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Should pension funds hedge currency risk? The case of Poland

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ABSTRACT

In this study, we identify the optimal hedge ratio for mandatory pension funds, defining the optimum as the value that minimizes the portfolio variance in accordance with the social objective of the mandatory pension system. Unlike most previous studies, we apply a dynamic framework to account for a regular inflow of contributions and impose specific investment constraints that make the simulation more realistic. Our outcomes challenge the conventional knowledge concerning the need for currency hedging. We discover that in the case of Poland, shortening the currency positions is undesirable, as it amplifies the portfolio variance. Moreover, we provide evidence that pension funds should internationalize their portfolios even further to fully exploit the available diversification gains. Finally, the obtained simulation results are matched with real data. The comparison presented tends to beg the question of how to overcome the home bias phenomenon.

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1. Introduction

Every manager of international assets' portfolio must carefully consider the issue of currency hedging. The exposure on foreign asset volatility can impact the overall portfolio risk in both directions, depending on the volatility of currency exchange returns. Therefore the question of optimal currency risk hedging is always a non-trivial one, but in the case of mandatory pension funds it gains the additional importance. In Central and Eastern European (CEE) countries these funds usually follow the defined contribution (DC) rule. Under this solution if the total asset value collected by the individual is insufficient to purchase a lifetime annuity, governments provide various policy solutions to enable retirees to reach the targeted consumption floor. These policy tools play a redistributive role, as they are financed from general taxes (Chłoń-Domińczak & Strzelecki, 2013). Consequently, a failure in the asset management process can lead to a higher tax burden, which hampers economic growth and further opportunities for pension system financing.

The research objective is to provide the evidence on the eventual portfolio risk reduction potential of currency hedging. To achieve this goal, we deliver a set of

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simulations concerning the optimal currency hedging ratio for mandatory pension funds in Poland, which would minimize the aforementioned risk of portfolio underperformance. We believe the presented outcomes may shed new light on regulatory policy in this area, which should support the financial sustainability of the pension system.

Our study contributes to the empirical literature by accounting for some important facts concerning the real investment context faced by pension funds that are frequently undressed in existing works. First, instead of a conventional one-period approach, we perform our analysis using a multi-period framework that accounts for the regular inflow of pension contributions and employing the concept of a time-weighted rate of return. Second, we impose specific investment constraints and rebalancing rules to better match reality. We argue that failing to adopt the aforementioned features renders it difficult to obtain convincing proof concerning the optimal hedge ratio. Third, the scarcity of studies on currency hedging presenting the perspective of an emerging market investor is the additional factor which motivates us to perform this research. Finally, abstracting from the Polish conditions examined in this study, we offer some general guidelines that may be applicable to other countries.

The remainder of the paper is organized as follows: Section 2 provides a brief overview of recent changes in the pension system landscape in CEE to highlight the relevance of the research question investigated in this paper. Section 3 surveys the literature and reveals the diversity of existing research outcomes. Section 4 describes our methodological approach and data employed data. Section 5 reports the empirical outcomes. Section 6 concludes the study.

2. Pension reforms pattern in CEE

The ageing of societies drove governments to restructure their pension systems in the late 1990s. The usual set of reforms consists of establishing a multi-pillar framework with two mandatory (first and second) and one voluntary (third) pillar following the recommendations of the World Bank from its seminal policy report (World Bank, 1994). While the first pillar operates on a pay-as-you-go (PAYG) basis, the second and third pillars have a capital character. Additionally, while the first pillars in CEE states operate under various rules, that is, defined benefit (DB), notional defined contribution or some hybrid solutions, the capital components are usually DC.

