An Empirical Study of the Determinants of Index Futures Basis: The Case of Warsaw Stock Exchange

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Abstract
Basis, representing the spread between spot and futures prices at a given moment, is one of the main indicators of the derivatives market. Its role is of special importance for hedgers, as the basis risk is believed to be one of the crucial factors of hedging performance. Previous studies have revealed that there are many market factors which could influence basis, such as spot market liquidity, volatility, interest rate, investor structure, etc. However, they are highly market-specific. This study uses the prices of the Warsaw Stock Exchange blue chip index (WIG20) and of the corresponding contract to examine the relationship between the basis and other market features that affect the spot-futures spread. The multiple regression and VAR methodologies are applied to identify the leading indicators of the WIG20 index futures basis and to explore possible causal relationships. The results indicate that as spot market volatility increases so does basis spread. The evidence of the Granger causality between basis and volatility was also found, however, under different market conditions the leading indicator changed.

Keywords: futures-cash basis, index futures, WIG20
JEL codes: G12, G13

1. Introduction

It is much easier for investors to estimate the risk of realizing hedging strategies if they know the regularities of the basis on a given market. A significant volatility of the basis may cause the hedging strategy to be ineffective, i.e. the losses on a market caused by the difference between the spot and futures prices may exceed the level accepted by the investor. The more volatile and unpredictable the basis the higher the risk of losses. A full compensation of profits and losses on the spot and futures market, i.e. a perfect hedge, is only possible when the increase of the price of the underlying asset is accompanied by the same, with respect to value and sign, increases of the price of the corresponding contract, i.e. the basis is stable. However, such a situation virtually never happens in real life. The basis can be influenced by a number of factors.

This study uses the prices of the Warsaw Stock Exchange blue chip index (WIG20) and of the corresponding contract to examine the relationship between the basis and other market features that affect the spot-futures spread. WIG20 index futures were the first derivatives on the Warsaw Stock Exchange, emitted in 1998. Until today they are the most liquid and heavily traded products on the WSE. In recent years the market has undergone significant changes: the participation of institutional investors associated with informed trading has grown and the regulations facilitating short sale on the stock market have been introduced. That has improved the conditions of the functioning of the arbitrage mechanism, which is believed to enhance spot-futures relation. The analysis covers the wide time interval (from 2004 to 2013), divided into three subperiods, which enabled to capture different market conditions and observe how determinants of the basis had been changing.

2. Literature review

The most popular model defining the relationship of the spot and futures prices is the cost-of-carry formula developed by Cornell and French (1983):

$$FV_t = S_t e^{(r-d)T} \tag{1}$$

where FV_t denotes the theoretical futures price at time t, S_t denotes the underlying asset price, r is the risk-free rate, d is the dividend yield, and T denotes the time to maturity. According to this model, changes in spot and futures prices should be perfectly correlated and this relationship is expected to be closer with decreasing time to maturity of a contract. The difference between the two prices, defined for a given moment, is the basis, which is the cost of carrying the underlying asset. For index futures that cost is the difference between the risk-free rate and the dividend yield. It is commonly believed that the model truly reflects the spot-futures relationship, even though it is based on very restrictive and unrealistic assumptions and many studies have shown that contract prices differ from the expected level defined by the cost-of-carry formula. That is why other models, e.g. by Hsu-Wang (2004), Ramaswamy-Sundaresan (1985), and Hemler-Longstaff (1991) have been developed. They do not demand such restrictive assumptions about market conditions as the cost-of-carry formula and they take into account the influence other factors have on the basis.

The study of Wu et al. (2011) presents the results of empirical research which suggest that the basis of index futures is influenced by stochastic risk-free rates, returns volatility, and the turnover of the underlying asset on the market. The impact of liquidity measured by bid-ask spreads on the basis is confirmed by the results of the analyses published in the study of Roll et al. (2007). For those analyses the authors used the VAR methodology. Their research also proves the reverse relationship – the basis has an influence on the liquidity of the spot market. Similar studies were conducted by Kadapakkam and Kumar (2009). They also discovered a two-way interaction between the basis and the liquidity of both spot and futures markets. Chen et al. (1995) developed a formal model taking into account the reduction of the basis in the conditions of increased liquidity. They confirmed it with empirical studies in which the model was tested using both realized and implied volatility. Likewise, Motladiile and Smit (2003) presented the results of analyses suggesting that the basis can be negatively correlated with the volatility of the market of the underlying asset, i.e. the index. The influence of the basis on the changes on the spot and futures markets has also been confirmed by studies of Wang and Chen (2007).

