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INTERNATIONAL DIVERSIFICATION OF PENSION FUNDS USING THE COINTEGRATION APPROACH: THE CASE OF POLAND

Radoslaw Kurach
Faculty of Economic Sciences
Wrocław University of Economics
Komandorska str.118/120
54-042 Wrocław
Poland
Tel.: +48 71 36 80 194
Fax: +48 71 36 80 176
E-mail: radoslaw.kurach@ue.wroc.pl

Radoslaw Kurach, PhD (in Economics) is Assoc. Professor at the Faculty of Economic Sciences, Wrocław University of Economics (Poland), where he delivers the courses on financial risk management, portfolio theory, macroeconomics and monetary policy. His current scientific research covers the area of pension fund portfolio management. He is the Chief Editor of *Business and Economic Horizons* and his papers have been published in various international journals like *Baltic Journal of Economics, Contemporary Economics, Romanian Journal of Economic Forecasting*. He also holds professional certifications – The Professional Risk Manager (PRM™) and ACI Dealing Certificate.

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ABSTRACT. ***In this study we present the method of portfolio selection suitable for long term investments and thus applicable to the pension funds industry. The choice of the portfolio is based on two stages. In the first one we identify the long-run co-movement using the cointegration analysis to eliminate the assets sharing common trends. Then, using the constrained set of assets from the first stage, we optimise the portfolio employing the Modern Portfolio Theory (MPT). By comparing the out-of-sample results we finally conclude that the portfolio supported by cointegration analysis performs significantly better than the one based solely on MPT. To illustrate this idea we identify the potential of the international diversification of the Polish Open Pension Funds (OPF) portfolios. We argue that the current OPF asset allocation exhibits insufficient foreign diversification (home bias) so it is desirable to change the regulatory policy to enable OPF investing abroad more.***

KEYWORDS: portfolio theory, cointegration analysis, pension funds, international diversification, Central and Eastern European countries.

JEL classification: G11, G23.

Introduction

The introduction of the mandatory pension funds in the Central and Eastern European (CEE) states in the late nineties still poses several questions about their investment policy. The need to establish proper methods of retirement savings portfolio management is undisputable as the possible failures in this process may have serious social consequences. Additionally, some characteristics of the pension liabilities do not allow easy adaptation of well-grounded practices relating to other financial investments. To exemplify the uniqueness of pension investments we should focus on the very wide investment horizon and its impact on portfolio choice. First of all, liquidity concerns are less important when compared to short-term investments. Secondly, the assets considered to be highly risky in the short-run become less volatile in the longer period due to the identified returns mean-reversion phenomenon (Poterba, Summers, 1989; Barberis, 2000; Spierdijk *et al.*, 2012). Finally, the investment horizon matters also for the assets co-movement measurement. As the Markowitz (1952) theory states, individuals should prefer assets, all other things being equal, that have low correlation coefficients. This enables to diversify idiosyncratic risks of securities and to reduce the overall portfolio volatility. However, Modern Portfolio Theory (MPT) is based on a few strong assumptions. MPT requires the asset returns to be normally distributed which implies the time-invariant variance and covariance matrix. In fact, the estimators instability has been widely recognised in literature (Bollerslev *et al*., 1998; Rey, 2000). Consequently, MPT seems to be still useful, but serving rather as general guidance when selecting long-term investments and the complementary use of other econometric techniques is desired.

In this study we would like to challenge this last issue. Therefore, our research objective is to support the adjustment of the classical MPT by the cointegration analysis which should lead to an improvement in portfolio performance of the pension funds looking for ways to ensure effective international diversification.

There are a few arguments that make the cointegration approach promising. Cointegration identifies long-term asset price dependencies, while correlation due to its instability makes the portfolio selection process highly related to the chosen sample. Alexander (1999, p.2.) states that long term co-movement may occur even when static correlations appear low. It is also possible that extremely high correlations do not confirm a long-term relationship. Additionally, cointegration allows for a short-term divergence between time series, while correlation is highly sensitive to the chosen lag structure.

