

**Krzysztof Kompa**

Warsaw University of Life Sciences  
e-mail: krzysztof\_kompa@sggw.pl

**Dorota Witkowska**

University of Lodz  
e-mail: dorota.witkowska@uni.lodz.pl

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**SYNTHETIC MEASURES OF THE EUROPEAN  
CAPITAL MARKETS DEVELOPMENT**

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**SYNTETYCZNE MIERNIKI ROZWOJU  
RYNKÓW KAPITAŁOWYCH W EUROPIE**

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**Summary:** The development of computer sciences and telecommunication together with legislation changes caused the globalization of capital markets and the increase of their role in the economy. To measure the level of the development of capital markets it is necessary to take into account several aspects that lead to providing multidimensional analysis. Therefore multivariate statistical methodology can be used for such a purpose. The aim of the paper is a comparison of the development of the capital markets, represented by the stock exchanges affiliated with the Federation of European Securities Exchanges (FESE). The development of selected equity markets is evaluated applying taxonomic measures calculated on the basis of FESE data concerning nineteen European stock exchanges in the years 2002-2011. Variables used for the synthetic indicators construction describe both the characteristics of the capital markets and the financial efficiency of the stock exchanges.

**Keywords:** capital market, linear ordering methods, taxonomic measure of development.

**Streszczenie:** Rozwój metod przetwarzania i transmisji danych wraz ze zmianami prawnymi spowodował globalizację rynków kapitałowych i wzrost ich znaczenia w gospodarce. Ocena stopnia rozwoju rynków kapitałowych wymaga prowadzenia analiz wielowymiarowych, dlatego metody wielowymiarowej analizy statystycznej mogą być z powodzeniem używane do tego celu. W artykule przedstawiono wyniki badań, których celem jest porównanie stopnia rozwoju 19 giełd kapitałowych zrzeszonych w Europejskiej Federacji (FESE). Ocena stopnia rozwoju prowadzona za pomocą mierników taksonomicznych wyznaczonych na podstawie danych FESE za lata 2002-2011.

**Słowa kluczowe:** rynek kapitałowy, porządkowanie liniowe, wektorowa taksonomiczna miara rozwoju.

## 1. Introduction

Economic growth in a modern economy hinges on effective financial sectors that pools domestic savings and mobilizes foreign capital for productive investment. There are three fundamental challenges through financial structure and economic growth, which are pointed out by the literature [Bekaert et al. 1995]. (1) Financial development increases the proportion of savings that is funneled to investments. (2) Financial development may change the savings rate and hence affect investments. (3) Financial development increases the efficiency of capital allocation. Therefore the role of capital markets in the global economy has been increasing, especially because of the globalization of the financial markets, which became possible thanks to the development of computer sciences and telecommunication together with legislation changes<sup>1</sup>. The progress however has been influencing the role of the capital markets, which have lost their traditional functions such as the reallocation of capital from investors to companies or the evaluation the market value of companies listed on the stock exchange. The introduction of new trading systems and new investment instruments has caused the increase of the role of big – institutional investors.

After World War II, domestic capital markets, represented by one (like in Austria) or more (in Spain) stock exchanges, were developing in all market-oriented economies. The London Stock Exchange had a leading position in Europe for decades. In 2006 the London market was still characterized by the biggest capitalization, turnover and number of companies listed, having 3.4 times more companies, and twice as high turnover than EUREX which was the second biggest stock exchange in Europe (see [Witkowska, Zdziarski 2008]).

The intensification of the integration process and financial market globalization in recent years changed the situation in Europe, and caused the development of regional stock exchanges like EURONEXT and OMX Exchanges that are Pan-European institutions and the CEE Stock Exchange Group (CEESEG), which is a holding. At present, EURONEXT is based on the Amsterdam, Brussels, London, Lisbon and Paris Stock Exchanges. The OMX Exchanges operate eight stock exchanges in Nordic (i.e. the Copenhagen, Stockholm, Helsinki and Iceland Stock Exchanges) and Baltic countries (i.e. the Tallinn, Riga and Vilnius Stock Exchanges), together with the Armenian Stock Exchange. While the CEE Stock Exchange Group comprises the stock exchanges of Vienna, Budapest, Ljubljana and Prague. However there are still some securities exchanges which represent the domestic market only<sup>2</sup>.