Following Wu et al. (2011) and Yan (2002), basis was defined as a daily difference of the futures and spot prices:

$$Ba = \ln F - \ln S \tag{2}$$

Basis could be also defined in a slightly different way. It is sometimes expressed as the difference ln*S*-ln*F* (Garcia and Sanders, 1996), $|(F-d)e^{-rt}-S|/S$ (Kadapakkam and Kumar, 2009) or $F-Se^{(r-d)t}$ (Chen et al., 1995). However, the last two formulas reflect more the perception of the basis as futures mispricing as they are based on the cost-of-carry formula. In such cases mispricing is close to basis spread only either in the period close to expiration or if it is assumed that dividend yield d and the risk-free rate r equal zero.

A hedging strategy results in the investor obtaining an effective price of the underlying asset in the amount of the sum of the futures price at the moment of opening the hedge position on the futures market, and of the basis at the moment of closing the position on the market. When the hedge position is being opened the basis is the source of uncertainty as to the result of the strategy. As mentioned above, usually the basis is not stable, hence the basis risk is inherent in hedging strategies and in some types of spread speculation. The basis risk can be measured with the use of basis variance, which can be expressed as follows (Sutcliff, 2006):

$$\sigma_{F-S}^2 = \sigma_F^2 + \sigma_S^2 - 2\sigma_{F,S}^2 \tag{3}$$

where σ_F^2 and σ_S^2 are, respectively, futures and spot variances and $\sigma_{F,S}^2$ means covariance between the spot and futures prices.

The essence of hedging strategies is that they allow a reduction of the risk on the cash market by shifting the risk to the basis risk which is usually smaller. The basis risk, in turn, is associated with the correlation between the prices of the underlying asset and of the contract. The weaker the relationship between the spot and futures prices the greater the basis risk. Equation (3) shows that if the correlation between the S_t and F_t prices is close to 1 then the risk of the basis is smaller than the risk of price changes on the separate spot and futures markets. Wu et al. (2011) pointed to the possible sources of basis risk. They found that hedgers bear the risk due to: 1) the imperfection of the derivative instrument as a substitute of the underlying asset, so their prices do not response in the same way to the influx of the same information, 2) hedgers’ lack of certainty as to the market timing of buying and selling 3) possibility of the settlement of a contract before its expiration. Figlewski (1984) stated that the basis risk is more important for index futures than for any other financial futures. He also enumerated a few possible sources of basis risk. The most important is the lack of formal linkage between the futures price and the index, apart from the final settlement price when the contract expires. As a contract is not completely matched to the underlying asset and, at the same time, it is formally unrelated, as regards the price, with the index, the cost-of-carry relation is loosened and external factors have a greater influence on the behavior of the basis. That is also the case when arbitrage between the spot and futures markets is hindered. Wrong functioning of the arbitrage mechanism is usually caused by market frictions but sometimes perfect arbitrage may be impossible because of too many stocks constituting the index. A replication of a basket of stocks within an index is possible if the index is narrow. Another basis risk source is connected with the activity of noise traders on the futures market. It may cause the price of a futures contract to deviate too much from its fundamental value. The issue of noise traders' influence on the volatility of the stock and futures market was raised e.g. in the study of Baklaci et al. (2011) and Schwert (1990).

