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# Does the slope of the yield curve of the interbank market influence prices on the Warsaw Stock Exchange? A sectoral perspective

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**Abstract.** The interest rate curve is often viewed as the leading indicator of economic prosperity in a broad sense. This paper studies the ability of the slope of the yield curve in the term structure of interest rates to impact the sectoral indices on the Warsaw Stock Exchange, using daily data covering the period from 1 January 2001 to 30 September 2020. The results of the research indicate an ambiguous dependence of the logarithmic rates of return of sub-indices on the change of the interbank interest rate curve. The only sectors showing a clear relationship of this type is energy and pharmaceuticals.

**Keywords:** stock market sub-indices, EGARCH, term structure of the interest rates

**JEL:** C58, E43, E44

## 1. Introduction

An interest rate is a primary short-term instrument at work in conventional macroeconomic models. As a part of the monetary transmission mechanism, it is one of many channels through which monetary policy operates (Kuttner & Mosser, 2002). Additionally, the monetary transmission mechanism incorporates the relationship between interest rates and the values of real and financial assets. The monetary transmission mechanism within market-oriented economic systems is defined by official short-term interest rates (the policy instrument) and various financial asset prices together with banks' and other financial intermidiaries' balance sheet variables (intermediate channels of monetary transmission), as well as by real economic activity and prices (final policy objectives). Monetary policy directly affects the interest rate curve (yield curve), which acts as a leading indicator in predicting the macroeconomic activity over longer horizons of time (Khandwala, 2015). The steepness of the yield curve can be perceived as an indicator of the 'health' of an economy, and shows its position in the business cycle. The yield curve becomes steep at the beginning of the business cycle. This is because the central bank usually keeps short-term interest rates low during economic downturns to stimulate the economy. As growth picks up, long-term rates begin to rise, which steepens the yield curve. The same process can be observed on the interbank market. Eventually, short-term

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rates become higher (due to the central bank's rate hikes), and the growth of interbank market longer-term rates begins to slow down, or the rates start becoming lower. Thus, the shape of the yield curve can flatten or even inverse, in which case a negative slope of the interest curve emerges. This situation indicates a possible slowdown or even a recession in the real economy in the following months. The slope is understood as the difference between the values of the longer-term interest rate versus the shorter-term one.

It has been observed that when the slope of the yield curve turns negative, a recession will most probably follow. Conversely, when the slope of the yield curve becomes positive, the economy begins to recover.

Central banks typically deal with uncertainty about the key relationships describing the economy. One of these relationships is the level of short-term interest rates. Uncertainty about the key interest rate describing the economy leads to a disagreement about the effects of the monetary policy and, in turn, to a disagreement as to the appropriate interest rate setting (Traficante, 2013).

Mishkin (1991) explains the association of yield spread and real economic activity in terms of the productivity of capital and the business cycle. In his interpretation, the real yield spread should be perceived as the difference between the long-run and short-run marginal productivity of capital. As far as the interbank market is concerned, the author sees the real yield spread as the difference between the long-term and the short-term interest rate. This difference is also the source of valuable information on the opportunity costs of employing capital over a longer rather than a short term.

The argument is that at the peak of the business cycle, the utilisation of capacity is at a high level, and short-run capital productivity is higher compared to longer-run capital productivity, since, in the long run, the economic activity is likely to slow down. On the other hand, at the trough, productivity in the short run is low and an upswing in the longer run is expected. Thus, there is a positive relationship between the yield spread and real economic activity.

Similar considerations can be observed on the stock exchange. An increase in the slope of the interest rate curve, implying an increase in capital productivity, is visible in rising stock prices.

In this setting, a robust monetary transmission mechanism works properly even when the policymaker does not know the detailed structure of the possible adjustments within the economy. The policymaker is supported in this task by the financial market participants via the process of adjusting prices.

