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Robust Approach to Analysis of International Diversification Benefits between US, UK and Emerging Stock Markets

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Abstract: *As is known skewness and outliers are frequently observed in return series, overlooking both concepts during the statistical analysis may cause misleading interpretations. In this paper similar movements of stock markets through the returns of developed and emerging stock markets are recognized and appealing portfolio diversification benefits are identified for investors of USA, UK and Turkey. Different from the previous studies, modified robust principal component analysis which considers skewness and outliers effects was used to investigate the best portfolio diversification. Sixteen stock markets are represented with five components according to findings obtained from analysis. Hence Egyptian, Hungarian, Polish, Thai and Indonesian stock markets provide appealing portfolio diversification opportunities for investors of Turkey. And for the investors of USA and UK, selected emerging markets except Mexican and Turkish offer good diversification benefit.*

Keywords: Global portfolio diversification, Emerging markets, Outliers, Skewness, Robust principal component analysis.

JEL Classification: C38, G11, G15

1. Introduction

As a natural result of globalization, economies are integrated and a remarkable quantity of empirical studies has been devoted to the investigation of financial market interactions and interdependencies. Interdependency and interaction of the stock markets define benefits of global portfolio diversification. For instance, low correlation between stock markets can be thought as an appealing benefit of global portfolio diversification especially in periods when stock markets are highly volatile. The degree of interdependency provides implication on potential risks as well as portfolio diversification benefit.

Interdependency and interaction of the stock markets subject has been appeared in several studies on different basis of methodologies. Used methodologies in those studies generally lean on VAR Model, Causality Tests, Cointegration Test, Multivariate VAR, Multivariate GARCH, Correlation Analysis, Rolling Correlation Analysis and Principal Components Analysis (See e.g. Ratner and Leal 1996; Choudhry, 1997; Kanas, 1998; Meric et al., 1998; Chen, Firth and Rui, 2000; Huang, Yang and Hu, 2000; Pagan and Soydemir, 2000 ; Scheicher 2001;Gilmore et al., 2002; Li, Sarkar and Wang, 2003; Laopodis, 2005; Gupta, Mollik, 2008; Kucukcolak, 2008, Meric et al., 2009; Gklezakou and Mylonakis, 2009; Aktar, 2009; Modi, Patel and Patel 2010, Caparole and Spagnolo, 2010; Huyghebaert and Wang, 2010). Although the subject has been extensively studied, methodological part of the previous studies had not been considered with a special emphasis on possible outliers and

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skewed pattern of the data. However, as it can be observed in empirical studies, return series have very large positive or negative values and besides generally it is probable to observe skewed pattern of distribution instead of normal pattern of distribution. An observation whose pattern differs from the majority of data is called an outlier. Outliers can heavily influence skewness, kurtosis and other estimations calculated for data, consequently robust techniques are proposed in academic literature. Contrary to other similar studies, in this study interdependency of stock markets has been analyzed with skewed robust principal component analysis (skewed-ROBPCA).

The interdependency of stock markets issue is studied with a sample of fourteen emerging stock market indexes, as well as US and UK stock market indexes. The stock market indexes of the emerging countries included in the study are: Brazil, Czech Republic, China, Indonesia, S. Africa, India, Korea, Hungary, Mexico, Egypt, Poland, Russia, Thailand and Turkey. The data are obtained from Morgan Stanley Capital International (MSCI) DataStream and span the period January 2002 to August 2010. For all indexes weekly log returns were calculated.

2. Methodology and Empirical Findings

Primarily, descriptive statistics of sixteen stock markets have been dealt. These descriptive statistics include stock exchange's weekly average returns, standard deviation, skewness, kurtosis, Jarque Bera test score, median, MAD and MC. MAD is a robust measure of dispersion. And MC is known as Medcouple (MC), it is a robust alternative to the the classical skewness coefficient proposed by Brys, Hubert and Struyf (2004). MC lies between (–1, 1) and a zero value is attained at the symmetric case.

In the second and last stage, robust version of principal component analysis (PCA) was used to evaluate the similar patterns and interdependency of stock markets. PCA is a common technique for finding patterns in high dimensional data. PCA reduces dimension and transforms data to a smaller set of new variables. These new variables are referred to as principal components which correspond to the eigenvectors of the covariance matrix. PCA process can be defined very briefly:

X_{nxp} is a data matrix (n observations and p variables), new components C_i, are linear combinations of

$$C_i = Xp_i \quad (1)$$

where

$$p_i = \arg\max_k \left\{ \operatorname{var}(Xk) \right\} \quad (2)$$

under restrictions;

$$\|k\| = 1 \text{ and } k \perp \{p_1, ..., p_{i-1}\} \quad (3)$$

Principal Components, C_i can be computed as the eigenvectors of classical covariance matrix. But as the principal components are the eigenvectors of classical covariance matrix, it is possible that the components have been adversely influenced by outliers. In this case it is preferable to use robust alternative of PCA, which is called as ROBPCA (Robust Principal Component Analysis). Robust statistical approaches aim to give reliable results in case of existence of outliers and when the strict model assumptions are not provided. ROBPCA was proposed by Hubert, Rousseeuw and Vanden Branden (2005), they asserted ROBPCA's ability of preventing outlier effects. Afterwards Hubert, Rousseeuw and Verdonck (2009) proposed more general robust PCA method that can cope with skewed data and named this as skewed ROBPCA. Both approaches are combination of projection pursuit method and MCD covariance estimation.