In traditional thinking, the performance of national stock exchanges is taken as a proxy for the health of the nation's economy or at least the investors' attitude to the

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<sup>1</sup> The globalization of financial markets means that investors from anywhere in the world may make transactions on any market (to some extent of course since there are limitations for some markets and states).

<sup>2</sup> A detailed description of European Stock Exchanges can be found in [Ziarko-Siwiek 2007].

country's prospects. At present, the majority of stock exchanges are not owned and controlled by national governments any more, and they have become international financial institutions, thus they operate like any other business but this aspect is rarely taken into consideration when concerning the development of capital markets.

The aim of the paper is the analysis of the development of selected European capital markets in the years 2002-2011. The research concerns stock exchanges affiliated with The Federation of European Securities Exchanges<sup>3</sup> (FESE) during the whole period of investigation. The position of the selected stock exchanges is evaluated applying pattern taxonomic measures i.e. the synthetic measure of development and the vector taxonomic measure of development, and non-pattern measure represented by the relative development indicator. The variables used for the synthetic indicators construction describe the characteristics of the capital markets (such as capitalization, turnover and number of companies listed) and the financial efficiency (such as revenue, costs and EBIDTA) of the stock exchanges.

After this brief introductory section, Section 2 presents the taxonomic measures of development which are applied in the empirical investigation, Section 3 describes the data and diagnostic variables used in the measure constructions, Section 4 contains the results of the research, and Section 5 concludes.

## 2. Taxonomic measures of development

Taxonomy deals with the ordering and classification of objects which are described by several features. Among different characteristics influencing the development of socio-economic phenomena and objects, stimulants and de-stimulants are distinguished. The increase of the former is conducive to the development of the phenomenon while the increase of the latter negatively influences the level of development.

In our investigation we evaluate the development level of European capital markets in the years 2002-2011, applying three synthetic measures: *SM* – the synthetic measure of development, *BZW* – the relative development indicator (non-pattern method), and *WSM* – the vector synthetic measure of development, which are evaluated for each securities exchange in the analyzed years.

The taxonomic pattern measures are based on the distance between the pattern and the analyzed object (e.g. the stock exchange). The pattern may be defined as a real or hypothetical object, which is given as a single value in the assumed time span or is distinguished for each considered period separately.

The synthetic measure of development *SM* (following [Hellwig 1968]) is the pattern method defined for the hypothetical objects that are characterized by maximal

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<sup>3</sup> The Federation of European Securities Exchanges represents securities exchanges from European Union member states and Iceland, Norway and Switzerland as well as corresponding members from European countries that have not yet negotiated joining the EU.

values of stimulants and minimal values of de-stimulants, estimated for every year separately, taking into consideration all the analyzed markets. The measure is defined as follows [Łuniewska, Tarczyński 2006, pp. 41-44]:

$$SM_{it} = 1 - \frac{q_{it}}{\bar{q}_t + 2 \cdot S_{qt}} \quad i = 1, 2, \dots, n; t = 1, 2, \dots, T \quad (1)$$

where for every period  $t$  and for each  $i$ -th stock exchange:  $SM_{it}$  – value of the synthetic taxonomic measure,  $q_{it}$  – the distance from the pattern,  $\bar{q}_t$ ,  $S_{qt}$  – average and standard deviation of distances  $q_{it}$ , respectively:

$$\bar{q}_t = \frac{\sum_{i=1}^n q_{it}}{n} \quad S_{qt} = \sqrt{\frac{\sum_{i=1}^n (q_{it} - \bar{q}_t)^2}{n}} \quad (2)$$

The distance measure between two objects is defined in terms of Euclidean distance:

$$q_{it} = \sqrt{\frac{\sum_{j=1}^k (z_{it}^j - z_{0t}^j)^2}{k}} \quad j = 1, 2, \dots, k, \quad (3)$$

where  $z_{it}^j$  – standardized variable describing the  $j$ -th feature observed in the  $i$ -th stock exchange in time  $t$ ,  $z_{0t}^j$  – value of the  $j$ -th variable of the pattern that is defined for each year and described by  $k$  variables, i.e.:

$$z_{it}^j = \frac{x_{it}^j - \bar{x}_t^j}{S_{xt}^j} \quad z_{0t}^j = \begin{cases} \min_{i=1,2,\dots,n} \{z_{it}^j\} & \text{if } x_{it}^j \in D \\ \max_{i=1,2,\dots,n} \{z_{it}^j\} & \text{if } x_{it}^j \in S \end{cases} \quad (4)$$