The issue of diversification gains resulting from the international asset allocation has been broadly discussed in empirical literature. However, relatively few papers have tried to identify the long term dependencies using the cointegration approach. The results are not unanimous as some of the papers confirm financial market integration between developed countries (Taylor, Tonks, 1989; Meric, Meric 1997) while others reject it (Kanas 1998; Yang *et al.*, 2004). We have also found conflicting results in the research on the co-movement between the emerging and the developed markets (Ratanapakorn, Sharma, 2002; Mukherjee, Bose, 2008), but the literature here is even more scarce as emerging economies started to liberalise their capital accounts mostly in the mid-nineties. It is also quite interesting that cointegration approach has been utilised in real estate market studies. Different from equity

market studies, the research into this area has been consistently supporting the inclusion of property assets to the securities portfolio (He, 1998; Gallo *et al*., 2013).

Our study contributes to the existing literature in a few ways. First of all, this paper presents the perspective of an emerging market investor (pension fund participant). Findings of the previous studies were based merely on USD-denominated returns while our study takes the exchange rate fluctuations of the local currency (PLN) into account. Secondly, we do not focus on the co-movement of a particular market (Poland) in relation with other local markets, instead analysing the interdependencies with regional trends. This kind of knowledge may be especially useful while making the strategic assets division. Thirdly, our optimisation target is to minimise the portfolio variance, as opposed to most of the studies maximising the risk adjusted returns measures. We argue that this approach is more justified if we do not dispose very long time series, like in the emerging market studies. Last but not least, our research covers the period of the current financial crisis, which enables us to verify the robustness of our selection strategy during the unprecedented financial turbulence.

To complete the stated research objective, this paper is organised as follows. In the next section we provide the overview of the most important facts regarding pension reforms in the CEE states. Here we underline the role of international diversification of pension fund portfolios, indicating opportunities and threats it poses for the local economies and future pensioners. Parts 3 and 4 contain the description of the methodology and data used in this study. Then, we present the quantitative results of the carried analysis together with their interpretation. Finally, we formulate the concluding comments and indicate the areas that require further exploration.

1. Pension Reforms in the CEE States

Population ageing was the main reason that pushed the CEE states towards serious reforms of their pension systems. According to the seminal World Bank (1994) report the multi-pillar system was advised in an effort to effectively diversify various risks which are present in every pension scheme. The World Bank (1994) recommended establishing two mandatory pillars: one of non-financial character (I pillar) and a capital scheme (II pillar). In the first pillar the contributions paid by the working generation are transferred directly to the retirees. In the second pillar, this transfer has an indirect character, as the securities of retirees are repurchased by younger generations. Therefore, the first pillar is prone to political risk, while the second is affected by security price risk. Both of the pillars are subject to macroeconomic conditions. For example, weak economic growth hits the non-financial pillar lowering its revenues, while in the second pillar the adverse transmission channel occurs via the diminishing securities valuation. It is clear that this risk is hard to diversify, but a well-designed pension system can at least minimise its negative externalities (Góra, 2003, pp.149-159). For this reason we argue that the crucial shift in the pension system was the reform towards the Defined Contribution (DC) rule. Unlike the Defined Benefit (DB) system, the DC system is actuarially balanced and resistant to demographic conditions. This is possible if a *per capita* contribution to the pension system is fixed and the pensions paid depend solely on the total of collected receivables in both of the pillars. We should note that the DC rule itself cannot guarantee the actuarial balance of the first pillar. The solvency of this pillar depends on the labour market conditions, so the rate of return on the receivables collected here must be in line with the rate of change of the nominal wage bill. In such case the indexation reflects changes in demography and productivity. It is then possible that this rate may be negative if worsening demographic conditions (diminishing number of the employed in the economy)

prevail over productivity growth, but this is necessary to keep the system actuarially balanced. It prevents the excessive tax burden imposed on future generations which would hamper the economic growth and consequently the financing opportunities of the pensions system. To compare the depth of the reforms at a cross-country scale, one needs to assess not only the size of the capital pillar, as it is frequently done, but also the rule that applies to the first pillar. *Table 1* summarises both of these issues.