Major computation steps of ROBPCA can be summarized as follows:

- Finding the SVD (singular value decomposition) form of the data for projecting the observations.

- Defining an outlyingness criterion for every sample by projecting all points on many univariate directions through two data points. The largest distance over all directions of each observation is called outlyingness. The points with the smallest outlyingness are then collected in an h subset and their empirical covariance matrix is found

- The initial subspace Vo is spanned by the k dominant vector of the covariance matrix which was found in the previous step.

- Weighting all the data points and assigning weight 1 to the data points which are close to Vo. Also the orthogonal distances of each observation in V0 are computed. Then the observations with the smallest orthogonal distances retain and their covariance matrix is derived. By using the dominant vectors of this covariance matrix a new improved subspace is defined.

- All data points are projected onto the new improved subspace. Within this subspace FMCD is performed to find a robust center and a covariance estimate of the projected samples. Again a reweighting procedure is performed here.

- In the final stage, the reweighted center and the covariance matrix are obtained which represent the original p dimensional space.

Skewed ROBPCA consists of the same steps as the ROBPCA algorithm but there were done three modifications:

1. Outlyingness criterion, it is replaced by a new measure, called the adjusted outlyingness. It is based on the adjusted boxplot.

2. The second adjustment concerns the cutoff value for the orthogonal distances.

3. The third modification occurs in the last steps of the algorithm. Instead of applying the reweighted MCD estimator, the adjusted outlyingness is calculated in the k-dimensional subspace and the mean and covariance matrix of the h points with the lowest adjusted outlyingness are computed.

Matlab Libra Toolbox was employed through the study for obtaining mentioned robust statistics.

2.1. Descriptive Statistics

Descriptive statistics of sixteen stock markets have been presented in Table 1, all values were obtained through return series. Herein the lowest weekly return is witnessed by UK and US markets at 0.01 while the highest weekly return comes from Brazil and Indonesian stock markets at 0.0019. During the same period Brazilian and Russian stock markets show the highest median value (0.0049 and 0.0037). An examination of SD and MAD dispersion statistics show that Turkish, Russian, Hungarian and Brazilian (0.0232- 0.0172, 0.0218-0.0152, 0.0207-0.0139, 0.0200-0.0148, respectively) markets are the most volatile while US is the less volatile market (0.0096-0.0066). The values of asymmetry (classical skewness and MC) and kurtosis reveal that stock returns for the period are not normally distributed, besides the null hypothesis of normal distribution of return series are rejected with the scores of Jarque- Bera statistics.

Table :1 Descriptive Statistics

Countries	Mean	Median	S.Deviation	MAD	Skewness	Kurtosis	JB	MC
UK	0.0001	0.0011	0.0113	0.0080	-0.9256	6.718	302.4	-0.0556
US	0.0001	0.0009	0.0096	0.0066	-0.975	10.4519	1042.3	-0.1003
Brazil	0.0019	0.0049	0.0200	0.0148	-1.293	8.9882	747.2	-0.177
Czech R.	0.0017	0.0031	0.0153	0.0107	-1.0477	8.2414	559.2	-0.0799
China	0.0013	0.0026	0.0156	0.0118	-0.4274	4.5859	56.5	-0.0886
Indonesia	0.0019	0.0034	0.0191	0.0137	-1.0047	8.1093	528.9	-0.0695
S.Africa	0.0011	0.0027	0.0153	0.0113	-0.9785	7.3499	399	-0.1052
India	0.0017	0.0037	0.0166	0.0119	-0.3612	6.4281	214.6	-0.1458
Korea	0.0008	0.0021	0.0167	0.0122	-0.8045	7.2697	364.9	-0.0615
Hungary	0.0010	0.0025	0.0207	0.0139	-1.4755	11.387	1389.5	-0.0318
Mexico	0.0011	0.0019	0.0149	0.0103	-1.4236	13.6422	2134.1	-0.0004
Egypt	0.0008	0.0026	0.0173	0.0115	-1.6535	10.7478	1247.4	-0.0737
Poland	0.0008	0.0026	0.0184	0.0132	-1.1138	7.3143	413.6	-0.0881
Russia	0.0010	0.0037	0.0218	0.0152	-1.3434	11.628	1435.3	-0.1607
Thailand	0.0011	0.0012	0.0153	0.0113	-0.454	7.1685	318.8	0.038
Turkey	0.0016	0.0029	0.0232	0.0172	-0.6246	5.1786	110.1	-0.0154

*Critical value for Jarque-Bera: 5.99

2.2. Robust Principal Components

Studies of Meric et al. (2009) and Modi, Patel, Patel (2010) are the latest articles that based on PCA technique to investigate the interdependency and interaction of the stock markets. But so far robustified versions of PCA as “ROBPCA” and “Skewed ROBPCA” have not been used in area of finance. And in this study, skewed ROBPCA was inevitably employed depending on the results of descriptive statistics (Table 1).