The division of mandatory pension contributions into two pillars resulted in a funding gap in public pension systems, as governments experienced difficulties in financing already paid benefits from the PAYG pillar. The policymakers' intention was to address this shortfall through privatization revenues or general public finance reforms. However, within a few years, it became clear that these assumptions were overly optimistic. The funding gap was heavily financed by additional public debt, which represented a less risky solution in terms of retaining political support. Moreover, the recent financial crisis has intensified the adverse pressure on central budgets. Consequently, after approximately a decade, governments decided to reverse their initial reforms by reducing the size of the second pillar relative to that of the first pillar (OECD, 2012).

Despite this policy shift, in many cases, a large part of retirees' second pillar savings can still be invested in foreign securities (Table 1).

Table 1. Investment limits on foreign assets for mandatory pension funds in selected CEE countries (% of assets).

Country	Foreign investments
Bulgaria	No quantitative limits on foreign assets
Estonia	No limit
Hungary	Within investments made abroad, the ratio of investments in non-OECD countries shall not exceed 20%
Poland	<ul style="list-style-type: none"> • OPF: 5% Since February 2014: • OPF: 10% in 2014, 20% in 2015, 30% beginning in 2016
Romania	No specific limits on investments on foreign assets. Limits are established for each asset class
Slovakia	No limit

Source: Own analysis based on OECD (2014).

As is clear from the above, foreign assets are of increasing importance in the Polish case. The previously established maximum investment limit (5%) was questioned by the European Commission, which accused Poland of breaking the rule on the free movement of capital by imposing limits that were overly restrictive. Ultimately, according to a ruling by the European Court of Justice of 21 December 2011, the Polish government was required to remove this excessive constraint. The expected growth in foreign assets in open pension funds (OPF) portfolios thus represents a good opportunity for reconsidering the existing investment and hedging strategy.

3. Literature review

There is no consensus on the optimal level of currency hedging for international investments, and hence we have chosen to focus primarily on two opposing views, providing arguments that may help to understand why this diversity of opinion exists. To avoid any doubts regarding interpretation, we must first clarify the meaning of the hedging ratio. We begin with the formula on the return on a portfolio that consists of domestic and foreign assets:

$$R_P = w_L R_L + w_H (R_H + R_X + R_H R_X), \quad (1)$$

where R_P denotes the portfolio return denominated¹ in the domestic currency (e.g. PLN), R_L is the return on domestic assets denominated in the domestic currency, R_H is the return on foreign assets denominated in a foreign currency (e.g. USD), R_X represents the exchange rate return (units of domestic currency per a unit of foreign currency, e.g. PLN per USD), and finally, w_H and w_L are the foreign and domestic asset weights, respectively.

We can ignore the last term $R_H R_X$ because it is small relative to $(R_H + R_X)$, which is a conventional approximation (Elton, Gruber, Brown, & Goetzman, 1995, p. 256). Let us introduce w_X , the weight of the foreign currency market position. Consequently, we can rewrite Equation (1) as follows:

$$R_P = w_L R_L + w_H R_H + w_X R_X, \quad (2)$$

where $w_L + w_H = 1$, and if we do not buy or sell forward contracts, $w_X = w_H$.

Given this equation, we can derive a hedge ratio h :

$$h = \frac{w_X - w_H}{w_H}. \quad (3)$$

If $w_X = w_H$, our hedge ratio is equal to 0, which means that we do not take any position on forward contracts and the portfolio is unhedged. If h is greater than 0, this means that we go long on a forward contract, and a value of h below 0 indicates a short forward position.

Perold and Schulman (1988) advocate full hedging ($h = -1$) of currency risk. They argue that currency return is a zero-sum gain (one person's gain is another's loss), and hence currency hedging reduces volatility alone and not the expected return. According to this interpretation, the use of currency derivatives offers a free lunch (with the exception of hedging transaction costs). Froot (1993) offers the contrary view, arguing that in the long run, real exchange rates tend to converge with purchasing power parity (PPP), meaning that the real exchange rate is approximately constant. In attempting to explain this extreme diversity of opinions, Froot (1993) notes that the need for hedging depends simply on the investment horizon: the longer the horizon, the less hedging is needed.

