansen & Lunde, 2005).

Despite many advantages of the simple GARCH model, for example, Nelson (1991) pointed out that from the definition the existence of a negative correlation between the future conditional variance and the current value of the modelled rate of return is excluded. In addition, the estimated coefficients often do not meet theoretical assumptions (the mentioned requirement of non-negativity). As a result, GARCH model has been expanded to include various modifications (Xekalaki & Degiannakis, 2010).

Some simple test to indicate a certain likelihood of the leverage effect is to check if there is a negative correlation between  $(x_t)^2$  and  $x_{t-1}$  (Andersen et al., 2009). One can also analyse a news impact curve (Jondeanu, Poon, & Rockinger, 2007), i.e., a graph of the conditional variance  $h_t$  vs. lagged innovation  $e_{t-1}$ .

The asymmetric GARCH models were examined for Warsaw Stock Exchange (WSE), for example, by Małecka (2011) and Rozkrut (2007). The problem of parameters' restrictions – by Galin (2008).

Fiszeder and Kwiatkowski (2005) analyzed selected 28 companies from WSE and came to the conclusion that in the case of stock market indices GARCH(1,1) describes the volatility in the best way out of other GARCH type models. On the other hand, Bartkowiak (2007) analyzed only the assets related to the derivatives markets. Their results are in part consistent with those from the developed markets. On the other hand, obtained concerns and doubts suggest that it is still worth to examine the Visegrad markets. In this sense, even the “stylized facts” are worth noting.

Pluciennik (2007) pointed out that the use of models with autoregression (i.e., AR-GARCH) results in a considerably better results than the simple GARCH(1,1) models for the WIG 20 index. GARCH models were also applied to volatility estimation on WSE and other Visegrad stock exchanges by Filipowicz (2013), Karkowska (2013), Doman (2004), Jakubowska (2015), Waszczuk (2013), Borys and Zemcik (2009), Borys (2011), Doman and Doman (2013), Wdowiński and Zglińska-Pietrzak (2005), Brzeszczyński and Welfe (2004), and others.

Finally, it should be mentioned that it usually happens that the sum of parameters in the variance equation in GARCH(1,1) model is equal to 1. In other words,  $c_1 + d_1 \approx 1$ . Such a restriction can be implemented into the model itself. Such a model is called I-GARCH (Fiszeder, 2009). However, this modification is not in the scope of this research.

## 4 DATA

In the view of just presented consideration, it is clear that the examination of the volatility of a risk premium (Chen, Grundy, & Stambaugh, 1990; Chou, 1988) for Poland and other Visegrad countries appears to be an interesting problem. For the purpose of this analysis, it is assumed that the risk premium is the difference between the yearly rate of return on the portfolio from the stock exchange (based on a market index) and yield of a 10-year treasury bonds. For the computations, it was assumed that there are 250 session days in a calendar year. A similar method was used by Sekula (2011) to analyze the Polish capital market, between 1995 and 2010. A broad estimation of the risk premium ranging from 2.9% to 8.6% was obtained.

The data daily were obtained for the database Stooq and Federal Reserve Bank of St. Louis, stock exchanges and central banks (Stooq.pl, 2015; Federal Reserve Bank of St. Louis, 2015; Prague Stock Exchange, 2015; Czech National Bank, 2015; National Bank of Slovakia, 2015). In case of Slovakia only SAX (all stocks) index was considered. In case of Hungary: BUX (all stocks) and BUMIX (small and medium stocks) indices. In case of Czech Republic: PX (big stocks) and PX-GLOB (all stocks) indices. In case of Poland: WIG (all stocks) and sWIG80 (small stocks) indices. The data were taken from the period between 28-11-2005 and 27-05-2015.

Computations were done in R (R Core Team, 2015) with a help of rugarch package (Ghalanos, 2014).

Much of the methodology present in Duan and Zhang (2013) is adopted. Usually, over 500 or even 1000 observations is preferred for GARCH model (Hwang and Valls Pereira, 2006; Raymond and Lam, 2006). In our case, the initial data consist of 2474 observations for each time series.

Of course, the volatility of a stock market is higher than bonds. Therefore, it also makes sense to model a bit less frequent data. As a result, daily, weekly and monthly data were analyzed and outcomes were compared.

Indeed, the volatility clustering is usually present at weekly, daily or more frequent data. Nevertheless, in case of GARCH models there is no direct transmission between different time periods estimation. Usually, daily frequency is found to be the most suitable one (Zivot, 2009).

As the inflation is relatively stable and low (less than two digits) in all analyzed countries, just nominal rates were computed. Indeed, if all cash flows are calculated without including the impact of the inflation, then consistent results are obtained.