where  $x_{it}^j$  – observation of  $j$ -th variable for the  $i$ -th stock exchange in time  $t$ ,  $\bar{x}_t^j$  – average and  $S_{xt}^j$  – standard deviation of  $j$ -th variable in time  $t$ :

$$\bar{x}_t^j = \frac{\sum_{i=1}^n x_{it}^j}{n} \quad S_{xt}^j = \sqrt{\frac{\sum_{i=1}^n (x_{it}^j - \bar{x}_t^j)^2}{n}} \quad (5)$$

and  $D, S$  – sets of de-stimulants and stimulants, respectively. The synthetic measure informs about the level of the stock exchange development, the bigger the value of the measure the better position of the capital market.

The relative development indicator ( $BZW$ ) does not require the definition of the pattern, and is evaluated as follows [Łuniewska, Tarczyński 2006, p. 54]:

$$BZW_{it} = \frac{\sum_{j=1}^k z_{jt}^i}{\sum_{j=1}^k \max_i \{z_{jt}^i\}} \quad (6)$$

where  $v_{jt}^i$  – normalized variables:

$$z_{jt}^i = v_{jt}^i + \left| \min_i \{v_{jt}^i\} \right| \quad v_{jt}^i = \begin{cases} \frac{x_{jt}^i}{\bar{x}_{jt}} & \text{if } x_{jt}^i \in S \\ \frac{\bar{x}_{jt}}{x_{jt}^i} & \text{if } x_{jt}^i \in D \end{cases} \quad (7)$$

The vector taxonomic measure  $WSM$  (following [Nermend 2009, pp. 63-89] idea) is the result of the analysis of  $k$  components of the vector of features describing the  $i$ -th classifying object (at the moment  $t$ ) along the projection vector lying between the pattern and anti-pattern desired for all the objects and periods. The value of the measure is evaluated using the following formula [Kompa 2014]:

$$WSM_{it} = \frac{\sum_{j=1}^k (z_{it}^j - z_{at_0}^j) \cdot (z_{0t_0}^j - z_{at_0}^j)}{\sum_{j=1}^k (z_{0t_0}^j - z_{at_0}^j)^2} \quad (8)$$

where for the reference period  $t_0$  (one for the whole period of analysis)  $z_{0t_0}^j, z_{at_0}^j$  – values of the  $j$ -th variable of the pattern and anti-pattern, respectively. The pattern and anti-pattern are defined as follows:

$$z_{0t_0}^j = \begin{cases} \min_i \{z_{it_0}^j\} & \text{if } x_{it_0}^j \in D \\ \max_i \{z_{it_0}^j\} & \text{if } x_{it_0}^j \in S \end{cases} \quad z_{at_0}^j = \begin{cases} \min_i \{z_{it_0}^j\} & \text{if } x_{it_0}^j \in S \\ \max_i \{z_{it_0}^j\} & \text{if } x_{it_0}^j \in D \end{cases} \quad (9)$$

On the basis of the values of the synthetic measures  $SM_{it}$ ,  $BZW_{it}$  and  $WSM_{it}$ , it is possible to classify the analyzed capital markets into homogenous groups in terms of the level of development. We distinguished four classes of objects:

- 1) leading capital markets for  $MR_{it} \geq MR_t + S_{MRt}$ ;
- 2) well developed capital markets for  $MR_t + S_{MRt} > MR_{it} \geq MR_t$ ;

- 3) catching up capital markets for  $MR_t > MR_{it} \geq MR_t - S_{MRT}$  ;  
 4) poorly developed capital markets for  $MR_{it} < MR_t - S_{MRT}$  .  
 where for each measure  $MR_{it} = \{SM_{it}, BZW_{it} \text{ and } WSM_{it}\}$ ,  $MR_t$  and  $S_{MRT}$  are the arithmetic mean and standard deviation of the measure, respectively.

### 3. Data and diagnostic variables

Our investigation concerns nineteen stock exchanges from European Union member states, Armenia, Iceland, Norway and Switzerland, being members of the Federation of European Securities Exchanges (see Table 1). Borsa Italiana and the Bucharest Stock Exchange are excluded from the analysis. The former because Borsa Italiana merged the London Stock Exchange in 2007 and both stock exchanges started to operate as the London Stock Exchange Group. In our investigation we consider this “new” financial institution, using for the years 2001-2006 data generated on the basis of FESE data from the London Stock Exchange and Borsa Italiana. The latter stock exchange was excluded because of the lack of reliable observations for the Bucharest Stock Exchange for the majority of the considered periods.