We further note other points that should be considered when establishing the optimal hedging ratio. The first is the extent to which PPP theory is accurate. We should acknowledge that the literature recognizes systematic deviations from PPP such as the Balassa–Samuelson effect (e.g. for many years in the Big Mac index, the case of Norway presents one of the highest USD prices for a hamburger). Second, the link between a particular security asset class returns and local inflation should be investigated. Third, the local perspective of an individual investor may be important. In verifying the links between currency and equity returns over the period 1975–2005, Campbell, Medeiros, and Viceira (2010) find that currencies traditionally regarded as reserve currencies (e.g. USD and CHF) have been negatively correlated with global stock markets. This quantitative finding may be explained by the phenomenon known in the literature as the *flight to liquidity/quality*, which has been confirmed by many studies (Beber, Brandt, & Kavajecz, 2009; Can Inci, Li, & McCarthy, 2011; Rosch & Kaserer, 2013). In periods of financial market turbulence, investors sell risky assets such as equities and reallocate their funds to the US treasuries or certain CHF-denominated debt instruments. The need for currency hedging therefore seems to be less justified for investors from emerging markets who have international equity exposure denominated in reserve currencies (Walker, 2008). Finally, even if we have a long-term investor such as a pension fund, the short-term perspective begins to prevail several years before the endowment. Governments that guarantee a minimum consumption floor may be more interested in short-term volatility to properly fund this guarantee and to minimize the risk of an additional tax subsidy. For this reason, we believe that at least in the final years of pension asset accumulation, it may be necessary to mitigate currency risk.

Despite numerous studies regarding currency hedging and international asset allocation, the list of works focusing on pension fund portfolios is limited. Bearing in mind pension funds' specific investment objective and extremely long investment horizon, the outcomes of other strands of portfolio research cannot be easily adapted to this context.

Berggrun (2005) addresses the problem of currency hedging for Dutch pension funds. The author notes that in a mean-variance context, the objective of currency hedging optimization can be twofold: to maximize the risk-adjusted return (measured by the Sharpe ratio) or to minimize portfolio variance. Employing this latter approach, Berggrun (2005) tests whether different hedging ratios provide statistically significant risk reduction

for the analysed portfolios composed of local (Dutch) and international (Japan, Sweden, Switzerland, the UK and the U.S.A) securities. The obtained results reveal that currency hedging is more appropriate for international bonds than for equity portfolios.

Pfau (2011) focuses on emerging countries' pension-savers by adopting their local perspective in assessing the optimal level of international diversification. Unlike Berggrun (2005), Pfau (2011) optimizes the expected utility of the mean-variance trade-off for different risk aversion levels. Pfau (2011) finds that approximately half of the portfolio should be invested in foreign assets. Moreover, he notes that the existing limits are usually highly binding for international assets inclusion.

A phenomenon of international under-diversification, known in the finance literature as *home bias*, has also been recognized in case of pension funds from various countries, for example, Denmark (Nørregaard, 2011), the Netherlands (Rubbiani, van Lelyveld, & Verschoor, 2014) and the UK (Babilis & Fitzgerald, 2005); however, the reasons for this phenomenon are mixed and remain unclear. The literature provides two sets of potential explanations: regulatory and non-regulatory. This second group of explanations includes the implicit and explicit costs of foreign investments, hedging against domestic risk, information asymmetries, corporate governance and transparency and behavioural biases (Kurach, 2012).

Zhang (2011) addresses the problem of extreme market moves risk by analysing various currency hedging instruments and their interactions. The findings of Zhang (2011) do not indicate that any particular type of derivatives (forwards or options) is preferable but confirm the results of other studies indicating that correlation between securities and foreign currency returns plays a dominant role in the assessment of diversification potential and in establishing optimal hedge ratio between Euro and USD assets.