Table 1. The general structure of the pension systems in the selected CEE countries the historical view

(as of 1 January 2008) Country	First pillar – unfunded	Second pillar (% of gross salary)
Bulgaria	DB	5
Croatia	DB	5
Czech Rep.	DB (since 2010 DC)	-
Estonia	DB	6
Hungary	DB	8
Latvia	DC	1
Lithuania	DB	5.5
Poland	DC	7.3
Romania	DB	2
Slovakia	DB	9
Slovenia	DB	-

Source: own study based on Chybalski, 2011, p.259.

Recently, in the CEE states we have witnessed significant policy changes regarding the second pension pillar (*Table 2*). First of all, the existence of the mandatory capital pillar has been questioned as some of the countries reduced the size of this pillar. This move has enabled the governments to find short-term relief during the period of public finance distress.

Table 2. Current changes in the second pillar contribution rates in the selected CEE countries

Country	Historical second pillar contributions (% of gross salary)	Weakening of the second pillar
Bulgaria	5	Planned increases in the contribution rate delayed
Estonia	6	Transfers to second pillar temporarily suspended from 1 June 2009 until 31 December 2010 and partly suspended also in 2011. There a compensation mechanism planned for 2014-2017 that will transfer additional social tax revenues to the funded scheme.
Hungary	9.5	Nationalised private system.
Latvia	8	8% reduced temporarily to 2%.
Lithuania	5.5	Reduced second pillar contributions from 5.5% to 2% temporarily; now proposing additional contributions from individuals.
Poland	7.3	In 2011, reduced second pillar contribution from 7.3% to 2.3%, with a possible increase to 3.5% in 2017 and beyond. Currently the existence of the mandatory capital pillar is under debate.
Romania	2	Postponed planned increase in second pillar contribution in 2010, but reintroduced increases beginning in 2011.
Slovakia	9	Contributions were reduced from 9% to 4% of gross wages and, conversely, contributions to first pillar increased from 9% to 14%.

Source: own study based on Égert, 2012, p.8, Schwartz, 2012, p.31, Segaert, Võrk, 2012, p.8.

At the same time the regulatory shifts regarding the second pillar were discussed. In case of Poland, the proposed ideas covered the following topics: age-dependent portfolios, establishing the external benchmark, passive portfolio management and finally a greater foreign assets allocation. This last shift was additionally motivated by the sentence of the

European Court of Justice dated 21 December 2011 which forced the Polish government to increase the 5% limit on foreign asset allocation to comply with the rule of free capital movement.[1]

International diversification of pension fund portfolios can diversify various risk types (*Table 3*). What is the most evident, according to an imperfect correlation of financial market fluctuations, is that the security price risk may be reduced. The other point is that greater exposition to international markets offers access to alternative investments (*e.g.* commodity futures), the presence of which on the local market is usually limited in case of CEE states. Next, foreign asset allocation also provides an opportunity to diversify credit risk. This topic seems to be very up-to-date as we observe a great divergence of credit ratings among the European countries. Finally, international asset holdings may to some extent immunise the portfolio against the adverse demographic changes. From the point of view of future pensioners it is plausible to invest a part of the portfolio in the countries where demographers project low dependency ratios, as in the long run the returns on capital should be greater there.