**Table 1.** List of analyzed stock exchanges

Name of the stock exchange	Name mark	Name of the stock exchange	Name mark
Athens Exchange	ATH	Irish Stock Exchange	ISE
BME (Spanish Exchanges)	BME	London Stock Exchange Group	LSE
Bratislava Stock Exchange	BSS	Luxembourg Stock Exchange	Lux
Bulgarian Stock Exchange	BSE	Malta Stock Exchange	MSE
CEESEG – Budapest	BUX	NASDAQ OMX Nordic	OMX
CEESEG – Ljubljana	LJS	NYSE EURONEXT	EUR
CEESEG – Prague	PSE	Oslo Børs	OSE
CEESEG – Vienna	ATX	SIX Swiss Exchange	SIX
Cyprus Stock Exchange	CSE	Warsaw Stock Exchange	GPW
Deutsche Börse	DAX		

Source: own elaboration.

Capital markets are described by selected features such as capitalization, number of companies listed, number of initial public offerings (IPO) and turnover<sup>4</sup>. To assess the position of a certain stock exchange, the liquidity ratio and average capitalization of the company is often used, while to evaluate the importance of the market in the whole economy, capitalization to GDP ratio is usually employed.

<sup>4</sup> These features are often used in such analyses, see [Ziarko-Siwiek 2007; Kompa, Witkowska 2014].

In our investigation we assume that the capital markets in Europe are represented by selected stock exchanges. As was already mentioned, at present only some European stock exchanges represent domestic markets (e.g. the Athens Exchange, BME, the Warsaw Stock Exchange) while other securities exchanges have a wider range and represent at least two domestic markets (e.g. the London Stock Exchange Group, OMX and the Euronext). Here the question arises if domestic “single” capital markets can compete with international ones. In our analysis we consider the following diagnostic variables: X1 – capitalization, X2 – number of companies listed, X3 – turnover, X4 – liquidity ratio i.e. turnover/capitalization, X5 – capitalization to GDP ratio, and X6 – average capitalization of the company i.e. capitalization/number of the companies listed.

Stock exchanges are financial institutions and their financial efficiency can be measured using revenue, cost and EBITDA (earnings before interest, taxes, depreciation and amortization) as diagnostic variables (see [Kompa 2014]). Therefore in our investigation we also use these variables, denoting them as X7, X8 and X9, respectively. One may notice that among all potential diagnostic variables<sup>5</sup> only X8 is the de-stimulant, while others are stimulants.

#### 4. Results of classification

Investigation is conducted using the three measures, described in Section 2, constructed for four different sets of diagnostic variables (S1-S4). Therefore we obtain several rankings of stock exchanges for the considered time span<sup>6</sup> (see Tables 2-6).

In the first step we evaluate the synthetic measure of development  $SM_{it}$  applying six diagnostic variables X1-X6 (denoted as the set S1). The ranking and clustering of stock exchanges due to the measure  $SM_{it}$  is presented in Table 2. As one can notice, EURONEXT together with the London, Spanish, German and Swiss stock exchanges are the most developed since they belong to the first class. The capital markets in transitional economies are usually classified as catching up markets, although the stock exchanges in Bratislava, Cyprus, Ljubljana and Malta in selected years belong to the fourth class i.e. they are poorly developed ones.

It is worth mentioning that variables X4-X6 are created from X1-X3, that especially amplify the influence of capitalization. Therefore to construct other measures  $MR_{it}$  ( $SM_{it}$ ,  $BZW_{it}$  and  $WSM_{it}$ ) only variables X1-X3 are used (i.e. set S2). According to the value of the taxonomic measures calculated for the three variables, the ranking and clustering of the capital markets are assembled (the results are presented in Tables 3-5).

<sup>5</sup> In our investigation we use all available data from FESE.

<sup>6</sup> In 2012 the London Stock Exchange Group, which is one of the most important in Europe, seceded from FESE, thus 2011 is the last period of our analysis.