Avalos and Moreno (2013) analyse the consequences of currency hedging by Chilean pension funds for the local derivatives market. The authors contend that the development of this market segment has primarily been driven by pension funds, which have been shortening their portfolios of international assets. Hence, pension funds have become natural hedgers for other domestic investors, which have been structurally short (e.g. banks) in foreign currency. Avalos and Moreno (2013) conclude that this fact explains why Chilean financial markets suffered significantly less stress relative to other emerging economies despite the relatively small size of Chile's currency reserve buffer. However, the authors do not investigate whether the observed level of currency hedging among Chilean funds is proper according to their investment policy objectives.

Danielsson (2014) provides a model of optimal currency hedging and applies it to the context of the Icelandic pension funds. The obtained results suggest that the optimal hedging ratio depends on the investment horizon (the longer the period, the less hedging is needed) and the stochastic process describing exchange rate volatility. Nevertheless, Danielsson (2014) applies the model to the situation of an investor who allocates all of his or her wealth to foreign securities. Danielsson (2014) concludes by suggesting that the analysis be extended to include local assets in the investment portfolio, which may substantially influence the ultimate findings.

In summary, the estimated hedge ratios vary considerably depending on the country, the asset classes investigated and the assumptions employed. We also note that research on pension funds operating in CEE is extremely scarce. Therefore, to provide a policy recommendation for a particular economy, the local conditions should be carefully taken into

account. However, it is tempting to formulate more general conclusions that should also be relevant for other countries. We provide the evidence that will fill this gap.

4. Methodology and data

To account for the features of pension asset accumulation discussed here, we set up the following dynamic framework. We assume that an individual enters the labour market at the beginning of the year 2001 and earns the average wage in the Polish economy every month. The rates of contribution of the gross salary to the second pillar are in line with the established regulations, that is, 7.3% for the period 01.2001–04.2011, 2.3% for the period 05.2011–12.2012 and 2.8% for the period 1.2013–12.2013.² The simplified asset universe in our simulation consists of local bonds, local equities and foreign assets. The established maximum investment limits are 40% of the portfolio weight for local equities and 5% for international assets to mimic the regulatory constraints that existed at the time. In the initial period, the portfolio weights are as follows: 60% for local bonds, 36% for local equities and 4% for international assets. The portfolio is rebalanced whenever the maximum limits are exceeded or at the beginning of each year to recover the initial portfolio composition. We adjust the contributions to the second pillar by the distributional fees charged by the OPF, which are 7% of contributions up to the end of 2009 and 3.5% in the subsequent period. These numbers are the caps on distributional fees that have been broadly applied by the majority of OPF.

As noted above, in the existing regulatory environment, the use of currency derivatives is strictly prohibited. In an attempt to determine the hypothetical hedge ratio for the entire period of analysis, we first find the optimal ratio for every year and then calculate its average value to formulate the general conclusion.

To hedge against foreign exchange risk, we use forward contracts. As Glen and Jorion (1993) state, forwards involve a commitment to buy or sell foreign currency and produce a random payoff but require no initial investment. Therefore, a rate of return cannot be defined for forward contracts, but it is possible to compare the return on the portfolio with and without forward contracts.

Portfolio return without forward contracts:

$$R_P = w_L R_L + w_H (R_H + R_X). \quad (4)$$

Portfolio return with forward contracts:

$$R_P = w_L R_L + w_H (R_H + R_X) + h w_H R_X, \quad (5)$$

where $w_H R_X$ is the payoff of a one-year forward contract; the value of this contract is equal to the value of the foreign investment.

The theoretical valuation of forwards is based on the uncovered interest rate parity; hence, the value of a one-year contract in month t is equal to the difference between the one-year local and foreign spot interest rate. The number of contracts bought or sold is optimized once per year in January, and the valuation of the contract is completed each month using a mark-to-market approach. We believe that this assumption is rather non-controversial, as the pension funds are long-term investors that do not need to change investment positions frequently. The eventual profit on a forward is invested in

the proportions given by our investment constraints, while the loss is covered by accumulated capital.