To the best of the authors' knowledge, no prior study has analysed the impact of the interest rate slope on the returns of the sectoral stock indices. Bhowmik & Wang (2020) presented an up-to-date literature review on the application of the GARCH class models for forecasting variance volatility in financial markets. According to

Alberg et al. (2008), the EGARCH model is the best predictor of daily data returns of the Tel Aviv stock market index. All these papers concern the stock market index volatility. No papers could be found, however, that deal with the impact of the slope of the interest curve.

Generally, there are two types of research relevant to this subject: the first type explores the applicability of the EGARCH model to modelling the volatility of financial processes, and the volatility of indices in particular. The second examines the reaction of prices or rates of return of securities (equities) to the central bank's decisions (Ehrmann & Fratzscher, 2004). The purpose of this paper is to test the impact of the slope of the interest rate curve on the returns of the stock market sub-indices. The formulated research hypothesis assumes that the increasing slope of the market interest rate curve has a significant impact on the yield rates of the sub-indices listed on the Warsaw Stock Exchange. In this study, we are interested in the short-term approach, although the estimation of the long-term relationship between the rates of return of sectoral sub-indices and the slope of the interest rate curve is also possible. This aspect, however, lies outside the scope of our considerations here.

This paper is of an empirical nature and is organised in the following way: Section 2 is devoted to the review of the relevant literature on the possible impact of the interbank market on stocks or stock indices. Section 3 describes the research methodology and the estimation procedure, and Section 4 presents the empirical results. Final conclusions are included in Section 5. All estimations are made in the Gretl program.

## 2. Literature review

The undertaken research relates to two currents in literature. The first is the monetary transmission mechanism as an institutional framework of the monetary policy. The second relates to asset pricing and market efficiency.

Theoretical relationships between monetary policy and financial markets are complex. Dreger & Wolters (2009) argue that a monetary policy shock, for example in the form of changes in the money supply or interest rates, eventually leads to shifts in investors' portfolios continuing until the relationship between liquidity and asset holdings is re-established. In other words, asset prices should react to changes in the interest rates of the interbank market, and such reactions should be observable. For central banks, the transmission of monetary impulses in increasingly integrated financial markets is of great importance (De Santis, 2008). According to Dale & Haldane (1995), the monetary transmission mechanism within market-oriented economic systems is defined by official short-term interest rates (the policy instrument) and various financial asset prices together with banks' and other financial intermediaries' balance sheet variables (intermediate channels of monetary transmission), as well as by real economic activity and prices (final policy objectives). The yield curve plots yield to maturity against the terms for the otherwise similar fixed-income securities. It is commonly assumed that the yield curve contains useful information. Pelaez (1997), however, claims that disagreement exists as to its nature and importance. The results obtained by Argyropoulos & Tzavalis (2016) are consistent with previous macroeconomic studies (Estrella & Hardouvelis, 1991; Gamber, 1996; Hamilton & Kim, 2002; Moneta, 2005; Wheelock & Wohar, 2009), and first and foremost confirm that the slope factor of the yield curve reflects future changes in the business cycle conditions. Assefa et al. (2017) find statistically significant negative effects of interest rates on stock returns in developed countries.

Interestingly, the money and capital markets are closely interrelated, because most corporations, financial institutions and investors are active in both of them. The study of asset pricing lies at the core of financial economics, and the fundamental finance principle asserts that the asset price equals the discounted future streams of cash flows. In the light of the above, two relevant factors have to be pointed out: the uncertainty of the expected cash flows and changes in the discount rate.

It is commonly assumed that stock prices are determined in a forward-looking manner. The stock prices reflect the private sector's expected future discounted sum of returns on the assets. Changes in asset prices can then result from changes in the expected future dividends, the expected future interest rate which serves as a discount rate, or from changes in the stock returns premium.

Stocks as a class of assets are presumed to be sensitive to macroeconomic conditions. Any aggressive change in stock prices can have negative implications for the economy, which makes the causal relationship between macroeconomic variables and stock returns an intriguing topic in empirical finance (Barakat et al., 2016). Gostkowska-Drzewicka & Majerowska (2018) studied the evidence of the industry's effect on companies listed on the Warsaw Stock Exchange.

