

**DOES SIMULTANEOUS INVESTING ON DIFFERENT STOCK
MARKETS ALLOW TO DIVERSIFY RISK?
THE COINTEGRATION ANALYSIS WITH MAIN FOCUS
ON WARSAW STOCK EXCHANGE**

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Abstract: This paper aims at examining the bilateral linkage between daily stock market indices, in which the leading index of WSE (WIG20) is the reference. Thus, the study is limited to pairs including WIG20 and indices which are listed on the financial centers of WSE's main foreign investors. The relationship between the markets is investigated throughout the cointegration theory. Further, the Granger causality is carried out in order to distinguish the directions of influence across the stock market environments. The obtained results shall explain the investor's tendencies in portfolio diversification.

Keywords: market stock exchange, stock exchange indices, WIG20, cointegration theory, Granger causality, portfolio diversification.

INTRODUCTION

The international portfolio diversification, as one of general techniques for reducing investment risk, has been among the most celebrated concepts in finance for more than half a century. Starting with the pioneering work in Modern Portfolio Theory presented by Markowitz [Markowitz 1952, 1959] together with later findings of Grubel [Grubel 1968], the concept of modern portfolio analysis was irrevocably extended from domestic to international capital markets. Since then there have been a numerous empirical studies which showed substantial advantages of international diversification.

In spite of different methods applied, the conclusions of early empirical studies, namely [Levy et al., 1970], [Grubel et al., 1971], [Lessard, 1973] and

[Solnik, 1974], were consistent with both Markowitz's and Grubel's predictions [Markowitz, 1952, 1959], [Grubel, 1968]. In fact, each of these studies indicated that movements of stock prices within different countries are characterized by low correlation, hence are almost unrelated to each other. This leads to the conclusions that simultaneous capital investing across these countries can bring benefits.

Nevertheless, it is worth mentioning that the studies cited above were written in times when the movement of capital between market exchanges was relatively limited by political and legal restrictions. Indeed, the relationship between the stock markets started to be visible when these restrictions were lifted with time.

Recently, numerous studies focus on cointegration techniques to investigate the existence of long-run benefits from international diversification, for instance: [Gilmore et al. 2005] and [Voronkova, 2004]¹⁵. These researches examine both bilateral and multilateral cointegration properties. According to these studies, the equity markets move in the same direction in the long-run and therefore there is no advantage of international diversification.

The U.S. market is found to be the dominant market in the financial world. What is interesting, it did not influence the market's behaviour of "new EU members"¹⁶ before its EU enrolment [Gilmore et al. 2002]¹⁷, [Kanas, 1998]¹⁸. On the other hand, the long-run linkages between Central European markets¹⁹ and the developed markets in Western Europe and the U.S can be found after the EU accession [Rousova, 2009].

The aim of this paper is to investigate long-run benefits from international portfolio diversification for foreign investors who invest within Warsaw Stock Exchange (WSE).

The question is whether the international investors present on WSE tend to exploit all benefits from portfolio diversification. Specifically, examined is the case of foreign investors who diversify portfolio by holding assets on both, WSE and on his/her home financial centre. The gains of portfolio diversification is investigated by bilateral relationship between Polish and other market. To achieve the goals, the framework of cointegration theory is adopted.

¹⁵ [Gilmore et al. 2005] and [Voronkova, 2004] show that process of integration of the Central and Eastern European countries into the EU resulted in their equity markets' comovements with other major EU countries and even with USA stock market (in case of Varonkova).

¹⁶ "new EU members" refer to Central and Eastern European countries which joined the EU on 1st May 2004, that is: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia and the Mediterranean islands of Malta and Cyprus.

¹⁷ Paper shows that Czech Republic, Hungary and Poland were not cointegrated with the U.S equity market during the period from 1995 to 2001.

¹⁸ The results for the period from 3rd January 1983 to 29th November 1996 show that the US market was not pairwise cointegrated with any of the European markets, namely the UK, Germany, France, Switzerland, Italy, and the Netherlands.

¹⁹ that is specifically Czech Republic, Poland and Hungary.

In fact, integration among stock markets is not constant over time mainly due to unexpected events, such as financial crises, for instance. For this reason, the study distinguishes additional period after the financial crisis that started at the end of 2008. This division helps to find out the eventual effects of the financial crisis on cointegration relationship. In other words, the study tries to answer the question whether the crisis caused the contagion or contrary weaken the linkage between the stock markets.