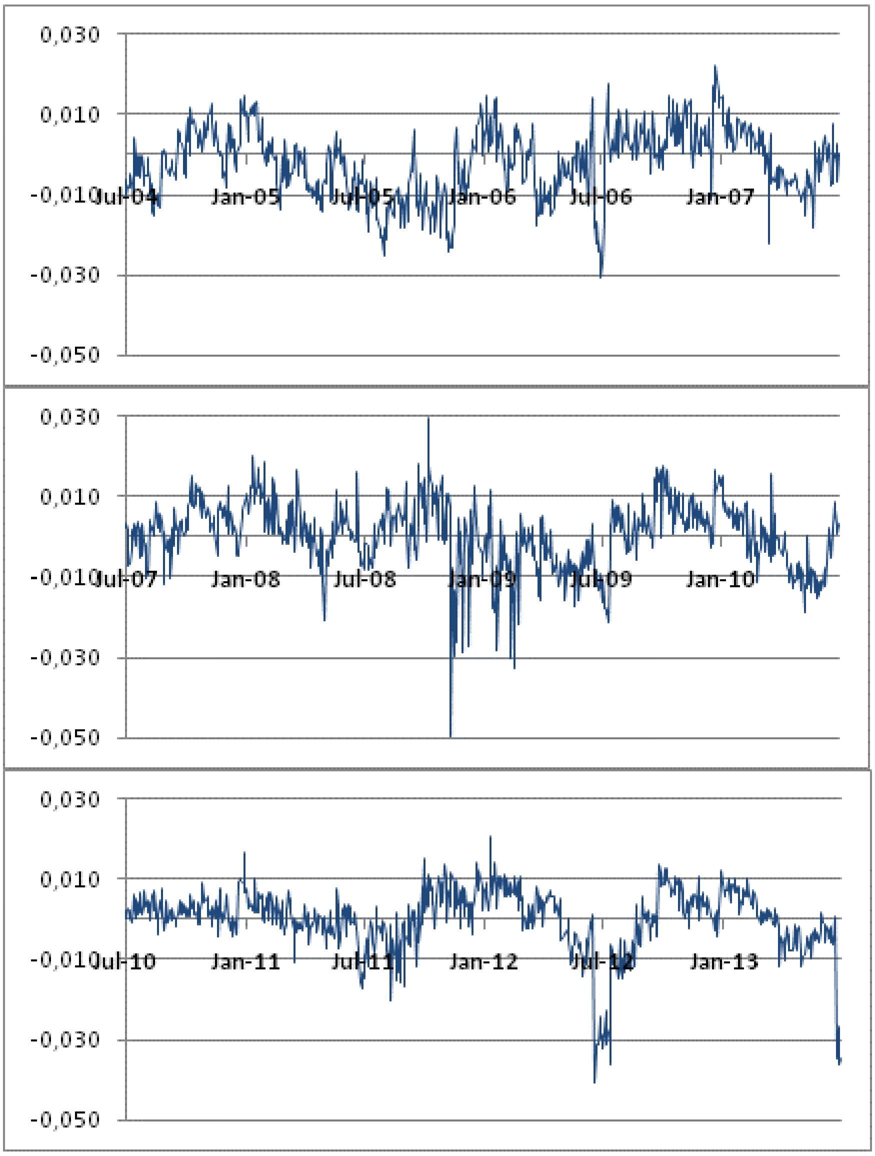
3. Data and methodology

In this study the basis of WIG20 index futures was analyzed. They are the most popular derivatives on the WSE and the huge trading volume of those instruments makes the Polish stock exchange the leader of futures trading in the CEE region. In 2012 the trading volume of WIG20 index futures amounted to PLN 198,406 mln. Although new categories of derivatives have been introduced to the WSE many of them did not remain on the market as the investors' interest in them was small. Those still on the market are much less popular than index futures.

The study period extended from 2004 to 2013 and was divided into three subsamples of comparative length, about 3 years each. That allowed us to notice the changes the Polish stock exchange underwent during that time and to study the basis in various market conditions. The first subsample covers the period from 1 July, 2004 to 29 June, 2007. At that time the market was on the rise. In 2004 the regulations forbidding the participation of investment funds in the futures market were liberalized and from that time on the percentage of individual investors in the market fell from over 80% to 60% in 2007. However, individual investors still had a much greater share in it than institutional ones, which made the Polish futures market look untypical. The second subsample covers the period from 2 July, 2007 to 30 June, 2010. As a result of the world financial crisis the spot and futures prices on the WSE plunged and the market was highly volatile. Only at the beginning of 2009 there was a turnaround and a growing trend became visible. At that time individual investors' share in the futures market remained at the stable level of 50%. The third subsample covers the period from 1 July, 2010 to 28 June, 2013. New legal regulations which lifted short-sale constrains appeared. It is believed that short sale strengthens the arbitrage mechanism which facilitates the approximation of spot and futures prices and the reduction of basis spread. At that time a horizontal trend prevailed on the stock exchange and volatility was relatively low.

The basis was defined with the use of daily closing prices. The total number of observations was 2257 trading days. The sets of futures prices only contained those series which were the closest to expiration, i.e. observations of prices of approximately the last 60 session days before expiration, during which the trading volume was the highest. It allows the study of futures contracts in the period of their greatest liquidity.