Table 3. Investment limits on foreign assets for mandatory pension funds in the selected CEE countries (% of assets)

Country	Foreign investments
Bulgaria	15%
Croatia	15%
Estonia	No limits on investments in the European Economic Area, OECD countries and certain other countries.
Hungary	Within investments made abroad, the ratio of investments in non-OECD countries shall not exceed 20%.
Latvia	No maximum limit for international investments, as long as pension funds invest in securities listed on stock exchanges in the Baltics, other EU member countries or the European Free Trade Area.
Poland	5%
Romania	No specific limits on investments in foreign assets. The limits are established for each asset class.
Slovakia	70% (Pension funds have to invest at least 30% of their assets into instruments of Slovak issuers).

Source: own study based on OECD, 2013, Pension Funds Online, 2013.

We should be aware that the increased foreign asset allocation can result in the externalities affecting the overall economy. First of all, the additional capital outflow may reduce the financing opportunities for the local enterprises. On the other hand, if the local capital market is not deep enough, the regulations forcing the domestic asset allocation can create an asset bubble. In such circumstances relaxing the limits on international investments may be desirable. Secondly, foreign security purchases can result in a sudden exchange rate depreciation. Cheaper domestic money improves the competiveness of the exported goods, but simultaneously makes the imported goods more expensive, which may further create an inflationary pressure. Roldos (2004) notes this exchange rate effect was observed in Chile (20% depreciation of peso) due to increasing the cap from 2% by end-1997 to 12% by end-1999 and in Canada (10% depreciation of the Canadian dollar), where the limit was raised by 10 percentage points to overall 30% share in the period from January 2000 to January 2002. In 2005 a significant depreciation of local currency was also observed in Peru after a similar circumstances (Carmona, 2006).

[1] The limit will be rising gradually to 30% of the overall portfolio value.

It should be noted that the discussed externalities can be both positive and negative and the prevailing effect depends on country-specific conditions (financial market development, inflation pressure, exchange rate regime, or trade openness). We should not be surprised that the diversity of the implemented regulatory solutions among the CEE states is then large.

It is worth to underline that the increased limit does not automatically lead to a greater international portfolio allocation. Frequently, institutional investors hold more domestic assets than the international portfolio theory recommends. This phenomenon is known in the literature as the „home-bias". According to Sercu, Vanpee (2007) the potential explanations of home bias can be categorized into five large groups: hedging domestic risk, implicit and explicit costs of foreign investments, information asymmetries, corporate governance and transparency, and behavioural biases. It is also possible that the regulatory failures may also have some significance (*e.g.* prohibition of using currency derivatives). Though it is important to properly identify the dominant motives of this phenomenon as the regulatory policy can fix it and improve the portfolio performance.

2. Methodology

In this part we provide the overview of the portfolio selection procedure employed in this study. In general, we compare the out-of-sample results of the two portfolios selected using two different approaches. Adopting the first approach, we base our selection on the MPT. In the second one, the MPT optimisation procedure is preceded by the cointegration analysis to identify the markets sharing common trends.

The description of the cointegration analysis contains only the basic facts, which should be enough to justify the use of this methodology in the carried research. However, the further detailed technical description can be found in Tsay (2005, pp.376-389).

According to the seminal works of Granger (1981), the regression analysis of non-stationary time series can lead to spurious correlations as some basic assumptions are not met. One of the solutions suggests detrending the time series, making them stationary. We should be aware that this approach has a serious shortcoming as the detrending procedure usually leads to the loss of the long-term information contained in the data (Piotrowska, 1998, p.39). The response to this drawback was suggested by Engle, Granger (1987), who recommended using the cointegration approach which combines the short-run dynamics with the long-run equilibrium adjustment.