Participants of financial markets are also often characterised as being forward-looking. Likewise, financial prices can be considered forward-looking with regard to those macroeconomic variables that can affect them and, therefore, often contain valuable information on their expected or future behaviour (Alonso et al., 2001).

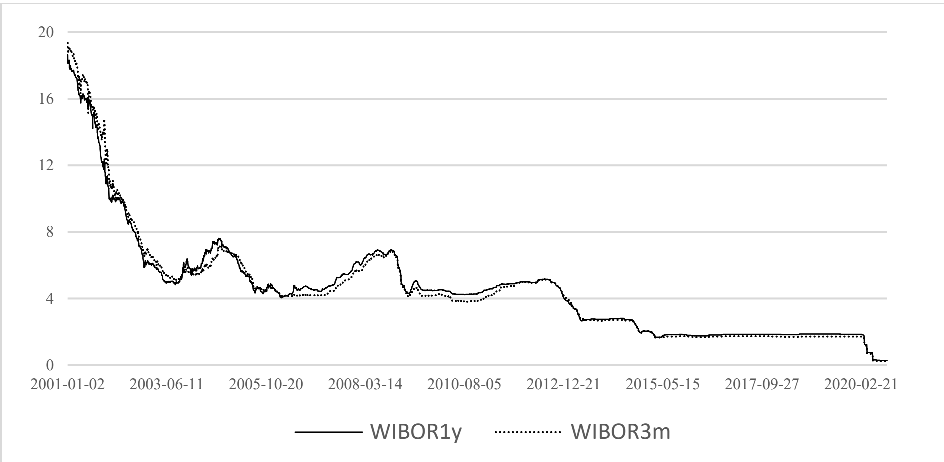
Explaining the relationship between macroeconomic variables and the stock market is important, as the latter has a systematic effect on the former. Economic forces affect discount rates, and through this mechanism, macroeconomic variables become part of the risk factors in equity markets (Chen et al., 1986). In an efficient capital market, stock prices adjust rapidly as new information becomes available; therefore, stock prices reflect all information about the stocks. This means that investors cannot use the readily-provided information to predict stock price movements and make profit by trading shares. In short, an efficient market incorporates new information quickly and completely. Stock prices also reflect the expectations towards the future performance of corporate profit. If stock prices reflect the above assumptions, they should be used as indicators of the economic activity; the dynamic relationship between stock prices and macroeconomic variables can be then used to guide countries' macroeconomic policies (Maysami et al., 2005). The most common means of linking macroeconomic variables with stock market returns is through the arbitrage pricing theory (APT), developed by Ross (1976). According to his theory, multiple risk factors can explain stock returns. The APT assumes that stock prices can be influenced by the behaviour of macroeconomic fundamentals, i.e. there are many channels for the relationships between the stock market and key macroeconomic variables. Chen et al. (1986) found that industrial production, changes in the term structure of interest rates, and changes in risk premiums, were all positively related to the expected stock return. Bernanke & Kuttner (2005) asserted that due to exogenous factors, changes in monetary policy – if not anticipated – affect the volatility of stock prices. Empirical studies point out to the importance of such economic variables as exchange rates, gross domestic product (GDP), basic interest rates, and inflation (Bhuiyan & Chowdhury, 2020). Other studies show explicitly the relationship between stock returns and interest rates (Assefa et al., 2017; Izgi & Duran, 2016; Papadamou et al., 2017). Interbank rates are capable of explaining the adjustments of stock prices, because their changes affect cash flows of companies, and may additionally affect the risk-adjusted discount rate (Flannery & Protopapadakis, 2002). Atanasov (2016) proves that value stocks are highly sensitive to upside movements in interest rate growth, whereas growth stocks rather tend to react to downside movements of interest rates.