Figure 1: WIG20 basis plot



Source: author's calculations

Figure 1 presents a chart of the basis of WIG20 index futures in the three subsamples and Table 1 presents the basic descriptive statistics of the basis. It is clear that in the whole studied period the basis had alternately positive and negative values. Variability measured by the standard deviation was the biggest in the second subperiod, but as the differences were not large, it can be concluded that during the entire period the variability remained at a comparable level. However, the range Q3-Q1 shows that in the third subperiod the dispersion of basis was lower, as the range decreased. Also, asymmetry in the whole database changed over time. There was a noticeable difference between the skewness in the first and in the third subperiod. While in the years 2004-2007 negative values of the basis dominated, in the period 2010-2013 there was a prevalence of the positive values of the basis. Also skewness of |*Ba*| was the highest in the third subperiod, which, together with the highest kurtosis, indicates that the basis spreads were generally lower than in the previous subsamples.

Table 1: Descriptive statistics

	I subp.	II subp.	III subp.
Ba			
Mean	-0,213	0,034	0,001
Median	-0,129	0,136	0,116
Minimum	-3,081	-4,987	-4,046
Maximum	2,227	2,982	2,080
Standard dev.	0,849	0,856	0,805
Skewness	-0,310	-0,762	-1,737
Kurtosis	-0,158	2,165	4,993
Percentil 5%	-1,725	-1,437	-1,276
Percentil 95%	1,104	1,281	0,999
Range Q3-Q1	1,137	1,052	0,832
No. of obs.	754	752	751
|Ba|			
	I subp.	II subp.	III subp.
Mean	0,694	0,655	0,563
Median	0,595	0,534	0,426
Minimum	0,001	0,002	0,000
Maximum	3,081	4,987	4,046
Standard dev.	0,532	0,551	0,576
Skewness	1,072	1,865	2,759
Kurtosis	1,145	7,025	10,096
Percentil 5%	0,054	0,054	0,040
Percentil 95%	1,742	1,657	1,404
Range Q3-Q1	0,721	0,671	0,548
No. of obs.	754	752	751

Source: author’s calculations

In order to specify the factors determining the basis of WIG20 index futures the following two equations were used:

$$Ba = \alpha_0 + \alpha_1 In + \alpha_2 Tu + \alpha_3 Vo + \alpha_4 TtM + \alpha_5 TtM^2 + \sum_{i=1}^{3} \beta_i Ba_{t-i} + \varepsilon_i \quad (4)$$

$$|Ba| = \alpha_0 + \alpha_1 In + \alpha_2 Tu + \alpha_3 Vo + \alpha_4 TtM + \alpha_5 TtM^2 + \sum_{i=1}^{3} \beta_i |Ba_{t-i}| + \varepsilon_i \quad (5)$$

where *In* represents the Warsaw Interbank Offer Rate (WIBOR) which is used as a proxy of the risk-free rate for Poland. *Tu* means the daily turnover on the spot market, *Vo* represents the daily realized volatility of the underlying asset, *TtM* means time to maturity of a contract and ε_i is the error term. The measure of realized volatility used in the study was defined by Andersen and Bollerslev (1998) as:

$$Vo = \sum_{n=1}^{N} R_{n,t}^2 \quad (6)$$

where particular $R_{t,i}$ mean intraday rates of return on a given day *t*. In this study the measure was calculated on the basis of 5-minute intraday returns.

The basis regression expressed with equation (5), in contrast to the regression expressed with equation (4) defines the relationship between the potential determinants and the basis spread given as an absolute value. Both models, (4) and (5), were considered in three variants:

Equation 1: *Ba = f(In, Tu, Vo),*

Equation 2: *Ba = f(In, Tu, Vo, TtM),*

Equation 3: *Ba = f(In, Tu, Vo, TtM,* Ba_{t-i}*),*

There were analogous variants for regression of the variable |*Ba*|. Following Wu et al. (2011) the first version of the equations only included the *In*, *Tu*, and *Vo* variables. In that case, however, control variables are not used for various effects which may have a great influence on the basis. That is why, following Motladiile and Smit (2003) and Chen et al. (1995), in the second variant additional *TtM* variable was introduced, as well as squared *TtM* representing non-linear relationship. It is expected that as a contract approaches to the expiration date the basis will be smaller. In the last version of the regression equation a lagged dependent variable was also added as a control variable.