Additionally, the Granger causality is carried out in order to distinguish the directions of influence across the stock market environments.

UNIT ROOT, COINTEGRATION AND GRANGER CAUSALITY

The research on the relationship between the markets is performed with use of cointegration theory. Since the stationarity of time series is the precondition for cointegration analysis, the first step is to test the stationarity of each time series. The Augmented Dickey-Fuller test (ADF), as an extension of the Dickey and Fuller method, is used [Dickey and Fuller, 1979; 1981]. It tests for the presence of unit root, which alternative of stationarity of the series investigated. Additionally, for the cointegration analysis purposes, all the series must be integrated of the same order.

The next step is application of cointegration analysis to test the presence of long-run equilibrium relationships. This paper uses Banerjee, Dolado and Mestre cointegration test [Banerjee et al., 1998]. Null hypothesis is that there is no cointegrating relationship among the variables.

Additionally, the simple Granger causality test is performed in order to distinguish directions of influence across the stock market environments [Granger, 1969]. Granger causality test allows to determine whether one index is useful in forecasting another. If the past values of the index A can be used to predict another index B more accurately than using just the past values of B index, it can be argued that A Granger-cause B. This means that if past values of A statistically improve the prediction of the B, then we can conclude that A Granger-causes B. The null hypothesis assumes no Granger causality and is verified by using F-tests.

In this study, the Granger causality test and cointegration tests are proceeded pairwise with up to 10 lags tested.

Confirming existence of Granger causality and cointegration can be considered as evidence against portfolio diversification opportunities.

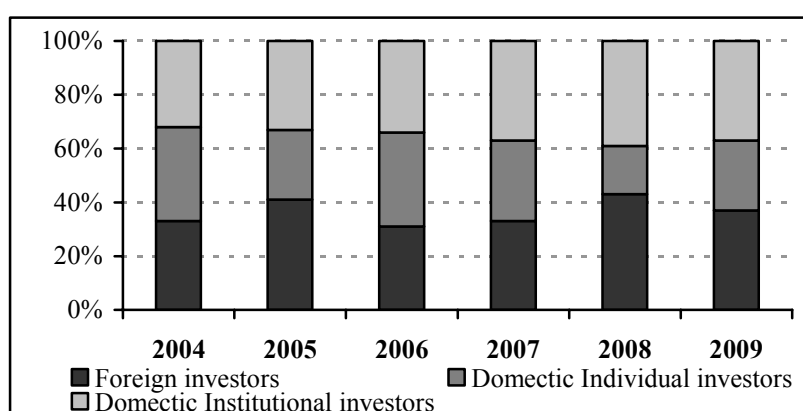
FOREIGN INVESTORS ON WSE

In view of the fact that WSE is of particular interest for this paper analysis, the stock market indices of countries of its main foreign investors are investigated. Thus, the decision on countries chosen as investors' origin was driven primarily by data availability to the researches conducted by WSE. In fact, these regular studies

provide information about the structure of its investors²⁰. It is worth noticing that foreign investors are identified here with the brokerage houses. Although we realize that nationality of brokerage house's customers does not necessarily coincide with placement of itself, it is the only source of data available.

Over the past years, according to the data published by WSE, foreign investors had the highest share in equity trading, followed by domestic financial institutions and individual investors [see Figure 1].