As we stated before, the social objective of the mandatory pension system is to guarantee the minimum consumption floor at the elderly age. Translating this policy task into optimization procedure, we define the optimal level of currency hedging as the one which minimizes the portfolio variance. This objective approximates the risk of portfolio underperformance given the established investment constraints.

To determine the minimum variance hedge ratio for year n , we use the realized portfolio returns without hedging in that year. Because there is a net positive cash flow from premiums each month, we use the true time-weighted rate of return (TWROR).

TWROR is a measure of the historical performance of an investment portfolio, which compensates for external flows. We define the external flows as net movements in portfolio's value that result from transfers of cash into or out of the portfolio, with no equal and opposite movement of value and that are not income from the investments in the portfolio, such as interest, coupons or dividends. Hence, in our case, the external flows simply refer to pension contributions. To compensate for these flows, the overall time interval under analysis is divided into contiguous sub-periods at each point in time within the overall time period whenever there is a flow of contributions. The returns over the sub-periods between external flows are linked geometrically (compounded), that is, by multiplying the growth factors in all sub-periods – the growth factor in each sub-period is equal to 1 plus the return over the sub-period (Bacon, 2003; Feibel, 2003). Therefore, the TWROR is:

$$1 + \text{TWROR} = \frac{W_1 - CF_1}{W_0} \times \frac{W_2 - CF_2}{W_1} \times \frac{W_3 - CF_3}{W_2} \times \dots \times \frac{W_n - CF_n}{W_{n-1}}. \quad (6)$$

where W_0 is the initial portfolio value, W_t is the portfolio value at the end of sub-period t , immediately after external flow CF_t , W_n is the final portfolio value, CF_t is the net external flow into the portfolio that occurs just before the end of sub-period t , and n is the number of sub-periods.

To summarize our optimization problem the objective function we minimize is $\text{Var}(\text{TWROR}_{i,t}(h_t))$, where $\text{TWROR}_{i,t}(h_t)$ denotes the portfolio return in month i of year t , which is a function of the hedge ratio (h) in the t th year.

The investment allocation regulations establish the set of optimization constraints:

$$\begin{aligned} w_{Li,t} &= w_{LEi,t} + w_{LBi,t}, \\ 0 &\leq w_{LEi,t} \leq 0.4, \\ 0 &\leq w_{LBi,t} \leq 1, \\ 0 &\leq w_{Hi,t} \leq 0.05, \\ w_{Li,t} + w_{Hi,t} &= 1, \end{aligned} \quad (7)$$

where $w_{LEi,t}$ is the weight of the domestic equities and $w_{LBi,t}$ is the weight of the domestic bonds in the portfolio.

Keeping in mind the portfolio rebalancing procedure at the beginning ($i = 1$) of each year (t) the January portfolio weights are following:

$$\begin{aligned} w_{LE1,t} &= 0.36, \\ w_{LB1,t} &= 0.6, \\ w_{H1,t} &= 0.04. \end{aligned} \tag{8}$$

To run the optimization procedure, we employ the generalized reduced gradient method (Lasdon, Waren, Jain, & Ratner, 1978).

The sample period includes 13 years (2001–2013) of monthly data, and the data availability for local bonds has determined the beginning of our sample. In our study, the asset universe is proxied by three indices: MSCI Poland (Polish equities; Reuters code: MSPLNDL), Thomson Reuters Polish Sovereign Polish Bond 10Y Index (Polish treasuries; Reuters code: BMPO10Y), and the MSCI World Index (World equities; Reuters code: MSWRLD\$(PI)). The MSCI World Index consists of the 24 developed country markets. Therefore, it should well reflect OPF foreign allocation opportunities, which are allowed to invest mainly in the securities listed on the OECD markets. To account for the perspective of Polish investors, the MSCI World indices values have been converted into PLN using the average USDPLN spot rate. To estimate the theoretical value of forward contracts, we employ the one-year Warsaw Interbank Offered Rate and the one-year US Interbank Offered Rate. The assumed transaction costs are 0.15% of traded assets, which is a typical value for the Polish financial market and do not differ substantially from transaction costs on other markets (Šperka & Špišák, 2013).