The aim of the next stage of the study was to reveal the possible causal relationships between the basis and the remaining variables, i.e. the interest rate, the turnover, which served as a proxy of liquidity, and volatility. For that purpose Vector Autoregression (VAR) methodology, developed by Sims (1980), was used. Bivariate VAR models were estimated for the pairs of variables: *Ba* and *In*, *Ba* and *Tu*, *Ba* and *Vo* and, respectively, |*Ba*| and *In*, |*Ba*| and *Tu*, |*Ba*| and *Vo*. On the basis of those models the Granger Causality tests with *F* statistics were conducted. While the regression models estimated in the first stage of the study point to possible dependencies between contemporaneous variables, VAR models allow the exploration of lead-lag relationships. The noticed causal relationships between the basis and other variables, then, can mean that they are good leading indicators, so it is possible to predict the future level of the basis with the use of past observations concerning selected market factors. In the analysis of causality one of the main factors determining the choice of the selected methods and tools is the character of the stochastic process the realization of which is the studied time series. Particularly important is the stationarity of the studied variables. That is why all variables were investigated with respect to stationary assessment, with the use of the Augmented Dickey-Fuller (ADF) unit root test. In this test the null hypothesis states that the process has a unit root so it is not stationary.

4. Results

Table 2 presents parameter estimates of the regression of the basis and of the absolute basis, in three different equations. The autocorrelation analysis has shown that there is a significant autocorrelation until the third lag, that is why the three initial lags of the basis have been included in the last version of the regression, i.e. Equation 3. The first equation, based on the previous studies by Wu et al. (2011) using Ordinary Least Squares (hereafter OLS) estimation, turned out to be seriously flawed because of error term serial correlation. Adding control variables *TtM* and TtM^2 did not bring about any improvement. In such case OLS estimators are not efficient, wherefore statistical inferences could be invalid. That is why Equations 1 and 2 were estimated again with the use of the generalized Cochrane-Orcutt (hereafter C-O) iterative procedure as described by Greene (2003). After the C-O estimation had been applied to both equations definitely better model properties were achieved than in the case of the OLS procedure. At the same time the results of the estimates of Equations 1 and 2 became more comparable to the estimations of Equation 3. Equation 3, presented in Table 2, was estimated with the use of the OLS procedure containing lagged basis. That equation is characterized by satisfactory model properties as a much better goodness of fit was achieved and no error term autocorrelation was found. However, the obtained results of the significance tests of particular parameters are mixed, both with respect to the differences between the studied periods of time and to the particular equations. In Equation 3, of 4 investigated factors, i.e. the interest rate, spot turnover, spot volatility, and time to maturity, *Ba* turned out to be explained solely by the *TtM* variable in the last subsample. The basis spread |*Ba*| was explained in the second subsample by *Vo*, and in the third one by *In*, *TtM*, and TtM^2.

In the case of Equations 1 and 2, however, we can see several differences in comparison to Equation 3. Firstly, in the *Ba* regression in the first subsample the parameter standing next to *Vo* is positive and statistically significant. Secondly, in the third subsample it was shown that the turnover also has a significant impact on the basis spread, however, that effect may have been due to a lack of the *TtM* and TtM^2control variables. The obtained values of the R^2 coefficient are quite high in comparison to the studies of other authors (see Wu et al. 2011, Chen et al. 1995, Motladiile and Smit 2003, Figlewski 1984). That is a thought-provoking result because, as has been indicated in the study of Roll et al. (2007), for the basis investigated in periods long before expiration we would expect more predictable deviations of basis, hence R^2 should be higher. However, in this study the analyzed time series of the basis consisted of 3-month periods, which was relatively close to the expiration.

Table 2: Multiple regression summary

Panel A: First subperiod (2004/07/01 – 2007/06/29)

	Ba Regression			|*Ba*| Regression		
Equation	1 (C-O)	2 (C-O)	3 (OLS)	1 (C-O)	2 (C-O)	3 (OLS)
const.	0,0007	0,0032	-0,0008	0,0069***	0,0040*	0,0001
$In*10^4$	-0,0007	-0,0007	1,0966	-0,8719	-1,0396	0,6035
$Tu*10^9$	0,8585	0,6173	0,3426	0,3490	0,6381	0,5277
Vo	2,0208**	1,8139*	1,3228	0,7475	0,9861	0,5849
$TtM*10^5$		-12,0254	-1,9881		13,4276	1,7131
TtM^2*10^6		1,1074	0,1585		-1,054	0,2054
$u(-1)/ Ba_{t-1}$	0,6089***	0,6096***	0,6063***	0,5169***	0,5004***	0,4932***
$u(-2)/ Ba_{t-2}$	0,1461***	0,1546***	0,1589***	0,1301***	0,1311***	0,1327***
$u(-3)/ Ba_{t-3}$	0,1274***	0,1200***	0,1107***	0,1309***	0,1281***	0,1287***
No of obs.	751	751	751	751	751	751
Adj. R^2	0,70	0,70	0,69	0,49	0,50	0,49
DW	2,00	2,00	1,99	2,00	2,00	1,98