**Table 2.** Ranking and clustering of the stock exchanges according to *SM6* (based on variables X1-X6)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	No. of the class
LSE	LSE	LSE	LSE	LSE	LSE	LSE	LSE	EUR	EUR	1
EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	SIX	DAX	
DAX	BME	BME	BME	SIX	BME	SIX	BME	BME	BME	
BME	DAX	DAX	DAX	BME	DAX	DAX	SIX	LSEG	SIX	2
OMX	OMX	OMX	OMX	DAX	SIX	BME	DAX	DAX	LSE	
SIX	SIX	SIX	SIX	OMX	OMX	OMX	OMX	OMX	OMX	
ISE	ISE	OSE	OSE	OSE	OSE	OSE	OSE	OSE	OSE	3
OSE	OSE	ISE	ISE	ISE	Lux	Lux	Lux	Lux	ISE	
Lux	Lux	Lux	Lux	Lux	ISE	PSE	PSE	GPW	PSE	
ATH	ATH	ATH	ATH	ATH	ATH	ISE	ATX	PSE	GPW	
BUX	PSE	PSE	PSE	ATX	ATX	ATX	ISE	ATX	ATX	
PSE	BUX	ATX	ATX	PSE	PSE	ATH	ATH	ISE	BUX	
CSE	ATX	BUX	BUX	BUX	BUX	BUX	GPW	BUX	ATH	
ATX	GPW	GPW	GPW	GPW	GPW	GPW	BUX	ATH	Lux	
GPW	CSE	MSE	MSE	CSE	CSE	MSE	CSE	MSE	BSE	
LJSE	MSE	LJS	CSE	MSE	BSE	CSE	MSE	CSE	CSE	
MSE	BSS	BSE	BSE	BSE	LJS	BSE	BSE	BSE	BSS	
BSSE	LJSE	CSE	LJS	LJS	MSE	LJS	LJS	LJS	LJS	
BSE	BSE	BSS	BSS	BSS	BSS	BSS	BSS	BSS	MSE	

Source: own elaboration.

**Table 3.** Ranking and clustering of the stock exchanges according to *SM3* (based on variables X1-X3)

No. of the class	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
1.	LSE	LSE	LSE	LSE	LSE	LSE	LSE	LSE	EUR	EUR	
	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	BME	BME
2.	BME	BME	BME	BME	BME	BME	BME	BME	LSE	LSE	
	DAX	DAX	DAX	DAX	DAX	DAX	DAX	DAX	DAX	DAX	DAX
	OMX	OMX	OMX	OMX	OMX	OMX	OMX	OMX	OMX	OMX	OMX
3.	SIX	SIX	SIX	SIX	SIX	SIX	SIX	SIX	SIX	SIX	SIX
	BSS	ATH	ATH	OSE	OSE	OSE	OSE	OSE	GPW	GPW	
	ATH	OSE	OSE	ATH	ATH	GPW	GPW	GPW	OSE	OSE	
	OSE	BSS	BSE	GPW	GPW	ATH	ATH	ATH	ATH	BSE	
	BSE	BSE	GPW	BSE	BSE	Lux	BSE	BSE	Lux	Lux	
	Lux	Lux	BSS	Lux	Lux	BSE	Lux	Lux	BSE	ATH	
	GPW	GPW	Lux	ATX	ATX	ATX	ATX	ATX	ATX	ATX	
	ISE	ISE	ATX	ISE	ISE	ISE	BSS	BSS	BSS	ISE	
	ATX	ATX	ISE	BSS	BSS	BSSE	ISE	ISE	ISE	CSE	
	CSE	LJS	LJS	CSE	CSE	CSE	CSE	CSE	CSE	BUX	BUX
	LJS	CSE	CSE	LJS	LJE	LJE	PSE	BUX	CSE	PSE	
	BUX	BUX	PSE	PSE	BUX	PSE	LJE	PSE	PSE	BSE	
	PSE	PSE	BUX	BUX	PSE	BUX	BUX	LJE	LJE	LJE	
MSE	MSE	MSE	MSE	MSE	MSE	MSE	MSE	MSE	MSE	MSE	

Source: own elaboration.



The limitation of the number of diagnostic variables causes changes in the stock exchange clustering and the disappearance of the fourth class (Table 3). There are only two stock exchanges i.e. London and Euronext, which are the best developed in all the analyzed years, although starting from 2008 the Spanish market belongs to the first class and from 2010 also the German market. The Swiss Exchange and the regional OMX market are classified as well-developed markets.