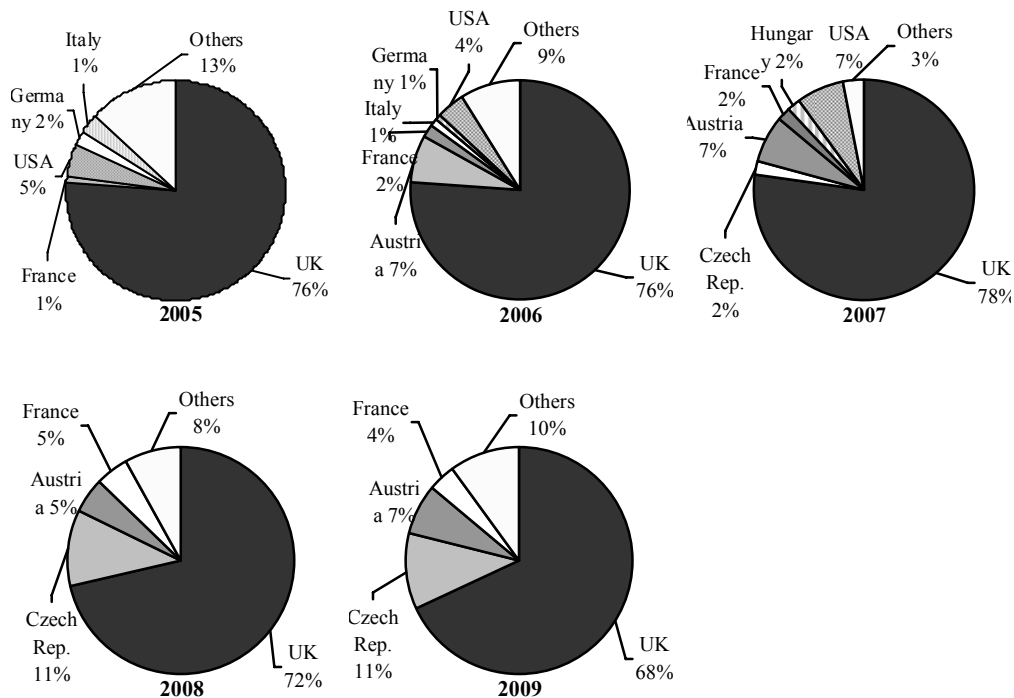
Figure 1. Investor structure on WSE (% shares in equity trading) for period between 2004 and 2009 (as of the end of the year)



Source: own investigation based on WSE data

²⁰ The analyses are based on Warsaw Stock Exchange Fact Book 2009. Official publication of WSE can be found at www.wse.com.pl.

Figure 2. Foreign investors structure on WSE (% shares in equity trading) for period between 2005 and 2009 (as of the end of the year)



Source: own investigation based on WSE data

What is more, there have been no changes in national origin of foreign brokers trading in shares [see Figure 2]. Indeed, brokers from Great Britain have been prevailing among foreign investors since the beginning of the period under investigation. The rest of shares in equity trading has been almost equally distributed among other foreign participants and when compared to Great Britain, gives a negligible contribution of these investors (less than 11% each).

To sum up, during the period under consideration the main investors that were present on Polish market were from: United Kingdom, Czech Republic, Austria, France, Italy, Germany, Hungary and the USA, and are identified in this study with main foreign investors groups present on WSE.

Therefore, in order to investigate the stock market linkage between WSE and home financial centres of its main foreign investors, daily closing quotes of WIG20 and leading indices from seven corresponding market stock exchange is used [see Table 1].

Table 1. Stock Market Indices

Country	Stock Market Exchange	Webpage	Index
Austria	Vienna Stock Exchange	www.wienerbourse.at/	ATX
Czech Republic	Prague Stock Exchange	www.pse.cz/	PX
France	Euronext Paris	www.euronext.com/	CAC40
Germany	Frankfurt Stock Exchange	www.boerse-frankfurt.de/	DAX
Hungary	Budapest Stock Exchange	www.bse.hu/	BUX
Italy	Borsa Italiana	www.borsaitaliana.it	FTSE MIB
Poland	Warsaw Stock Exchange	www.wse.com.pl/	WIG 20
United Kingdom	London Stock Exchange	www.londonstockexchange.com/	FTSE 100
United States of America	New York Stock Exchange	www.nyse.com/	S&P 500

Source: own Investigation based on official Stock Market Exchange webpages

DATA DESCRIPTIONS

All data used in the study was obtained from the same source, namely from the webpage: *www.finance.yahoo.com*. Study covers the period between 1st January 2004 and 12th March 2010 (1575 observations for each stock market index). The additional subperiod covers the series between 12th March 2009 and 12th March 2010 which represent the data after the financial turmoil that started by the end of 2008.

The basic statistical characteristics of the sampled indices for the whole period under consideration and subperiod are presented respectively in Table 2 and Table 3.