Panel B: Second subperiod (2007/07/02 – 2010/06/30)

	Ba Regression			|*Ba*| Regression		
Equation	1 (C-O)	2 (C-O)	3 (OLS)	1 (C-O)	2 (C-O)	3 (OLS)
const.	0,0006	0,0014	0,0003	0,0072***	0,0053***	0,0020***
$In*10^4$	-0,2125	0,8664	1,1697	-3,1655	-2,7896	-1,2821
$Tu*10^{12}$	-2,9591	-2,9177	-1,5802	-1,4947	-1,1238	-0,6427
Vo	-0,2980	-0,2910	-0,2525	1,7904***	1,8252***	1,6137***
$TtM*10^5$		-17,3226	-7,3355		9,5509	2,4288
TtM^2*10^6		3,1350	1,2548*		-0,9746	0,0418
$u(-1)/ Ba_{t-1}$	0,4024***	0,3999***	0,4000***	0,2485***	0,2332***	0,2339***
$u(-2)/ Ba_{t-2}$	0,1932***	0,1926***	0,1898***	0,2012***	0,1957***	0,1673***
$u(-3)/ Ba_{t-3}$	0,2229***	0,2221***	0,2205***	0,1471***	0,1425***	0,1420***
No of obs.	749	749	749	749	749	749
Adj. R^2	0,52	0,52	0,51	0,27	0,27	0,27
DW	2,03	2,03	2,03	2,02	2,02	2,01

Panel C: Third subperiod (2010/07/01 – 2013/06/28)

	Ba Regression			|*Ba*| Regression		
Equation	1 (C-O)	2 (C-O)	3 (OLS)	1 (C-O)	2 (C-O)	3 (OLS)
const.	-0,0042	-0,0087**	-0,0019	0,0031	-0,0017	-0,0008
$In*10^4$	7,0425	6,4428	2,6063	9,5546	13,0605**	4,6971**
$Tu*10^{10}$	7,5359	5,7735	3,5890	-10,8363**	4,2992	2,2045
Vo	-0,5263	-0,4544	-0,2176	-0,1942	-0,7257	-0,3864
$TtM*10^5$		56,7204***	6,3983*		-12,7756	-7,5491***
TtM^2*10^6		-9,7787***	-1,1257**		4,8823***	2,0461***
$u(-1)/ Ba_{t-1}$	0,5115***	0,5093***	0,5018***	0,4876***	0,4200***	0,4159***
$u(-2)/ Ba_{t-2}$	0,2002***	0,2011***	0,2021***	0,2042***	0,2265***	0,1856***
$u(-3)/ Ba_{t-3}$	0,2096***	0,2052***	0,2086***	0,1582***	0,1963***	0,1592***
No of obs.	748	748	748	748		748
Adj. R^2	0,71	0,72	0,71	0,56	0,63	0,59
DW	2,01	2,01	2,00	2,00	2,01	1,94

Source: author's calculations

As shown in Table 4, the studied variables are stationary, with the exception of the interest rate, for which the test statistics calculated in the second and third subsample did not allow the null hypothesis rejection. Nevertheless, also for that variable a causality analysis was conducted, taking into account the possibility that the results may have an impact on the conclusions. The remaining studied variables are stationary in their levels.