A similar classification is visible in Table 4 although the list of stock exchanges belonging to the first two groups is shorter. The application of the non-pattern method *BZW* changes the ranking, and the German market seems to be better developed than the joint Italian and British markets. The Spanish market is classified to the third group in all the years, while the OMX stock exchange kept its high position in years 2002-2006. Clustering provided according to the vector taxonomic measure (Table 5) gives quite similar results to *BZW* if the first class is considered, although the position of the Spanish market is more similar to the one generated by *SM3* (i.e. *SM* based on X1-X3).

**Table 4.** Ranking and clustering of the stock exchanges according to *BZW* (variables X1-X3)

No. of the class	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1.	DAX	DAX	DAX	DAX	DAX	DAX	EUR	EUR	EUR	EUR
	EUR	EUR	EUR	EUR	EUR	EUR	DAX	DAX	DAX	DAX
2.	LSE	LSE	LSE	LSE	LSE	LSE	LSE	LSE	LSE	LSE
	OMX	OMX	OMX	OMX	OMX	BME	BME	BME	BME	BME
3.	SIX	SIX	SIX	BME	BME	SIX	SIX	SIX	OMX	SIX
	BME	BME	BME	SIX	SIX	OMX	OMX	OMX	SIX	OMX
	ATH	ATH	ATH	ATH	ATH	ATH	OSE	OSE	OSE	OSE
	OSE	OSE	OSE	OSE	OSE	ATX	ATH	ATH	ATH	GPW
	Lux	Lux	Lux	ATX	ATX	GPW	ATX	ATX	GPW	ATX
	GPW	GPW	ATX	GPW	GPW	OSE	GPW	GPW	ATX	ATH
	ATX	ATX	GPW	Lux	Lux	Lux	Lux	Lux	Lux	Lux
	PSE	ISE	ISE	ISE	ISE	ISE	ISE	ISE	ISE	PSE
	ISE	PSE	PSE	PSE	PSE	PSE	PSE	PSE	PSE	ISE
	BUX	BUX	BUX	BUX	BUX	BUX	BUX	BUX	BUX	BUX
	LJS	LJS	LJS	CSE	CSE	CSE	CSE	CSE	CSE	MSE
	CSE	CSE	CSE	BSE	LJSE	BSE	MSE	MSE	MSE	CSE
	MSE	MSE	MSE	LJS	MSE	LJS	LJS	LJS	LJS	LJS
	BSS	BSS	BSS	MSE	BSE	MSE	BSE	BSS	BSS	BSS
BSE	BSE	BSE	BSS	BSS	BSS	BSS	BSE	BSE	BSE	

Source: own elaboration.

The further research concerns the evaluation of stock exchanges as enterprises in terms of their financial efficiency i.e. variables X7-X9 (denoted as the set S3), and taking into account both market characteristics and financial conditions simultaneously (i.e. the set S4 consists of variables X1-X3 & X7-X9).

Table 6 contains the results of the classifications of all the stock exchanges in all the analyzed years, using ten indicators (i.e. measures *MR* constructed for four sets of variables). The bold digits denote the number of the class where the analyzed market belongs the most often, and the number in parenthesis – the number of cases when a certain market belongs to the defined cluster. Additional information concerning the position of the Warsaw Stock Exchange is given in the last row. Since the results of clustering applying different indicators may differ, the most often conducted classification of stock exchanges using all 100 rankings is presented in the last column.