The series (two or more) which are individually non-stationary (but have to be integrated in the same order) are said to be cointegrated if their linear combination which is stationary exists. For example, if two series are first-order integrated: $X_t \sim I(1)$ and $Y_t \sim I(1)$, it means that there exists β, such that $Y_t - \alpha - \beta X_t \sim I(0)$. This last expression is called the error correction term or cointegrating equation. Hence, the very simple example of the Vector Error Correction Model (VECM) with one cointegrating equation and one lag of difference terms presents as follows:

$$\Delta X_t = \gamma_1 (Y_t - \alpha - \beta X_t) + \tau_{11} \Delta X_{t-1} + \tau_{12} \Delta Y_{t-1} + \varepsilon_{1t}$$
$$\Delta Y_t = \gamma_2 (Y_t - \alpha - \beta X_t) + \tau_{21} \Delta X_{t-1} + \tau_{22} \Delta Y_{t-1} + \varepsilon_{2t}$$

where τ can be interpreted as a short-run reaction of the dependent variables to the changes in the lagged right-hand side variables and γ parameters measure the speed of return to the long-run equilibrium between variables X_t and Y_t in case of shocks. One can also see a VECM as Vector Auto Regression (VAR) model designed to be used with a non-stationary,

but cointegrated variables. In fact, for the portfolio selection process we do not need to estimate the whole VECM, rather than to identify only if the cointegration relation exists. For this purpose we will utilise the Johansen (1988) procedure. The technical description of this approach is quite intensive and outside the matter of this paper, but we need to note that its results strongly depend on the chosen lag length of the verified VECM. Having analysed this issue, Johansen (1991, p.1566) and Johansen, Juselius (1992, p.220) stated that the VECM residuals ε_t cannot exhibit the autocorrelation in order to obtain solid results. We will include this finding into our estimation strategy, recognising it as the necessary condition. Additionally, in the lag selection process we will also take into account the Akaike Information Criterion (AIC). This criterion compares models with a different number of variables (lags) giving values based on the goodness of fit and penalising for losing the degrees of freedom. Therefore, our strategy of identifying cointegration relations is as follows:

1. We check the integration order of the two analysed time series: the Polish stock market index and one regional index.
2. If the pair is found to have the same integration order higher than 0, we estimate the VAR models in levels for different lag lengths, where the maximum lag length is 8. We run this step to find the appropriate lag length *m* for the Johansen procedure.
3. From the estimated VAR models we choose the one with the lowest (the best) AIC value.
4. We verify the autocorrelation of residuals. If autocorrelation is found, we increase the lag by one step, as long as the autocorrelation process disappears.
5. Having the appropriate lag length *m* from the step 4, we apply the Johansen trace test for the lag length $m-1$ and find the number of cointegrating vectors (we reduce the number of lags by one since we run the model in first differences now).
6. If the number of cointegrating vectors is positive, we may assume that in the long run the two indices share a common trend so the diversification gains are limited. Hence, in our portfolio we include only the indices where the number of cointegrating relations with the Polish market was found to be zero. The cointegration-based pre-selection stage ends here.

From now on we set up the portfolio weights by minimising the portfolio variance. For this purpose we employ the variance-covariance matrix, estimated by using *ex-ante* data.

At first glance it is a rather contradictory view of the MPT fundamentals, where the objective is to maximise the expected risk-adjusted return. However, following Merton (1980) and Jorion (1985), Petrella (2005) notes that the expected returns are more difficult to estimate than variances. Additionally, Dimson *et al.* (2006) provide a comprehensive analysis of the equity premia of seventeen countries and a World index over a 106-year sample proving that even a ten year data period, like in our study, may be too short to obtain solid estimates of the expected returns. Dimson *et al.* (2006) found that on average the investors expected a premium on the World index of around 3-3.5% on a geometric mean basis, but the variation of the estimates through the decades was extremely high. It was possible to find the decades with the positive two digit excess returns as well as the prolonged periods of the negative equity market premia. Consequently, Dimson *et al.* (2006, p.11) concluded it would be misleading to project the future equity premium from the data for the previous decade. This statement seems to be even more justified if we take the extremely long perspective of a future pensioner. Therefore, comparing only the rate of risk reduction while measuring the diversification benefits seems to be both theoretically and empirically supported.

