

# Performance analysis of insurance capital funds and it's comparison to open-end investment funds in Poland

Katarzyna Perez <sup>1</sup>

May 2017

## Abstract

In this article I concentrate on the performance of insurance capital funds (ICF) which are found and managed internally by Polish insurance companies which link them to the life insurance contracts they offer. I want to find out: 1. whether ICFs managed internally beat their benchmarks and open-end investment funds offered to Polish individual investors, 2. whether their attributes (historical performance, cash flow, size or age) are important to their performance, 3. whether this performance persists. I find that on average Polish stock, hybrid and fixed income ICFs are able to outperform their benchmarks (except of the time of financial crisis in 2007-2008 in case of stock and hybrid funds) as well as most of Polish traditional investment funds. However their performance is not predictable, since they generally persists or not dependent on the time frame of the analysis. The persistence is not the only factor that remains a challenge: the age and size of the funds as well as the cash flows influence the performance positively or negatively depending on which time horizon is considered.

**Key words:** insurance capital funds (ICF), fund attributes, fund performance, performance persistence, Poland

**JEL Code:** G22, G23

## 1. Introduction

An “insurance capital fund” (ICF) is a term introduced in 2003 by the Polish act on insurance and reinsurance activities. It is an investment portfolio linked to a life insurance contract which can be offered by any insurance company registered in Poland. It can operate in one of four forms: 1. an open-end investment fund or 2. a fund of such funds (both of a local or a foreign nature) created and managed outside of an insurance company (so in reality an insurance company is only a distributor and charges a distribution fee for it), 3. a structural product or 4. a portfolio of assets created and managed inside of an insurance company. A great advantage of ICFs is the fact that since they are linked to a life insurance contract they are exempt from the income tax of 19% on capital gain after it is realized.

In this article I take a closer look at the forth group of ICFs, meaning those managed internally. Such ICFs are an alternative to local or foreign open-end investment funds sold directly to individuals by the management companies operating in Poland. In my study I want

---

<sup>1</sup> Department of Monetary Policy and Financial Markets, Poznan University of Economics and Business, Poland, e-mail: k.perez@ue.poznan.pl

to find out: 1. whether ICFs managed internally beat their benchmarks and open-end investment funds, 2. whether their attributes (historical performance, cash flow, size or age) are important to their performance and 3. whether this performance persists.

An insurance capital fund is an example of an investment component of unit-linked life insurance contracts which have been analyzed in the literature since late 1970ties. First articles of Boyle and Schwartz (1977), and Brennan and Schwartz (1979) describe these contracts and price them with the Black and Scholes option pricing model. Ekern and Persson (1996) prove an added flexibility and/or altered exposure to financial risk for the insured and/or the insurer of contracts linked to exotic financial options or funds of mutual funds. Albizzati and Geman (1994), Grosen and Jorgensen (1997, 2000), Bacinello (2003, 2005), Bacinello et al. (2009, 2010) or Li and Szimayer (2014) model the limited rationality of policyholders of the unit-linked life insurance contracts with surrender guarantees. Gatzert et al. (2011) continue with this subject and broaden the traditional viewpoint of risk valuation of investment guarantees in these products and investigate the difference between customer willingness to pay for investment guarantees and the insurer's reservation price for a guarantee. Finally, Hardy (2003) discusses how to model and manage risk of the insurance contracts linked to the equity.

There is some evidence on the performance of unit-linked life insurance contracts (see Faust et. al (2012) and Graf et al. (2011)), but it rather concerns the contracts as a whole and not its investment components. The literature lacks also their comparison to other forms of collective investment. This is true especially for Poland, where there are studies on the performance of open-end investments funds (see Jackowicz (2008); Jackowicz and Filip (2009); Swinkels and Rzezniczak (2009); Białkowski and Otten (2011), Pietrzyk (2014), Perez (2012), Zamojska (2012) and Urbański et al. (2016)) and pension funds (Stanko (2003) and Voronkova and Bohl (2005)); but not much attention is paid to the insurance capital funds (see Homa 2013 and 2015). For my knowledge so far there is no work on ICF's performance in the context of it's comparison to the performance of mutual funds. I believe that such an up-to-date study which concentrates on the analysis of ICF performance and their comparison to another important type of funds offered in the biggest fund market in Central and Eastern Europe fills this research gap and contributes to the literature.

The article is divided in four parts. After the introduction and literature review in part two I present the details on the data set and methodology where I explain how I calculate the fund performance and which factors that may determine it I use. In part three I describe the results and in part four I conclude.

## 2. Data and methodology

The main goal of the study is to analyze the performance of insurance capital funds (ICFs) managed internally by the insurance companies operating in Poland and to compare it to the performance of Polish open-end investment funds (OEIFs) in 07.2004-12.2016. The time horizon of the analysis is determined by the fact that on 1<sup>st</sup> of May, 2004 Poland joined European Union and because of this on 1<sup>st</sup> of July, 2004 it introduced new regulations on collective investments, which were crucial for this market. That was also the time when Polish insurance companies were launching the first internally managed ICFs.