**Table 5.** Ranking and clustering of the stock exchanges according to *WSM* (variables X1-X3)

No. of the class	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1.	DAX	DAX	DAX	DAX	DAX	DAX	DAX	DAX	DAX	DAX
	EUR	EUR	EUR	EUR	LSE	LSE	EUR	BME	EUR	EUR
2.	LSE	LSE	LSE	LSE	EUR	BME	LSE	EUR	BME	LSE
	BME	BME	BME	BME	BME	EUR	BME	LSE	LSE	BME
3.	ATH	ATH	OMX	OMX	SIX	OMX	SIX	OMX	OMX	OMX
	SIX	OSE	ATH	SIX	OMX	SIX	OMX	SIX	SIX	SIX
	OMX	Lux	SIX	ATH	ATH	ATH	ATH	ATH	OSE	OSE
	OSE	GPW	OSE	OSE	OSE	GPW	ATX	ATX	ATH	GPW
	Lux	ISE	ISE	GPW	GPW	ATX	OSE	GPW	GPW	ATX
	ISE	BUX	Lux	ATX	ATX	OSE	GPW	Lux	ATX	ATH
	BUX	ATX	GPW	ISE	ISE	Lux	ISE	PSE	Lux	Lux
	LJS	PSE	ATX	Lux	Lux	PSE	Lux	OSE	BUX	PSE
	GPW	BSE	BUX	BUX	BUX	BUX	PSE	BUX	PSE	BUX
	BSS	MSE	PSE	PSE	PSE	CSE	BUX	ISE	ISE	ISE
	ATX	LJS	MSE	BSE	BSE	BSE	MSE	MSE	MSE	MSE
	MSE	BSS	BSE	MSE	MSE	LJS	BSS	BSS	LJS	BSS
	BSE	SIX	LJS	BSS	LJS	MSE	BSE	BSE	BSS	BSE
	PSE	CSE	BSS	LJS	BSS	BSS	LJS	LJS	BSE	LJS
CSE	OMX	CSE	CSE	CSE	ISE	CSE	CSE	CSE	CSE	

Source: own elaboration.

The second column in Table 6 contains information about the classifications of all the considered markets in all the analyzed years, using the already discussed indicators

evaluated for the capital markets' characteristics. The Athens, Budapest, Prague, Vienna, Irish, Luxembourg, Malta, Oslo and Warsaw Stock Exchanges are always classified as catching up capital markets. While none of the securities exchanges is classified into the first or the second class only. The biggest diversification among classes is visible for the BME and SIX Swiss Exchange.

The Warsaw Stock Exchange, due to the ordering presented in Tables 2-5, maintains its positions from 7-th to 15-th in the rankings. The most frequent positions of GPW are in the middle of the rankings i.e. 9-th and 10-th positions, although the average position evaluated from 40 rankings is 10.3.

The evaluation of the stock exchanges in terms of their financial efficiency i.e. using variables X7-X9 (as is done in [Kompa 2014]) gives slightly different classifications of the six leading securities exchanges (column 3 in Table 6). Deutsche Börse kept its first position in all the pattern ordering, and in the years 2002-2007 when *BZW* was used. EURONEXT keeps its second place most often, the London Stock Exchange – the third position, while GPW is ninth.

**Table 6.** Clusters created by the stock exchanges according to analyzed measures, based on different sets of variables, in the years 2001-2011

Name of the stock exchange Sets of diagnostic variables	Belonging to the class			
	S1 and S2	S3	S4	Total
1	2	3	4	5
Athens Exchange	3(40)	3(30)	3(30)	3
BME (Spanish Exchanges)	1(12), 2(18), 3(10)	2(21), 3(9)	1(24), 2(6)	2
Bratislava Stock Exchange	3(32), 4(8)	3(30)	3(30)	3
Bulgarian Stock Exchange	3(39), 4(1)	3(30)	3(30)	3
CEESEG – Budapest	3(40)	3(30)	3(30)	3
CEESEG – Ljubljana	3(38), 4(2)	3(30)	3(30)	3
CEESEG – Prague	3(40)	3(30)	3(30)	3
CEESEG – Vienna	3(40)	3(30)	3(30)	3
Cyprus Stock Exchange	3(39), 4(1)	3(30)	3(30)	3
Deutsche Börse	1(28), 2(12)	1(30)	1(30)	1
Irish Stock Exchange	3(40)	3(30)	3(30)	3
London Stock Exchange Group	1(18), 2(22)	1(4), 2(26)	1(30)	1
Luxembourg Stock Exchange	3(40)	3(30)	3(30)	3
Malta Stock Exchange	3(39), 4(1)	3(30)	3(30)	3
NASDAQ OMX Nordic	2(31), 3(9)	2(21), 3(9)	2(27), 3(3)	2
NYSE EURONEXT	1(32), 2(8)	1(18), 2(12)	1(30)	1
Oslo Børs	3(40)	3(30)	3(30)	3
SIX Swiss Exchange	1(5), 2(9), 3(26)	2(11), 3(19)	2(16), 3(14)	3
Warsaw Stock Exchange	3(40)	3(30)	3(30)	3
The most often/average position	9.5/10.3	10/9.5	9/9	9.5/9.6

Source: own elaboration.