## 3. Data and methodology

The conducted empirical analysis is based on daily data of the WIBOR rates relating to 1-year and 3-month deposits. In practice, the difference in interbank deposit rates for these terms should be seen as a proxy for economic expectations. The greater the positive value of the observed difference, the more favourably interpreted the economic outlook. The 3-month rate is of particular importance for the assessment of the economic outlook, as it is a price-setting parameter for variable-rate loans granted to enterprises. Therefore, any other possible slopes and differences are outside the scope of interest of this study. The analysis extends over the period from 1 January 2001 to 30 September 2020. It produced 4,944 daily observations in total. Figure 1 presents the evolution of these rates (expressed as a percentage) during the considered period. Sharp declines in the initial years can be observed, followed by fluctuations related to the economic crisis of 2008–2009. In the following years, the

WIBOR 1-year and 3-month rates were at a similar level. Subsequent breakdowns were connected with the outbreak of the pandemic and the related economic crisis.

**Figure 1.** WIBOR 1Y and WIBOR 3M rates




Source: authors' calculation based on data from the Stooq.pl (n.d.) financial website.

Figure 2 shows the differences between 1-year and 3-month rates. Except the initial period of some fluctuation in the banking market (i.e. before Poland joined the European Union in 2004), the slope of the Polish interbank market interest rate curve was mostly positive. The period 2012–2013 deserves particular attention due to the financial crisis in Greece, followed by a banking crisis in Cyprus.

**Figure 2.** Differences between WIBOR 1Y and WIBOR 3M rates


Source: authors' calculation based on data from the Stooq.pl (n.d.) financial service.

The Warsaw Stock Exchange consists of eight sectors and numerous subsets. Indices, including sector indices, are determined. Currently, 14 sectoral sub-indices are listed. Our analysis focuses on 9 of them, according to the classification adopted by the Stooq.pl portal. These are the sub-indices of the banking, construction, chemical, pharmaceutical, energy, oil and gas, food, and real estate sectors, as well as one macrosector index – the WIG GAMES. The initial listing of particular indices on the stock exchange took place at different times, which resulted in obtaining time series of varied length.

The relevant literature suggests using a GARCH type model for modelling daily returns. The equations of the GARCH(1,1) model, based on Bollerslev (1986), can take the following form:

$$y_t = \mu + \varepsilon_t, \tag{1}$$

$$\varepsilon_t | I_{t-1} = N(0, h_t), \tag{2}$$

$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}, \tag{3}$$

where $y_t$ is the return series, $h_t$ is the conditional variance, $I_t$ is the set of all available information, and $\varepsilon_t$ is the error term. In order to ensure a non-negativity of the conditional variance, the following restrictions are imposed $\omega > 0$, $\alpha \geq 0$, $\beta \geq 0$. The requirement for covariance stationarity of $\varepsilon_t$ is $\alpha + \beta < 1$.

Lin (2018) and Wei et al. (2020) apply the exponential GARCH model to describe the volatility asymmetry of returns. The EGARCH model was introduced by Nelson (1991). It allows including the asymmetric impact of positive and negative rates of return on variances. Thus, based on the above-mentioned works, the conditional variance is defined as:

$$lnh_t = \omega + \alpha\{\theta z_{t-1} + \gamma[|z_t| - E(|z_{t-1}|)\} + \beta lnh_{t-1}, \tag{4}$$

where $z_t = \varepsilon_t / \sqrt{h_t}$. It is not necessary to introduce any restrictions on the parameters of such equations, mainly due to the logarithmic form of the last equation.[1]

To test the impact of the interest rate slope on the returns of sub-indices, the additional variable to equation (1) of the above model was introduced. So the equation takes the form:

$$y_t = \mu + \delta x_t + \varepsilon_t, \tag{5}$$

[1] An overview of the GARCH class models can be found, for example, in Fiszeder (2009).

where $x_t$ represents the slope measured by the differences between one-year and three-month market interest rates (WIBOR 1Y minus WIBOR 3M).