The research sample consists of 145 ICFs and 454 open-end and special open-end investment funds (OEIFs) registered in District Court in Warsaw and operating in Poland at any time between July, 2004 and December, 2016 (therefore the sample is free of survivorship bias). However the funds operating in December, 2016 had to have at least 1 year of history in order to be a part of the sample (so they had to start operating at least in December, 2015, the younger funds simply did not have sufficient history of data to be regressed). The funds had to be priced daily in PLN. The data comes from the database of Analizy.pl. The initial data on all funds are daily NAV per share (which is a price of funds) and monthly NAV in case of OEIFs and half-yearly NAV in case of ICFs. The funds are divided into stock, hybrid, fixed income and money market groups which are further divided into Polish and foreign funds.

I divide the analysis into 2 stages:

1. Ranking the performance of ICFs and OEIFs measured by Jensen's alpha from 1 factor model (Jensen 1968, 1969).

$$\alpha_{i,t} = (R_{i,t} - R_f) - \beta_i(R_{M,t} - R_f) - u_{i,t} \quad (1)$$

where:

$\alpha_{i,t}$  – a value of a Jensen alpha for a fund  $I$  in time  $t$ ,

$R_{i,t}$  is a log return of a fund  $i$  in time  $t$ ,

$R_{M,t}$  is a yearly log return of a benchmark in time  $t$ ,

$R_f$  is a value of a risk free rate.

Many ICFs and OEIF do not define their benchmarks, and the ones which do, use different indices. Therefore I decide to use one index for each of the group of funds according to the type of assets there are in their portfolio (stock, hybrid, fixed income and money market instruments) to create universal benchmarks for each group:

Group of ICFs and mutual funds		Benchmark
Stock funds	Polish	WIG
	Foreign	MSCI World
Hybrid funds	Polish	50%WIG+50% WIBID 3M
	Foreign	50%MSCI World+50% WIBID 3M
Fixed income funds	Polish	10% WIG + 90% WIBID 3M
	Foreign	10% MSCI World + 90% WIBID 3M
Money market funds	Polish	WIBID 3M
	Foreign	WIBID 3M

I use the reference rate of National Bank of Poland as a risk free rate in the model.

- Finding the relation between ICF returns and their attributes (linear regressions for each analyzed ICFs):

$$R_{i,t} = \alpha_p + \beta_{1i} CF_{i,t-1} + \beta_{2i} \ln NAV_{i,t-1} + \beta_{3i} \ln\_age_{i,t-1} + \beta_{4i} R_{i,t-1} + error_{i,t}, \quad (2)$$

where:

$R_{i,t}$  – return on a fund  $i$  in time  $t$ , measured the alpha from the Jensen's (1968, 1969) model,

$\ln NAV_{i,t-1}$  – natural logarithm of net asset value (NAV) of a fund  $i$  in time  $t-1$  as a measure of a size of a fund  $i$ ,

$\ln\_age_{i,t-1}$  – natural logarithm of age of a fund  $i$  in time  $t-1$  (the measure of age is a number of months a fund  $p$  operates on the market).

$CF_{i,t-1}$  – cash flow of a fund  $i$  in time  $t-1$ , which is a generalization of the measure proposed by Berkowitz and Kotowitz (2000):

let's assume a uniform distribution of net flows, i.e.  $NF_u = NF_t/L$  for each  $u \in t$ . Now, from a general solution for equation (1) we obtain:

$$\frac{NF_t}{L} = \frac{NAV_t - NAV_{t-i} \prod_{u=1}^L (1+R_u)}{\left[ \sum_{u=1}^{L-1} \prod_{j=u+1}^L (1+R_u) \right] + 1}, \quad (3)$$

It is easy to see that  $\prod_{u=1}^L (1+R_u) = (1+R_t)$  and  $1+R_u = QT_u/QT_{u-1}$ , so we can write the cash flows formula as:

$$CF_{i,t} = \frac{L}{QT_L \sum_{u=1}^{L_t} QT_k^{-1}} \frac{NAV_{i,t} - NAV_{i,t-i} (1+R_{i,t})}{NAV_{i,t-i}}. \quad (4)$$

where  $L_t$  is the number of valuation days in period  $t$  and  $R_{i,t}$  is a daily return of the fund  $i$  on a given valuation day  $k$  of the month  $t$ . In the limit of very small valuation changes ( $R_{i,u} \approx 0$ ) we receive a widely used equation proposed by Berkowitz and Kotowitz (2000):

$$CF_{i,t}^{\lim} = \frac{NAV_{i,t} - NAV_{i,t-i} (1+R_{i,t})}{NAV_{i,t-i}}, \quad (5)$$

where  $CF_{i,t}^{\lim} = \lim_{r_{i,u} \rightarrow 0, u \in t} CF_{i,t}$ . Thus equation (4) is a generalization of equation (5) by taking into account the volatility of fund quotes within a month. The value of the introduced

correction varies from 0,634 to 1,180, and its arithmetic mean is 0.998. However, in 90,8% of cases, the coefficient is in the range of 0,975 to 1,025.