3. Data

The asset universe in our study contains the local (Polish) equity index together with the four regional stock indices. Therefore, we have utilised the following proxies (in alphabetical order): MSCI Emerging Markets Asia Price Index (EMA, Reuters Code: MSEMFA$), MSCI Emerging Markets Europe Price Index (EMEUR, Reuters Code: MSEEUR$), MSCI Emerging Markets Latin America Price Index (EMLA, Reuter Code: MSEFLA$), MSCI European Monetary Union Price Index (EMU, Reuters Code: MSEMUI$), MSCI Poland Price Index (POL, Reuters code: MSPLNDL), MSCI World Index Price Index (WRD, Reuters code: MSWRLD$(PI)).

The sample period spans over the last eighteen years and the data has a daily frequency (1.01.1996-31.12.2012). We split this sample period into two parts: 1996-2005 and 2006-2012. The first ten years are used only for the portfolio selection process (the MPT based selection only or cointegration and the MPT), while the data from the latter period is used to verify the portfolio performance. To closely mirror the perspective of a Polish investor, all the values of foreign indices have been converted into PLN using the USD/PLN spot rate. We assume no transaction costs and the short sale is not allowed. This last point is motivated by the existing regulatory framework of the OPF asset allocation policy. Prior to the carried analysis, the variables have been transformed into natural logarithms.

All of the time series used in this study have been obtained from Reuters Datastream.

4. Empirical Results

Using the 1996-2005 subsample we start by testing each of the time series to determine their order of integration running the standard Augmented Dickey-Fuller test (ADF). The results are presented in *Table 4*.

Table 4. ADF test results

	ADF t-Stat		
	Levels	1st diff.	Integration order
EMA	-1.75686	-42.8968***	I(1)
EMEUR	0.00611	-45.3036***	I(1)
EMLA	-0.34242	-35.156***	I(1)
EMU	-1.41974	-49.0684***	I(1)
POL	-2.60681*	-45.0684***	I(1)
WRD	-1.46547	-35.2945***	I(1)

Source: own study.

We note that all of the variables are integrated of the order first. There have been some doubts regarding the POL index as the null in case of ADF test in levels can be rejected at a 10% significance level. However, this is a borderline result, as the precise *p-value* is 0.0916. ADF test is known to have a relatively weak power (Diebold, Rudebusch, 1991; DeJong *et al.*, 1992), so in order to dispel our doubts we have run the additional stationarity test – Kwiatkowski–Phillips–Schmidt–Shin (1992). In KPSS the null states variable is stationary, which is different from the ADF. The results of KPSS have been the following: 0.95182*** (levels), 0.13652 (1st differences). This cross check has enabled us to conclude that POL is also I(1) variable.

As all of the time series are integrated of the same order, it is possible to carry the cointegration analysis. According to the described procedure we estimate the VAR bivariate models (POL + regional index) in levels to find the appropriate lag length for the Johansen cointegration test. The summary is presented in *Table 5*.

Table 5. Bivariate VAR (POL + regional index) lag length selection

Regional index	Lag order selected	AIC
EMA	3	No
EMEUR	4	No
EMLA	3	Yes
EMU	3	Yes
WRD	4	Yes

Source: own study.

In the case of EMLA, EMU and WRD, the AIC has indicated the models which have not exhibited autocorrelation of residuals. For EMA and EMEUR, the AIC has shown lag order two, but with this specification the autocorrelation has been noted, so we have decided to add the additional lags. The autocorrelation has been verified using the LM test up to the fourth lag.

Finally, we are able to run the Johansen trace test. This test is done sequentially starting from the null hypothesis that the cointegration rank (the number of cointegrating vectors) is zero. We increase this rank by one step as long as we cannot reject the null.