## 5 ANALYSIS

It can be observed from Fig. 1 that the risk premium in Poland, Czech Republic and Hungary behave quite similarly. In case of Slovakia this behavior is less volatile and takes more moderate values. This can be the effect of relatively smaller capitalization of Bratislava Stock Exchange and Eurozone accession.

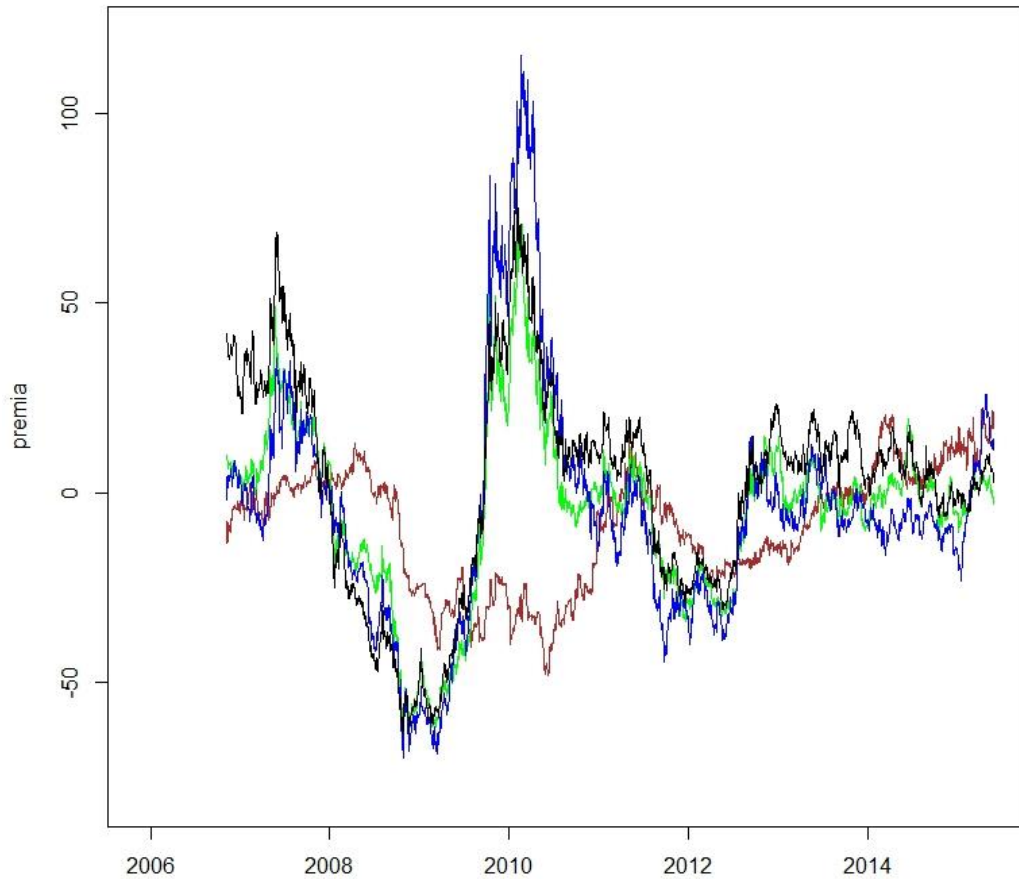


Fig. 1: Risk premium in pp points Poland (black), Czech Republic (green), Slovakia (brown) and Hungary (blue)

Tab. 1: Outcomes of ADF test and ARCH LM test for risk premium time series

	PL	SK	CZ	HU
<b>ADF statistics</b>	-1.9844	-1.5802	-2.2035	-2.0716
<b>p-value</b>	0.5849	0.7561	0.4922	0.5480
<b>ARCH-LM statistics</b>	2170.3980	2176.8800	2170.3380	2170.1060
<b>p-value</b>	0.0000	0.0000	0.0000	0.0000

Tab. 2: Akaike information criteria for different GARCH type models for risk premium

AIC	PL	SK	CZ	HU
<b>GARCH(1,1)</b>	7.4751	6.9036	7.1289	7.3525
<b>ARMA(1,1)-GARCH(1,1)</b>	4.0091	3.1658	3.8534	4.2983
<b>ARMA(1,0)-GARCH(1,1)</b>	4.0125	3.1653	3.8552	4.2996
<b>ARMA(0,1)-GARCH(1,1)</b>	6.6685	6.1991	6.3633	6.7013

The stationarity of all four time series were checked with a help of augmented Dickey-Fuller test (ADF). The outcomes are reported in Tab. 1.