The financial time series used in this study are obtained from Reuters Datastream, while the average wage data are provided by the Central Statistical Office of Poland.

5. Empirical results

We begin our verification procedure from the general outlook at the financial time series used in this study.

A visual inspection of [Figure 1](#) indicates that the World (WE) and Polish (PE) equities share the same trends, while the co-movement between the international asset proxy and Polish bonds (PB) is limited. Indeed, the correlation estimates between the monthly returns of these time series are 0.70 and 0.17, respectively. Moreover, we note a significant negative correlation between the returns of WE and the exchange (−0.68). Consequently, in adopting the Polish perspective, we find the drivers of international diversification potential in currency movements rather than in cross-country variation in market tendencies. We expect the optimal hedge ratio for OPF to be greater than zero.

This finding can only serve as hypothetical guidance at this stage of our analysis. We should keep in mind that one of the stylized facts regarding financial asset prices behaviour states that low correlation of returns disappears when we most need it. The literature highlights the phenomenon of conditional co-movement in financial time series (Baumöhl & Lyócsa, 2014; Syllignakis & Kouretas, 2011), and hence we need to analyse the dynamic behaviour of correlation coefficients ([Figure 2](#)).

Focusing on the period of the financial market crash (2007–2009), we notice two results. While it is true that the correlation between international and local assets grows rapidly,

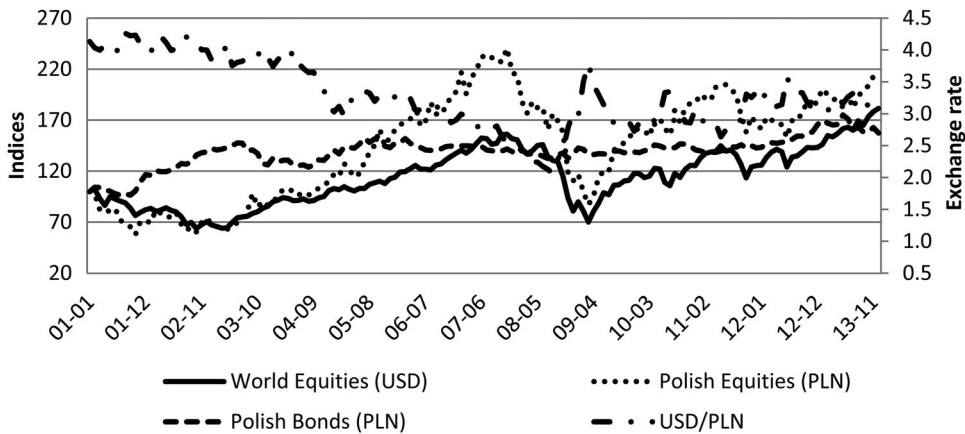


Figure 1. Financial variables developments for the period 2001:01–2013:12. Source: Own analysis.
 Note: To clarify the above chart, the values of the security indices have been converted such that January 2001 (01–01) values are equal to 100 in each of the three cases.

which may result in amplified adverse portfolio performance, the correlation with currency returns moves in the opposite direction. Therefore, the greater the long position in foreign reserve currency, the greater the potential to minimize portfolio losses. This outcome confirms the aforementioned flight to liquidity/quality phenomenon. Consequently, going short in the currency market cannot rescue portfolio performance in a period of financial stress.

Turning to the core of our analysis, we seek to estimate the precise hedging ratio, expecting its value to be positive. We run two scenarios in applying the aforementioned assumptions of our research strategy. In the first, we do not use currency forwards; the portfolio weights are simply determined by regulatory constraints. In the second scenario, we allow the use of FX hedging, optimizing the number of forward contracts to minimize portfolio variance. Finally, we assess whether the portfolio variances from the two scenarios differ significantly according to the *F*-test.