Additionally, we introduced the difference $x_t$, defined above, into the variance, giving:

$$lnh_t = \omega + \upsilon x_t + \alpha\{\theta z_{t-1} + \gamma[|z_t| - E(|z_{t-1}|)\} + \beta lnh_{t-1}. \tag{6}$$

As mentioned before, the application of GARCH class models for financial data can be found in the literature. For example, Ugurlu et al. (2014) modelled stock market returns volatility for data from Bulgaria, the Czech Republic, Hungary, Poland and Turkey, applying the GARCH class models. Fałdziński et al. (2021) used ARCH models to forecast energy commodities. Due to the 'fat tails' of returns distributions, it is suggested to apply the $t$ distribution to the conditional distribution of $\varepsilon_t$ (Fiszeder, 2009).

## 4. Results

To determine the relationship between the logarithmic rates of return of selected stock exchange sub-indices and the slope of the interest rate curve, Pearson's linear correlation coefficients were determined. Additionally, correlation coefficients were calculated between the rates of return and differences of interest rates lagged by one period (one day). The results are presented in Table 1.

**Table 1.** Descriptive statistics of indices' returns[a]

| Indices | Variables | |
|---|---|---|
| | $x_t$ | $x_{t-1}$ |
| WIG – banking | 0.023 | 0.010 |
| WIG – construction | −0.066 | −0.078 |
| WIG – chemicals | −0.027 | −0.033 |
| WIG – pharmaceuticals | −0.082 | −0.078 |
| WIG – energy | −0.087* | −0.090* |
| WIG.GAMES | −0.053 | −0.056 |
| WIG – oil and gas | −0.025 | −0.026 |
| WIG – food | −0.019 | −0.031 |
| WIG – real estate | 0.022 | 0.017 |

a Data source: Stooq.pl financial service (n.d.).
* Statistically significant at 0.05 significance level.
Source: authors' calculation.

Generally, the correlations are not statistically significant at the 0.05 significance level. The only exception is the dependency between the return of the WIG – energy and the differences in the interest rates. It is not a surprising result, and it is consistent with the findings of Atanasov (2016). The energy-sector companies tend to be perceived as value stocks. In their financial statements, an important cost item is interest payments on external capital, and on their balance sheets, it is long-term debt with financial institutions. This results from a relatively high degree of financing fixed assets with long-term debt and hence the direct sensitivity to changes in interest rates is observed. Additionally, the value stocks are expected to pay dividends that refer directly to the level of the WIBOR 1Y rate.

In the next step, the proposed model, described by equations (4) and (5), was estimated. Results are presented in Table 2.

**Table 2.** Results of the estimation of the EGARCH(1,1) model with the slope in the conditional mean equation[a]

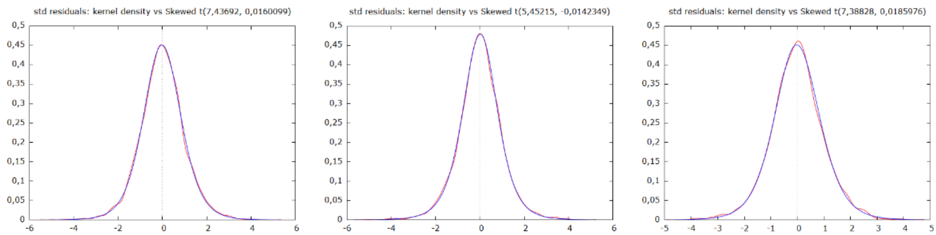
| Indices | Conditional mean | | Conditional variance | | | | Conditional density | |
|---|---|---|---|---|---|---|---|---|
| | $\mu$ | $\delta$ | $\omega$ | $\alpha$ | $\gamma$ | $\beta$ | $\eta$ | $\lambda$ |
| WIG – banking | 0.000 | −0.000 | −0.197* | 0.123* | −0.042* | 0.988* | 7.437* | 0.016 |
| WIG – construction | 0.000 | 0.000 | −0.261* | 0.146* | −0.027* | 0.983* | 5.452* | −0.014 |
| WIG – chemicals | 0.001* | 0.001 | −0.303* | 0.154* | −0.041* | 0.978* | 7.388* | 0.018 |
| WIG – pharmaceuticals | 0.007* | −0.049* | −0.528* | 0.327* | −0.042 | 0.963* | 4.894* | 0.031 |
| WIG – energy | −0.000 | 0.001 | −0.206* | 0.138* | −0.040* | 0.988* | 6.607* | 0.008 |
| WIG.GAMES | 0.002 | −0.005 | −0.833* | 0.357* | −0.085 | 0.927* | 5.359* | −0.068 |
| WIG – oil and gas | 0.000* | 0.000 | −0.184* | 0.111* | −0.027* | 0.988* | 8.269* | 0.002 |
| WIG – food | 0.000* | −0.000 | −0.525* | 0.254* | −0.030 | 0.962* | 5.318* | −0.012 |
| WIG – real estate | 0.000* | −0.000 | −0.150* | 0.124* | −0.024* | 0.994* | 6.656* | −0.010 |