Table 6. Johansen trace test results

VAR model	Hypothesised no. of cointegrating vectors	Trace stat.	*p-value*	Result
EMA	None	19.93052	0.01	1 cointegrating vector
	At most 1	3.62845	0.0568	
EMEUR	None	19.77646	0.0106	1 cointegrating vector
	At most 1	0.014236	0.9049	
EMLA	None	19.19272	0.0132	1 cointegrating vector
	At most 1	0.053304	0.8174	
EMU	None	9.515509	0.3198	No cointegrating vectors
	At most 1	1.366467	0.2424	
WRD	None	22.79179	0.0033	1 cointegrating vector
	At most 1	1.628441	0.2019	

Source: own study.

Assuming the typical 5% significance level, we note that only in the case of the EMU index there has been no cointegrating relation with the Polish market (*Table 6*). Therefore, using the cointegration pre-selection stage, we conclude that the portfolio should be further optimised using only two assets: POL and EMU. We will compare the *ex-post* results of this portfolio with the one selected from the whole set of the asset universe.

Our optimisation objective is to find the Minimum Variance Portfolio (MVP), so we need only a variance-covariance matrix. We base our estimates on the 1996-2005 subsample delivering the following numbers:

Table 7. Volatility estimates

	EMA	EMEUR	EMLA	EMU	POL	WRD
Std. dev. (daily)	1.53%	1.83%	1.76%	1.33%	1.74%	1.14%
Std. dev. (yearly)	24.37%	29.01%	27.93%	21.07%	27.55%	18.10%

Note: In the carried estimations we use the daily standard deviation. Yearly figures have been displayed for convenience only.

Source: own study.

Table 8. Correlation matrix

	EMA	EMEUR	EMLA	EMU	POL	WRD
EMA	1					
EMEUR	0.5207521	1				
EMLA	0.4237567	0.4962946	1			
EMU	0.2333845	0.2748515	0.2526017	1		
POL	0.3370113	0.4381877	0.1939394	0.0517216	1	
WRD	0.4996823	0.5878743	0.7164726	0.3196703	0.2498665	1

Source: own study.

A quick inspection of the obtained numbers enables us to formulate two basic facts. First of all, the less risky asset in the analysed period was the WRD index (*Table 7*), which should not be surprising as this index groups the well-developed, hence, the most liquid markets. Secondly, the results of the pre-selection step are consistent with the correlation analysis (*Table 8*) – the only index that has not cointegrated with POL has also the lowest correlation. However, it is quite surprising that the cointegration analysis has identified long-term co-movement of other indices with Polish market, while the correlation coefficients are only moderate.

Finally, we select the two portfolios.

Table 9. Selected portfolios and their expected risks (based on the 1996-2005 sample)

	EMA	EMEUR	EMLA	EMU	POL	WRD	Expected std. dev. (daily)
MPT portfolio	7.12%	0.00%	0.00%	33.79%	17.98%	41.11%	0.92%
Cointegration + MPT portfolio	0.00%	0.00%	0.00%	63.80%	36.20%	0.00%	1.08%

Source: own study.

Using the in-sample data where the variance and covariance matrix is known, the variance (expected std. dev. in *Table 9*) of the traditionally selected portfolio is certainly lower compared to the cointegration-based portfolio, as this first one is based on the unrestricted set of assets. On the other hand, a problem that really matters to an investor is the out-of-sample results, rather than in-sample simulation output. Therefore, we verify the portfolio performance using the 2006-2012 data. We additionally assume that both of the portfolios are rebalanced every first business day of each year to recover the initial portfolio weights (*Table 9*).

At the end of 2012 the out-of-sample performance measures were striking. While the portfolio based solely on the MPT experienced a daily volatility of 1.55%, the cointegration-based portfolio was less risky with a standard deviation of 1.40%. Moreover, the standard F-

test confirmed that the difference in variances was statistically significant at a 1% level (F(1825,1825) = 1.21923; one-sided *p-value* = 0.00001).