Table 2. Main descriptive statistics (1st January 2004 – 12th March 2010)

Country	AUSTRIA	CZECH	FRANCE	GERMANY	HUNGARY	ITALY	POLAND	UK	USA
Index	ATX	PX	CAC 40	DAX	BUX	FTSE MIB	WIG20	FTSE 100	SP500
Mean	3 147.00	1 271.80	4 390.50	5 543.10	19 265.00	31 125.00	2 494.40	5 321.40	1 211.80
Median	3 179.60	1 274.00	4 321.60	5 519.80	20 781.00	31 878.00	2 384.80	5 330.50	1 213.90
Minimum	1 412.00	628.50	2 519.30	3 647.00	9 380.00	12 621.00	1 327.60	3 512.10	676.53
Maximum	4 981.90	1 936.90	6 168.10	8 105.70	30 118.00	44 364.00	3 917.90	6 732.40	1 565.20
Standard Deviation	1 027.30	349.81	874.74	1 233.50	5 251.10	7 447.80	680.30	771.98	185.95
Skewness	0.08	-0.03	0.18	0.36	-0.28	-0.27	0.36	-0.05	-0.36
Kurtosis	1.62	1.84	1.98	2.06	1.99	2.13	1.90	1.89	2.74
Jarque-Bera test	126.06	87.87	78.38	91.71	87.14	68.95	112.97	82.26	38.14

Source: own calculations

For the whole period measures for skewness and excess kurtosis show that PX, BUX, FTSE MIB and FTSE are negatively skewed, whereas ATX, CAC 40,

DAX, WIG20 are positively skewed. All series are leptokurtic and are not normally distributed.

For the subperiod all indices have characteristics typical for financial series that is negative skewness, positive kurtosis and time series are not normally distributed.

Table 3. Main descriptive statistics (12th March 2009 – 12th March 2010)

Country	AUSTRIA	CZECH	FRANCE	GERMANY	HUNGARY	ITALY	POLAND	UK	USA
Index	ATX	PX	CAC 40	DAX	BUX	FTSE MIB	WIG20	FTSE 100	SP500
Mean	2 310.20	1 044.10	3 513.40	5 301.20	18 074.00	21 026.00	2 105.10	4 807.00	1 005.00
Median	2 453.10	1 117.60	3 640.10	5 481.30	19 457.00	21 627.00	2 187.30	4 987.70	1 032.20
Minimum	1 467.30	677.30	2 694.30	3 953.60	9 461.30	13 804.00	1 452.80	3 712.10	750.74
Maximum	2 752.40	1 220.30	4 045.10	6 048.30	23 210.00	24 426.00	2 489.40	5 599.80	1 150.20
Standard Deviation	312.07	140.00	349.71	535.11	3 597.60	2 340.10	269.96	518.81	105.35
Skewness	-0.75	-0.80	-0.52	-0.73	-0.63	-0.97	-0.58	-0.36	-0.52
Kurtosis	2.47	2.31	2.09	2.56	2.15	3.45	2.25	1.78	2.08
Jarque-Bera test	26.74	32.33	20.39	24.88	24.42	42.13	20.29	21.02	20.63

Source: own calculations

RESULTS

As first step, the ADF test was applied both to the levels and first differences of each series [see Table 4]. Appropriate number of lags for the ADF test was selected according to the Schwarz information criterion. For the levels, the results show that the null hypothesis of a unit root cannot be rejected at 5% significance level. The first-differenced series rejects the null hypothesis, indicating that time series are stationary. Consequently, all series are integrated I(1).

Given that the first differences are integrated of the same order (1), hence stationary, the Granger causality tests are performed [see Table 5]. WIG20 Granger-causes DAX (null hypothesis rejection for all 10 lags), PX (null hypothesis rejection for lags from 2 to 10), BUX (null hypothesis rejected for lags from 4 to 10), ATX (null hypothesis rejected for lags 7 and 8) and S&P 500 (null hypothesis rejection for all 10 lags).

WIG20 is Granger-caused by CAC (null hypothesis rejected for lags 3 and from 7 to 10), PX (for all 10 lags), BUX (for all 10 lags), ATX (for all 10 lags), FTSE (for lags from 8 to 10) and FTSE MIB (for lags 3, 4 and from 7 to 10).

Results indicate that WIG20 is influenced by strong and developed markets in Germany, UK and Italy. Moreover, WIG20 influences and is simultaneously influenced by stock markets of Central and Eastern Europe (Austria, Hungary and Czech Republic). In other words changes in the CEE indexes cause changes in WIG20 index with up to 10 days lags. The reverse situation is also true with less WIG20's lags. Granger-causing S&P500 by WIG20 doesn't necessarily indicative.

In chosen subperiod some important changes occurred and significantly less dependency can be observed [see Table 5]. There are no causalities between WIG20 and CAC, FTSE, FTSE MIB. There is also a decrease in number of lags in WIG20's influence on DAX or ATX and an increase in WIG20's influence on PX. A decrease in influence on WIG20 is noted for BUX and ATX.