a Data sources: Stooq.pl financial service (n.d.).
* Statistically significant at 0.05 significance level (the result of 0.000 means that the estimated value of the parameter is below 0.0005).
Source: authors' calculation.

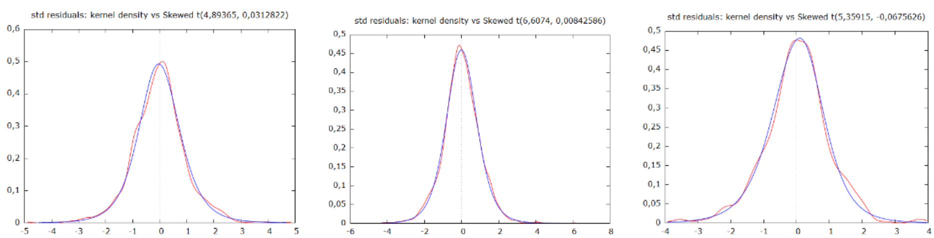
The last two columns in Table 2 feature estimated parameters of the conditional density, assuming skewed $t$ distribution of error terms $t(\eta, \lambda)$. Parameters of the distribution were estimated jointly with the EGARCH parameters. The parameter responsible for the asymmetry of distribution is insignificant in all cases. Figure 3 contains the distribution of the residuals obtained on the basis of the estimated models presented in Table 2. High leptokurtosis of distributions is clearly visible in all the pictures.

**Figure 3.** Distribution of residuals obtained from the models presented in Table 2

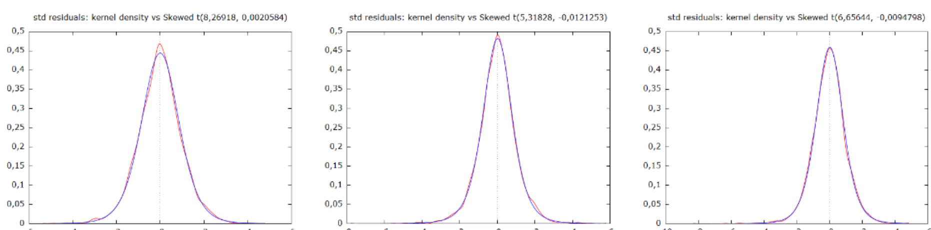
(a) WIG – banking (b) WIG – construction (c) WIG – chemicals




(d) WIG – pharmaceuticals (e) WIG – energy (f) WIG.GAMES




(g) WIG – oil and gas (h) WIG – food (i) WIG – real estate




Source: authors' calculation.

It can be observed that the estimates of most of the structural parameters connected with the volatility were statistically significant. It confirms the rationality of applying this model and is consistent with the results obtained by Wei et al. (2020). The exception is the gamma parameter which proved statistically insignificant for two sectoral sub-indices and one macrosector index. The structural parameter connected with the WIBOR slope was insignificant in all cases, except the one for the WIG – pharmaceuticals. This indicates that rates of return of sub-indices do not respond to changes in the shape of the interest rates curve.