Conclusions

In this study we have presented the portfolio selection method comprised of the cointegration analysis and the MPT approach. The cointegration pre-selection step fulfilled its objective, *i.e.* it enabled us to identify the long-run trends, which resulted in the superior out-of-sample portfolio performance. Therefore, this method may be especially useful for the long-term investment selection, particularly in the pension fund management process.

Besides the research objective we aimed to achieve, we also note the issues requiring further research exploration.

First of all, we did not impose any limits on foreign assets and the only restriction applied was the short-sale constraint. Applying country-specific limits may diminish the size of diversification gains, so an additional analysis should be carried out. Nevertheless, we should keep in mind that the limit on international securities in Poland is highly binding, as the optimal share of foreign assets was well above 50% for both optimised portfolios.

Secondly, the MPT approach assumes multivariate normal distribution. Nowadays it is a well-recognised phenomenon that the empirical distributions are usually leptokurtic which results in the underestimation of the extreme events under the mean-variance framework. This issue may be especially important with regards to wealth-protecting portfolios, *e.g.* it reflects well the investment objective of the pension fund participant several years prior to retirement. Successful modelling of the higher moments of the joint distribution is then necessary. The copula functions approach (Deng *et al.*, 2011; Boubaker, Sghaier, 2013) seems to be promising, but this area definitely needs further attention.

Thirdly, we should keep in mind that all values of indices have been transformed to PLN to mirror the perspective of a Polish investor. This transformation reflects the situation whenever there is no currency hedging applied. It is worth to check the potential international diversification gains whenever the FX derivatives are in use.

Last but not least, it is tempting to verify the stability of long-run dependencies between various markets. The rolling (Brada *et al.*, 2005) and recursive (Hansen, Johansen, 1999) cointegration approach may be applicable for this purpose. This kind of analysis may shed additional light on whether the recent crisis was only a temporary episode or if it changed market dependencies and consequently the international diversification opportunities in a permanent way.

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TARPTAUTINIS PENSIJŲ FONDŲ DIVERSIFIKAVIMAS NAUDOJANT KOINTEGRACIJOS METODĄ. LENKIJOS ATVEJIS

Radosław Kurach

SANTRAUKA

Šiame tyrime pristatomas portfelio, tinkamo ilgalaikėms investicijoms, pasirinkimo metodas. Jis gali būti taikomas pensijų fondų sričiai. Portfelio pasirinkimas paremtas dviem etapais. Pirmame etape nustatomas ilgalaikis bendras judėjimas naudojant kointegracijos analizę pašalinti turtą, pasižymintį bendra tendencija. Tada, pasitelkus apribotą turto rinkinį iš pirmo etapo, portfelis optimizuojamas taikant Šiuolaikinę portfelio teoriją. Palyginus su imčiai nepriskiriamais rezultatais, daroma išvada, kad portfelio, kuriam taikoma kointegracijos analizė, rezultatai daug geresni, nei portfelio, paremto tik Šiuolaikine portfelio teorija. Siekiant pagrįsti šį teiginį, nustatoma Lenkijos atvirų pensijų fondų portfelių tarptautinio diversifikavimo galimybė. Straipsnyje taip pat pateikiama neseniai įvykdytų pensijų sistemų pokyčių VRE šalyse apžvalga nurodant norimų reglamentų pokyčių kryptį.

Straipsnyje teigiama, kad dabartinis atvirų pensijų fondų turto paskirstymas pasižymi nepakankamu diversifikavimu į užsienį (polinkis investuoti savo šalyje), todėl norima keisti reguliavimo politiką, kad atviriems pensijų fondams būtų leista daugiau investuoti užsienyje. Tačiau padidėjęs kapitalo išvežimas gali nulemti keletą teigiamų ir neigiamų išorės veiksnių, todėl šio pokyčio rezultatas priklauso nuo vietos makroekonominių sąlygų.

REIKŠMINIAI ŽODŽIAI: portfelio teorija, kointegracijos analizė, pensijų fondai, tarptautinis diversifikavimas, Centrinės ir Rytų Europos šalys.