General information concerning the classification of the analyzed stock exchanges by three synthetic indicators which are calculated using the set of variables S4 is presented in column 4 in Table 6. It is visible that the securities exchanges are classified into three classes only, and Deutsche Börse, EURONEXT and the London Stock Exchange Group have the leading positions together with the Spanish stock exchanges. OMX and the Swiss Exchange make up the second class. The other financial institutions belong to the third class. Adding information about the financial performance of the stock exchanges improved the position of BME and the London Stock Exchange Group, which were moved from the second to the first class. Also OMX and the SIX Swiss Exchange were classified into the second class instead of the third cluster. Although the Warsaw Stock Exchange remains in the third class it improves its position if financial efficiency is taken into account, which is visible in the higher position in the most frequent and average rankings.

**Table 7.** Spearman correlation coefficient evaluated for analyzed measures

Variable sets	Pair of measures	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
S2	<i>BZW/SM</i>	0.740	0.788	0.7965	0.890	0.861	0.884	0.856	0.854	0.877	0.858
	<i>BZW/WSM</i>	0.881	0.590	0.954	0.9702	0.963	0.942	0.967	0.933	0.972	0.979
	<i>SM/WSM</i>	0.809	0.502	0.818	0.8930	0.891	0.860	0.851	0.823	0.875	0.865
S2 vs. S1	<i>SM6/SM3</i>	0.729	0.767	0.756	0.8028	0.815	0.853	0.777	0.819	0.834	0.863
S3	<i>BZW/SM</i>	0.983	0.983	0.983	0.988	0.991	0.990	0.993	0.986	0.991	0.993
	<i>BZW/WSM</i>	0.881	0.589	0.954	0.970	0.963	0.942	0.967	0.933	0.972	0.979
	<i>SM/WSM</i>	0.921	0.661	0.981	0.988	0.974	0.970	0.974	0.946	0.979	0.983
S4	<i>BZW/SM</i>	0.993	0.974	0.991	0.993	0.998	0.993	0.993	0.984	0.998	0.998
	<i>BZW/WSM</i>	0.988	0.990	0.983	0.995	0.997	0.993	0.990	0.983	0.995	0.998
	<i>SM/WSM</i>	0.953	0.942	0.918	0.977	0.965	1.000	0.977	0.965	0.977	0.977

Source: own elaboration.

Applying different synthetic indicators, the problem of sensitivity of the objects ordering appears. Using the Spearman correlation coefficients, the positioning of the stock exchanges was compared (Table 7). One may notice, that all rankings are alike because the values of the correlation coefficient are high. The exceptions appear in 2003 since vector measure *WSM* gives different results than the others (if sets of variables S2 and S3 are used for their construction). It is also visible that the orderings provided due to *SM* calculated for two sets of variables (i.e. S1 and S2) are pretty similar. The identical ordering is obtained if it is provided according to the two pattern measures evaluated on the basis of diagnostic variables S4 for 2007.

## 5. Conclusions

The development of the financial sector influences economic growth, thus the capital market plays an important role in market-oriented economies. At present two types of stock exchanges can be distinguished in Europe, i.e. the ones that operate mostly on the domestic market and the ones that operate on the international market. The biggest securities exchanges are financial institutions that are not controlled by the national governments any more, hence they operate like any other business. Therefore it seems necessary to consider also their financial efficiency to evaluate the level of their development.

The leading capital markets are represented by EURONEXT, the London Stock Exchange Group and Deutsche Börse. The BME, the SIX Swiss Exchange and NASDAQ OMX Nordic create the class of well-developed markets. Therefore it can be said that the position of the stock exchange does not depend on the range of the market, domestic or international, maybe because the majority of stock exchanges in Europe lists both domestic and foreign companies.

The classifications obtained due to the different taxonomic measures for the same set of variables, show a similarity with the exception of the vector synthetic measure of development in 2003. Also the application of different sets of variables to evaluate *SM* gives similar results of the stock exchanges ordering. Extending the set of diagnostic variables by the ones describing the financial performance of stock exchanges causes polarization in the ordering of these financial institutions. However, the class of poorly developed capital markets appears only when clustering is provided due to *SM6*.

The capital markets in post-communist countries have quite a short history and they are catching up markets, except for the stock exchanges in the Baltic States, which belong to NASDAQ OMX. The Warsaw Stock Exchange represents the biggest capital market in European transitional economies, and it holds the middle positions in all the rankings, and its position seems to have been improving in the analyzed time span.

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