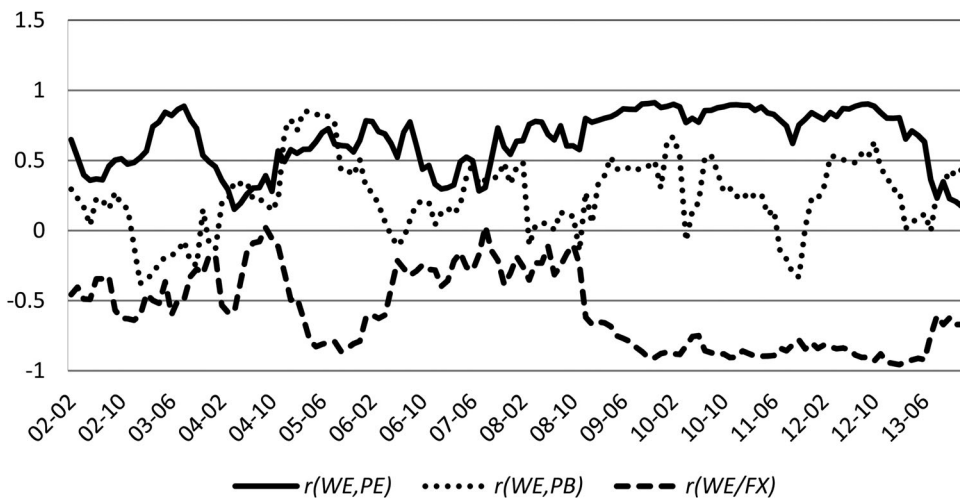


Figure 2. 12-month rolling correlation coefficients. Source: Own analysis.

The obtained estimates are presented in [Tables 2](#) and [3](#).

The results presented in [Table 3](#) confirm the preliminary findings, which suggested a long position in foreign currency. As the changing financial market conditions and the inflow of premiums indicate, the optimal hedge ratio from year to year exhibits large swings, but in 9 out of 14 cases, it was found to be positive. Finally, we also observe that the OPF portfolio risk can be significantly reduced after adding more foreign assets or increasing the long position on the currency forward market ([Table 2](#)).

To support the robustness of our empirical conclusions, we repeat this comparison under modified assumptions. We remove the outlier observations, defined as the 5% lowest and 5% highest World Market index returns. Then, we re-estimate our two scenarios, with and without the use of currency forwards. We also repeat these steps when performing the analysis after deleting outliers for the USDPLN spot rate. Despite changing the aforementioned characteristics of our optimization procedure, the final outcomes do not change substantially in both cases ([Tables 4](#) and [5](#)).

Table 2. Hedging ratio estimates.

Year	2001	2002	2003	2004	2005	2006	2007
<i>h</i> -ratio	21.14	−6.30	−3.25	−2.52	12.65	0.03	−0.68
Year	2008	2009	2010	2011	2012	2013	Average
<i>h</i> -ratio	2.28	8.23	6.87	4.09	6.30	10.74	4.58

Source: Own analysis.

Table 3. Portfolio standard deviations and *F*-test value for equality of two variances.

Scenario first standard deviation	Scenario second standard deviation	<i>F</i> -test value	<i>p</i> -value
0.1008	0.0810	1.5496	.0034

Source: Own analysis.

Table 4. Hedging ratio estimates for two cases of deleted outliers.