**Table 3.** Results of the estimation of the EGARCH(1,1) model with the slope in the conditional mean and variance equations[a]

| Indices | Conditional mean | | Conditional variance | | | | | Conditional density | |
|---|---|---|---|---|---|---|---|---|---|
| | $\mu$ | $\delta$ | $\omega$ | $\upsilon$ | $\alpha$ | $\gamma$ | $\beta$ | $\eta$ | $\lambda$ |
| WIG – banking | 0.000 | −0.000 | −0.197* | 0.000 | 0.123* | −0.042* | 0.988* | 7.435* | 0.016 |
| WIG – construction | 0.000 | 0.000 | −0.261* | 0.000 | 0.146* | −0.027* | 0.983* | 5.452* | −0.014 |
| WIG – chemicals | 0.001* | 0.001 | −0.302* | −0.003 | 0.154* | −0.041* | 0.978* | 7.394* | 0.018 |
| WIG – pharmaceuticals | 0.003 | −0.025 | −2.096* | −6.355* | 0.590* | −0.085 | 0.696* | 5.203* | 0.013 |
| WIG – energy | −0.000 | 0.001 | −0.237* | −0.038* | 0.143* | −0.041* | 0.984* | 6.650* | 0.008 |
| WIG.GAMES | 0.000 | 0.001 | −0.852* | −0.215 | 0.358* | −0.088 | 0.921* | 5.313* | −0.068 |
| WIG – oil and gas | 0.000* | 0.000 | −0.184* | 0.001 | 0.111* | −0.027* | 0.988* | 8.266* | 0.002 |
| WIG – food | 0.000* | −0.000 | −0.528* | 0.005 | 0.255* | −0.030* | 0.962* | 5.322* | −0.012 |
| WIG – real estate | 0.000* | −0.000 | −0.150* | −0.004 | 0.123* | −0.025* | 0.994* | 6.668* | −0.010 |

a Data sources: Stooq.pl financial service (n.d.).

* Statistically significant at 0.05 significance level (the result of 0.000 means that the estimated value of the parameter is below 0.0005).

Source: authors' calculation.

Adding the WIBOR slope to the conditional variance, the model was estimated again, and the results are presented in Table 3 (equations (5) and (6)). They generally confirm our previous findings. For this model, the WIBOR slope was insignificant for all the analysed series in the conditional mean, and significant only for two sectoral sub-indices: the WIG – pharmaceuticals and the WIG – energy in the conditional variance.

## 5. Conclusions

The aim of the study described in this paper was to show whether the slope of the interest rate curve affects the formation of the rates of return of selected sub-indices listed on the Warsaw Stock Exchange. The conducted analysis, based on Pearson's linear correlation coefficient, showed no direct relationship between these factors. The econometric verification of the estimated EGARCH(1,1) model in two versions, i.e. with the slope in the conditional mean equation and with the slope in the conditional mean and variance equations, confirmed the above findings. It can therefore be stated, on the basis of the significance of the structural parameters, that the sectoral sub-index returns did not respond to changes in the curve's slope. It means that our hypothesis, stated in the introduction, needs to be rejected for most of the sub-indices. Under the monetary transmission mechanism, the credit channel operates for sub-indices (and companies) listed on stock exchanges. Based on the analysis carried out for sub-indices of the Warsaw Stock Exchange, it can be concluded that the quotations will react to changes in the slope of the interest rate curve in a heterogeneous manner. At the same time, we can observe a specific information assymetry, i.e. the energy and pharmaceutical industries reacting more strongly than the others. This is because their expected future profits and cash flow are more affected, as these industries (and companies) will experience higher market costs for re-financing debt after the slope of the interbank market interest rate curve has increased, even without any tightening of the monetary policy.

It should be pointed out that the variation in response to the change in the interest rate slope depends on the characteristics of the industry (sub-indices), to which the individual companies are affiliated.

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