Unfortunately, from the augmented Dickey-Fuller test, assuming 5% significance level, it can be concluded that all series are non-stationary. On the other hand, the ARCH-LM test (see Tab. 1)

supports at 5% significance level that ARCH effects are present in all analyzed series. The ARCH-LM test for weekly and monthly data (detailed outcomes not reported here) also support the existence of ARCH effects in all analyzed countries. Therefore, it is reasonable to consider GARCH models for these time series.

Four types of GARCH models were evaluated for each country for risk premium based on daily data. However, the generalized error distribution was assumed (the estimated distribution parameters are not reported here) instead of the normal one. For all countries, except Slovakia, the most preferable type of a model is ARMA(1,1)-GARCH(1,1) model, if Akaike information criteria is considered (see Tab. 2). But even in the case of Slovakia the difference between ARMA(1,1)-GARCH(1,1) and the preferred model is very small. It can be noticed that including ARMA term in the base GARCH(1,1) model strongly improves the information criteria. However, the inclusion of AR term has much greater positive impact on the criterion than MA term. The difference between ARMA(1,1)-GARCH(1,1) models and AR(1)-GARCH(1,1) is very small basing on the Akaike information criteria. Because of the simplicity and

the outcomes of the previously mentioned researches AR(1)-GARCH(1,1) model was selected as the preferred one.

As a result, the following model is reported in more details:

$$X_t = a_0 + a_1 \cdot X_{t-1} + \epsilon_t,$$

where:

$$\begin{aligned} \epsilon_t &= u_t \sqrt{h_t} \\ u_t &\sim N(0,1) \\ h_t &= c_0 + c_1 \cdot (\epsilon_{t-1})^2 + d_1 \cdot h_{t-1}. \end{aligned}$$

Such a model was estimated for daily (Tab. 3), weekly (Tab. 4) and monthly data (Tab. 5).

It seems that there is not much difference between outcomes obtained on the base on different time frequency. Moreover, decrease of the frequency can lead to more statistically insignificant terms in the model. Fortunately, all evaluated models managed to completely describe the ARCH effect. High p-values of ARCH-LM test for post-estimation (Tab.3, 4 and 5) indicates that there remained no ARCH effects in the estimated models. Moreover, the estimated parameters seem to be numerically quite similar in all four countries.

Tab. 3: Estimates of AR(1)-GARCH(1,1) for risk premium based on daily data

	PL	SK	CZ	HU
<b>a<sub>0</sub></b>	42.024320	-13.217436	8.603385	-2.147171 <sup>!</sup>
<b>a<sub>1</sub></b>	0.999638	1.000000	0.997779	0.997276
<b>c<sub>0</sub></b>	0.034018	0.056731 <sup>!</sup>	0.072766	0.063531
<b>c<sub>1</sub></b>	0.059882	0.047726 <sup>!</sup>	0.108344	0.079757
<b>d<sub>1</sub></b>	0.931621	0.944421	0.871929	0.908876
<b>ARCH-LM</b>	0.3017	0.9948	0.8322	0.7839

<sup>!</sup> Not-significant at 5% significance level

Tab. 4: Estimates of AR(1)-GARCH(1,1) for risk premium based on weekly data

	PL	SK	CZ	HU
<b>a<sub>0</sub></b>	38.551851	-8.133543	7.68422	2.86400 <sup>!</sup>
<b>a<sub>1</sub></b>	0.998599	0.981912	0.98764	0.99201
<b>c<sub>0</sub></b>	0.886614 <sup>!</sup>	0.163908 <sup>!</sup>	2.17150	1.62778 <sup>!</sup>
<b>c<sub>1</sub></b>	0.079558 <sup>!</sup>	0.035997 <sup>!</sup>	0.19423	0.12563
<b>d<sub>1</sub></b>	0.875370	0.948648	0.70303	0.81875
<b>ARCH-LM</b>	0.0601	0.7359	0.9873	0.6348

<sup>!</sup> Not-significant at 5% significance level

Tab. 5: Estimates of AR(1)-GARCH(1,1) for risk premium based on monthly data

	PL	SK	CZ	HU
<b>a<sub>0</sub></b>	5.447453 <sup>!</sup>	-8.13248	-5.132260	-14.84248 <sup>!</sup>
<b>a<sub>1</sub></b>	0.927750	0.97863	0.847593	0.90852
<b>c<sub>0</sub></b>	0.000001 <sup>!</sup>	1.64803 <sup>!</sup>	0.000124 <sup>!</sup>	47.25805
<b>c<sub>1</sub></b>	0.006111 <sup>!</sup>	0.18614 <sup>!</sup>	0.000002 <sup>!</sup>	0.95257
<b>d<sub>1</sub></b>	0.985064	0.77606	0.993966	0.00000 <sup>!</sup>
<b>ARCH-LM</b>	0.7450	0.9129	0.5893	0.8156

<sup>!</sup> Not-significant at 5% significance level

The volatility of such understood risk premium is very high, as one can see from Fig. 1. From Tab. 1 it can be seen that the value of a<sub>0</sub> parameter for Poland is very high, whereas in Slovakia it is negative. Also, in Hungary it is a small but negative number. In Czech Republic it is a moderate positive number.