Skewed Robust Principal Component Analysis was used to group the sixteen stock markets in terms of their similar movements over time. To study the similarities weekly log returns of sixteen stock markets have been standardized by subtracting by median and dividing by MAD. The analysis has yielded five statistically significant components with eigenvalues greater than unity. The obtained first five components explain 72.2 % of total variance. Besides, for maximizing factor loadings of stock markets in each component with similar movement patterns, Varimax Rotation was used.

Below table indicates correlations of stock markets in a component that are highly correlated. The stock markets in the same principal component move closely together in the same or opposite direction and provide less portfolio diversification benefit. On the contrary, the stock markets in different principal components are less correlated and provide better portfolio diversification benefit.

Table 2: Skewed Robust Principal Components Analysis Results

Stock Markets	Components				
	I	II	III	IV	V
UK				0.2962	
US				0.3452	
Brazil	0.2926				
Czech R.	*-0.2660*		0.4119		
China	0.8854				
Indonesia					0.3714
S.Africa	0.4879				
India	0.9237				
Korea	0.2935				
Hungary			0.4063		
Mexico				0.2848	
Egypt		0.7724			
Poland			0.2916		
Russia	0.7205				
Thailand					0.4251
Turkey	0.9741			*-0.2347*	
Eigen Value	99.021	16.790	13.775	11.680	10.410
Cum. Variance	0.4820	0.5585	0.6161	0.6792	0.7226

First principal component is a group of Turkish, Indian, Chinese, Russian, South African and Brazilian stock markets; they have their highest factor loadings in this component (0.9741, 0.9237, 0.8854, 0.4879 and 0.2926 respectively). By means of first obtained country group, it is possible to interpret that including these stock markets in the same portfolio would not provide good diversification benefit. Czech stock market has also higher factor loading (-0.2660) in the first principal component. This indicates that Czech stock market does not move in the same direction with other countries in the first component.

Egyptian stock market has its highest factor loading in the second principal component (0.7724). This stock market has a low correlation with all the other stock markets; hence Egyptian investors may perceive the other stock markets as an appealing portfolio diversification opportunity.

Third principal component represents the group of European emerging markets that include Czech, Hungarian and Polish stock markets with component of 0.4119, 0.4063 and 0.2916 respectively. This result implies that including these stock markets in the same portfolio would not provide good diversification benefit.

Fourth principal component is group of USA, UK and Mexican stock markets with component of 0.3452, 0.2962 and 0.2848 respectively. According to this result, including these stock markets in the same portfolio would not provide good diversification benefit but USA, UK and Mexican investors have good portfolio diversification potential with the other stock markets. Turkish stock market has also higher factor loading (-0.2347) in the fourth principal component. This indicates that Turkish stock market does not move in the same direction with USA, UK and Mexican stock markets.

Fifth principal is a group of Thai and Indonesian stock markets with component of 0.4251, 0.3714 respectively. It is inferred from the fifth component that including these stock markets in the same portfolio would not provide good diversification benefit but Thai and Indonesian investors have good portfolio diversification potential with the other stock markets.

3. Conclusion

The co-movements of sixteen selected countries were examined with regard to pattern of return series. As can be seen from the descriptive statistics in Table 1, return series are not normally distributed. Since it is intended to find similar movements of stock markets in the study, skewed Robust principal component analysis was used for non-normally distributed data. This approach provides an adopted way for skewed and outlier included data. Obtaining new rotated components (in Table 2) provide portfolio diversification benefit opportunities for investors. The stock markets with high factor loadings in the same principal component provide less portfolio diversification benefit, contrary, stock markets with high factor loadings in different components provide attractive portfolio diversification benefit.

Market returns of sixteen countries lie on five different components. Turkish, Indian, Chinese, Russian, South African and Brazilian stock markets lie on the first component. Only Egyptian market lies on the second principal component. Czech, Hungarian and Polish stock markets lie on the third component. USA, UK and Mexican stock markets lie on the fourth component and lastly Thai with Indonesian stock markets lie on the fifth component. In the light of this result it is possible to interpret that investors of USA and UK have good portfolio diversification benefit with markets in the first (except Turkish), second, third and fifth components. It is also possible to infer from this information that markets in second, third and fifth components provide good portfolio diversification for Turkish investors.

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