	Year	2001	2002	2003	2004	2005	2006	2007
Deleted WE outliers	<i>h</i> -ratio	23.32	−6.35	−3.23	−2.52	12.60	0.03	0
	Year	2008	2009	2010	2011	2012	2013	Average
	<i>h</i> -ratio	4.56	10.70	6.91	3.93	6.28	10.81	5.16
	Year	2001	2002	2003	2004	2005	2006	2007
Deleted USDPLN spot rate outliers	<i>h</i> -ratio	21.14	−6.29	−12.58	−3.07	12.52	0.02	0
	Year	2008	2009	2010	2011	2012	2013	Average
	<i>h</i> -ratio	−1.60	8.23	6.82	2.07	6.23	10.64	3.39

Source: Own analysis.

Table 5. Portfolio standard deviations and *F*-test value for equality of two variances for two cases of deleted outliers.

Case	Scenario first std. deviation	Scenario second std. deviation	<i>F</i> -test value	<i>p</i> -value
Deleted WE outliers	0.0979	0.0706	1.9246	.0000
Deleted USDPLN spot rate outliers	0.1029	0.0821	1.5728	.0026

Source: Own analysis.

6. Conclusions and policy recommendations

The overall conclusion from our study indicates the drivers of international diversification potential from Polish perspective. As we have shown, within a single asset class, exchange rate volatility has the dominant impact on overall portfolio risk. For this reason, investors from the CEE economies, which continue to have their national currencies and floating exchange rates, can expect significant diversification gains when investing in well-developed markets. This does not mean, however, that the pension funds from those economies that adopted the euro (e.g. the Baltic states) should not internationalize their portfolios. In this latter case, doing so may remain a desirable choice if the local markets are not deep enough and there is a risk that an asset bubble might emerge.

Additionally, our study found the past investment ceiling on international portfolio holdings (5%) to be highly binding in case of Poland, as the estimated optimal hedge ratio was well above unity (4.58). It means that the value of long position in currency forwards should be more than five times greater comparing to the observed value of securities denominated in foreign currency to achieve the minimum variance portfolio. This finding can have a direct practical implication whenever the use of currency derivatives is not forbidden. Otherwise, due to the existing ban on currency hedging in case of Polish funds, this means that more foreign assets should be purchased to fully exploit the diversification potential. However, the observed reality is very far from our simulation's predictions, as the OPF have not even fully utilized the available investment opportunities. According to the Polish Financial Supervision Authority (PFSA) reports (PFSA, 2015), the OPF were investing no more than 1.5% of their assets in foreign securities up to the year 2013, and this value increased to 3.76% in 2014.³ Hence, the aforementioned phenomenon of home bias is also observed in the case of OPF.

This finding is surprising in light of the results of the survey of the OPF managers, conducted by the PFSA in 2010 ('OFE wybierają za granicą', 2010). In an effort to assess the importance of particular motives for low international exposure, the PFSA found the legal prohibition on using FX derivatives and the higher depositary fees for foreign assets to be the two most popular answers. In the context of the results of our simulation, the 'banned currency hedging' explanation seems completely unexpected, but it may indeed indicate the role of some behavioural biases such as mental accounting (Barberis & Huang, 2001; Kahneman & Tversky, 1984). Moreover, we should note that until 2014, the investment benchmark for assessing OPF performance had an internal charter, which was the weighted average of OPF performance. Therefore, among the pension funds, the phenomenon of herding has been observed, as OPF portfolios have become very similar (Kominek, 2012). It is likely that none of the fund managers was willing to risk relative underperformance, which was penalized financially. Hence, the less risky strategy was to mimic the investment behaviour of peers. These two arguments confirm that the reasons for home bias are rather complex, and hence any eventual regulatory shifts must be considered in detail to effectively support greater international exposure.

Notes

1. 'Denominated returns' means that the value is based on index values denominated in a particular currency. Of course, the rate of return and its variance do not have any currency unit; however, this abbreviation seems to be useful.

2. The sample period ends here, as in 02/2014, approximately 51.5% of the OPF portfolio composed of Polish T-bonds was transferred to individual accounts in the first pillar.
3. Again, this jump was merely due to massive reduction of the Polish T-bonds portfolio in 02/2014.

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