Table 3: Unit root test results

Variable	ADF (without intercept and trend)	ADF (with intercept)	ADF (with intercept and trend)
Panel A: First subperiod (2004/07/01 – 2007/06/29)			
Ba	-4,7090***	-4,8641***	-4,8944***
|*Ba*|	-3,0837***	-6,3020***	-6,3026***
In	-0,7479	-2,3136	-4,1597***
Tu	-1,4960	-4,7462***	-8,0887***
Vo	-3,6547***	-6,4087***	-6,7774***
Panel B: Second subperiod (2007/07/02 – 2010/06/30)			
Ba	-4,7166***	-4,7237***	-4,8657***
|*Ba*|	-3,4680***	-6,8874***	-6,9393***
In	-0,8183	-2,0321	-3,2002*
Tu	-6,4819***	-6,5564***	-6,6637***
Vo	-4,1255***	-5,8670***	-5,8856***
Panel C: Third subperiod (2010/07/01 – 2013/06/28)			
Ba	-2,8508***	-2,8356*	-3,0246
|*Ba*|	-2,9088***	-5,0412***	-5,3987
In	-0,4621	-1,8640	-1,4424
Tu	-1,3535	-4,3250***	-5,0761***
Vo	-4,4039***	-5,6827***	-5,6770***

Source: author's calculations

A further stage of the study were statistical tests of the occurrence of causality in Granger's sense between the basis and the remaining variables. The tests were conducted in pairs and their results are presented in Table 4. In this case the lags of the variables in the VAR models were chosen with the use of the Schwartz Bayesian criterion. Only in the first subsample it was demonstrated that volatility could be the leading indicator for the basis and basis spread. The spot market turnover was the cause for |*Ba*| and *vice versa* in the third subsample. With the minimum level of the p-value being 5% for the rejection of H0 it can also be concluded that *Ba* and |*Ba*| were the leading indicators of *Vo* in the second and third subsample.

Table 4: Granger-causality test results

	Ba	|*Ba*|	*In*	*Tu*	*Vo*
Panel A: First subperiod (2004/07/01 – 2007/06/29)					
In	0,59	0,91			
Tu	0,90	0,40			
Vo	7,27***	3,27**			
Ba			0,69	0,20	1,42
|*Ba*|			2,47*	2,35*	0,33
Panel B: Second subperiod (2007/07/02 – 2010/06/30)					
In	0,23	0,06			
Tu	0,69	0,30			
Vo	1,07	1,38			
Ba			0,68	0,96	4,90***
|*Ba*|			1,39	0,34	9,28***
Panel C: Third subperiod (2010/07/01 – 2013/06/28)					
In	1,40	0,30			
Tu	1,20	3,14**			
Vo	1,73	1,56			
Ba			0,41	0,36	2,67**
|*Ba*|			0,67	3,79**	3,11**

Note: Null hypothesis: row variable does not Granger-cause column variable. Table presents F-statistics for pairwise Granger-causality tests.

Source: author's calculations

5. Conclusion

In this study the basis of WIG20 index futures from Warsaw Stock Exchange was analyzed. The investigation revealed that for a long time basis was independent from the spot market as both its liquidity and volatility were uncorrelated with the basis. Also, no stable, statistically relevant relationship between the basis and the interest rate was found. However, it was determined that WIG20 volatility had an impact on the basis spread in the situation of significant changes on the spot market (the second subsample). The sign of the slope coefficient by *Vo* in the regression equation was positive which means that the more unstable the situation on the market of the underlying asset the greater the absolute difference between the spot and futures prices. That is inconsistent with the results obtained by Chen et al. (1995) and Motladiile and Smit (2003) who discovered that volatility has an inverse impact on the basis – the greater the volatility the smaller the basis. They explain that phenomenon with the activity of hedgers who desire protection against the increased risk on the spot market. It seems, however, that in the case of the WSE the hedging strategy is still used relatively rarely and that is why the correlation between volatility and the basis is positive. The time to maturity had a surprisingly little impact on the explanation of the basis, determining it only in the third subsample. Nevertheless, the obtained estimates of the parameters lead to mixed conclusions as the signs of the estimations of the parameters next to the *TtM* and TtM^2 variables are positive and negative in various models, and one could have expected that in the |*Ba*| equation they would be only positive. Chen et al. (1995) stated that a negative slope coefficient of the time-to-maturity should not raise controversy if *Ba* is negative in the studied period. In such a case the basis returns to the zero level as the contract approaches the expiration date.

An analysis of causality has also been conducted which showed that spot market volatility was leading indicator for basis in the years 2004 – 2007 but that from 2007 the basis and basis spread turned out to be ahead of volatility. However, for all three studied subsamples it has been established that the actual values of the basis strongly depend on the past ones and that it is a positive correlation. That is why useful information about the future basis, for a hedging strategy, can be drawn primarily from past observations concerning that factor because, generally speaking, the basis is insensitive to the studied factors. We may suppose that the reason for it is the speculators' supremacy on the Polish futures market.

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