Next, AR(1)-GARCH-M(1,1) models for daily data were estimated. However, in this case it were time series with bond yields and returns from market indices considered as variables (i.e., x<sub>t</sub>). Not the difference between them as previously. In particular, the following equations were estimated

$$x_t = a_0 + a_1 \cdot x_{t-1} + b \cdot h_t + e_t,$$

where

$$e_t = u_t \sqrt{h_t}$$

$$u_t \sim N(0,1) \text{ and}$$

$$h_t = c_0 + c_1 \cdot (e_{t-1})^2 + d_1 \cdot h_{t-1}.$$

However, also in this case the generalized error distribution was assumed (details not reported here). Due to the clarity and simplicity the details of the estimations are not reported. Only the parameter b, which is of the most importance. It can be understood as the risk premium itself for a particular time series. The outcomes are presented in Tab. 6.

Tab. 6: Estimates of a risk premium based on AR(1)-GARCH-M(1,1) for daily data

parameter b	PL	SK	CZ	HU
<b>bonds</b>	-0.000185 <sup>!</sup>	-0.000185 <sup>!</sup>	-0.000185 <sup>!</sup>	NA
<b>all stocks</b>	4.04227	0.000000 <sup>!</sup>	-0.025733 <sup>!</sup>	1.90555
<b>small stocks</b>	NA			-0.057735
<b>big stocks</b>			NA	

<sup>!</sup> Not-significant at 5% significance level

NA estimation not available due to numerical problems reported by R

Tab. 7: Correlation between (x<sub>t</sub>)<sup>2</sup> and x<sub>t-1</sub> for daily data

	PL	SK	CZ	HU
<b>bonds</b>	0.9917661	0.9868588	0.9772921	0.9815614
<b>all stocks</b>	0.2666952	-0.745914	-0.09816701	0.5869707
<b>small stocks</b>	0.7344908			0.2710908
<b>big stocks</b>			-0.02099556 <sup>!</sup>	

<sup>!</sup> Not-significant at 5% significance level

Unfortunately, in three cases the estimation of the model was not possible due to the numerical problems in the programme. Moreover, only for all stocks in Poland, all stocks in Hungary and small

stocks in Hungary the estimated parameter was statistically significant. However, only in case of small stocks in Hungary there were not any numerical problems with the diagnostic of the

model. The ARCH-LM test indicated that the ARCH effect does not remain. But Ljung-Box test indicates autocorrelation.

Yet, basing on these outcomes it can be slightly deliberated that there exists a small leverage effect for small stocks in Hungary. However, comparing the parameters between the models for small and all stocks, it could be concluded that small stocks are less risky. It is contradictory to the well-known theory.

Finally, a correlation between  $(x_t)^2$  and  $x_{t-1}$  was tested for the time series. The results are presented in Tab. 7.

The correlation is negative and statistically significant only in two cases: for all stocks in Slovakia and all stocks in Czech Republic. However, AR(1)-GARCH-M(1,1) model did not confirm the leverage effect in these cases. The tentative indications of the leverage effect reported in Tab. 6 and 7 are not consistent. Therefore, there are no significant arguments to support the hypothesis of the leverage effect in any of the analyzed case.

## 6 CONCLUSIONS

Basing on daily data and considering the historical period of 250 stock sessions the risk premium

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(difference between yield of 10-year treasury bonds and return from all listed stocks) was found to be between -64% and 82% in Poland. The arithmetic mean is 1.89% and the geometric mean is -2.55%. In Slovakia it is between -48% and 22%. The arithmetic mean is -9.06% and the geometric mean is -10.46%. In Czech Republic it is between -66% and 74%. The arithmetic mean is -4.65% and the geometric mean is -7.84%. In Hungary it is between -70% and 115%. The arithmetic mean is -4.94% and the geometric mean in -9.83%. Obtaining a negative risk premium for the analyzed countries is somehow in agreement with the studies of, for example, Gabrish and Orłowski (2011).

It was also found that simple AR(1)-GARCH(1,1) model can quite well describe the volatility of a risk premium. Moreover, it was found that daily data are generally superior over weekly and monthly data in case of the modelling.

Unfortunately, AR(1)-GARCH-M(1,1) model was not able to provide any significance evidence on whether a risk premium is influenced by the size of the companies. Yet, as GARCH type models constitute quite numerous family of models, there is a huge place for further researches in this direction.

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