Table 4. ADF Test results (1st January 2004 – 12th March 2010)

Country	Index	levels ²¹	First difference	Conclusion
Austria	ATX	-1,316	-14,1099	I(1)
Czech Republic	PX	-1,551	-13,9403	I(1)
France	CAC 40	-1,327	-14,3275	I(1)
Germany	DAX	-1,302	-14,6469	I(1)
Hungary	BUX	-1,719	-13,4408	I(1)
Italy	FTSE MIB	-1,269	-14,0153	I(1)
Poland	WIG20	-1,301	-14,6806	I(1)
United Kingdom	FTSE 100	-1,551	-14,2512	I(1)
United States of America	SP500	-1,372	-14,5581	I(1)

Source: own calculations

Table 5. Granger Test results

Index	1 st January 2004 – 12 th March 2010		12 th March 2009 – 12 th March 2010	
	WIG20 Granger causes...	...Granger causes WIG20	WIG20 Granger causes...	...Granger causes WIG20
CAC	x	3, from 7 lags	x	x
DAX	to 10 lags	x	to 2	x
PX	from 2 lags	to 10 lags	3, from 5 to 10	to 10
BUX	from 4 lags	to 10 lags	x	from 1 to 4, 6, 9
ATX	from 7 to 8 lags	to 10 lags	7	from 1 to 4
SP500	to 10 lags	x	to 10	x
FTSE	x	from 8 lags	x	x
FTSE MIB	3	3-4, from 7 lags	x	x

Source: own calculations

Cointegration tests results are shown in Table 6. In period 2004-2010 WIG20 is cointegrated with PX (null hypothesis rejected for lags 1 and 2), ATX

²¹ The critical values of the ADF t-statistic as reported by STATA, the econometric software used for performing the unit root test, are -2.329, -1.646, -1.282 at the 1%, 5% and 10% levels of significance, respectively.

(for lags 1 and 2) and FTSE (null hypothesis rejection for all 10 lags). In subperiod 2009-2010 WIG20 is cointegrated with CAC (for lags from 1 to 8), DAX (for all 10 lags), BUX (for lags from 1 to 5 and for 7th lag), S&P500 (for all 10 lags) and FTSE (for lags from 1 to 5 and for 7th lag). No cointegration with FTSE MIB was observed. Therefore stronger cointegration WIG20 with most of the indices considered in our study can be observed.

In some cases, the results for the cointegration and Granger causality test seem to be in conflict with each other. The explanation is based on the consideration that the Granger causality test explores the short-term relationships among variables whereas cointegration tests are used to examine long-term relationship.

Table 6 Cointegration Relationships

	1 st January 2004 – 12 th March 2010	12 th March 2009 – 12 th March 2010
CAC	1	from 1 to 8
DAX	x	from 1 to 10
PX	from 1 to 2	x
BUX	x	from 1 to 5 and 7
ATX	from 1 to 2	x
SP500	x	from 1 to 10
FTSE	from 1 to 10	from 1 to 5 and 7
FTSE MIB	x	x

Source: own calculations

CONCLUSION

The aim of this paper was to investigate possible interactions between Warsaw Stock Exchange index - WIG20 - and indices of home country financial centres of WSE's main foreign investors.

The results suggest that since the year of Polish accession to the European Union, Polish market has shown particularly strong relationships with stock markets from the CEE region. The influence is two-sided and is visible in short and long horizon, which was proved by the results of the Granger and cointegration test, respectively. These findings seem to be in line with the previous studies conducted by [Gilmore et al. 2005] and [Voronkova, 2004]

Furthermore, the findings reveal that every stock market were sensitive to financial turmoil which started at the end of 2008. In fact, in the short term strength of relationship between WIG20 and other markets seem to decrease. WIG20 is Granger-caused by indices of neighbouring stock markets of the CEE region. However in the long-run the Polish market reacts strongly at signals from the most matured and developed markets, that is the USA, United Kingdom, Germany and France.

Finally, taking into account that comovement can be found for Polish market and other European markets (especially LSE and all CEE stock markets), increasing integration among these financial markets gradually reduces benefits derived from international diversification in the long term perspective. However, the US investors can still benefit from investing in emerging markets, like WSE, both in short and long time horizon.

In conclusion incentives for investing on WSE are not connected with portfolio diversification due to strong dependencies between analysed stock markets.

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