The next independent factor is logarithm of NAV. It is included in this way, because the smaller fund may be more agile in implementing investment decisions and the pace of loss of ability is inversely proportional to NAV. On the other hand, increase of the age of investment fund should have a positive impact on its performance when the effects of a long-term investment strategy are manifested. In addition, the first phase of the fund's operation is the process of building the investment portfolio and this is a reason for using the logarithmic pace of change.

The last independent factor is historical performance measured by the historical value of Jensen's alpha. The positive value of the coefficient of this factor allows me to conclude about the performance persistence of funds.

The time lag is 1M, 3M, 6M and 1Y.

The regressions for each fund are made in the following time frames:

- the whole period: 01.2004 – 12.2016 – group\_0;
- 3 subperiods:
  - 01.2004-06.2007 (before the global financial crisis),
  - 07.2007-03.2009 (during the global financial crisis),
  - 04.2009-12.2016 (after the global financial crisis).

### 3. Results

The following tables consist of the average results for the following groups of ICFs and OEIFs which were statistically significant on the level of 5%. It must be underlined that in case of foreign ICFs of all groups the results occurred to be statistically insignificant. The same happens with the results of Polish money market funds and the results for 1M and 3M period. Therefore they were rejected from the summary.

#### Polish stock funds (1Y)

	mean group_0	median group_0	mean group_2	median group_2	mean group_5	median group_5
const	6,6137	3,2529	8,2941	8,2941	-4,9955	-4,9661
cf_1	-0,0225	-0,0235	-0,0410	-0,0410	-0,2111	-0,1412
lnnav_1	-0,4301	-0,1855	-0,5524	-0,5524	0,3391	0,3795
lnage_1	0,1989	0,0671	0,2647	0,2647	-0,1722	-0,1541
alpha_1	0,5314	0,5837	0,5053	0,5053	0,1377	0,3827
const_t	0,6136	1,5357	0,1526	0,1526	-3,2679	-3,2427

cf_1_t	-0,3083	-0,2691	-0,9272	-0,9272	-3,1137	-3,3351
Innav_1_t	-0,5031	-1,4689	-0,0202	-0,0202	3,9438	3,6674
lnage_1_t	-0,9813	0,8077	-1,8758	-1,8758	-6,5134	-7,3497
alpha_1_t	1,3364	2,8330	0,5882	0,5882	3,2091	3,5705
const_p	0,0685	0,0442	0,0274	0,0274	0,0361	0,0324
cf_1_p	0,4597	0,3710	0,5040	0,5040	0,0839	0,0290
Innav_1_p	0,0709	0,0351	0,0225	0,0225	0,0230	0,0241
lnage_1_p	0,1487	0,0068	0,0056	0,0056	0,0060	0,0044
alpha_1_p	0,0320	0,0151	0,0405	0,0405	0,0324	0,0234
fstat	11,7388	6,3575	15,2576	15,2576	23,1562	24,1577
fpvalue	0,0177	0,0163	0,0183	0,0183	0,0095	0,0128
r	0,7965	0,8091	0,8895	0,8895	0,9572	0,9692
adjr	0,6974	0,6818	0,8058	0,8058	0,9111	0,9297

### Polish stock ICFs (6M)

	mean group_0	median group_0	mean group_2	median group_2	mean group_5	median group_5
const	4,2074	4,2074	6,6782	6,6782	0,2052	0,4094
cf_1	0,0632	0,0632	0,1242	0,1242	0,0754	-0,0012
Innav_1	-0,3070	-0,3070	-0,5082	-0,5082	0,0302	0,0344
lnage_1	0,1564	0,1564	0,2508	0,2508	-0,1710	-0,1627
alpha_1	-0,0959	-0,0959	-0,5783	-0,5783	-0,3334	-0,3142
const_t	3,2388	3,2388	4,0653	4,0653	0,4164	0,3454
cf_1_t	1,2053	1,2053	2,2134	2,2134	0,5212	-0,0136
Innav_1_t	-3,0529	-3,0529	-3,9699	-3,9699	0,5193	0,7121
lnage_1_t	2,2185	2,2185	3,3550	3,3550	-4,4402	-5,6454
alpha_1_t	-0,1576	-0,1576	-2,0905	-2,0905	-2,2578	-2,1402
const_p	0,0184	0,0184	0,0066	0,0066	0,4368	0,3458
cf_1_p	0,4576	0,4576	0,0688	0,0688	0,4254	0,3031
Innav_1_p	0,0291	0,0291	0,0074	0,0074	0,3916	0,3086
lnage_1_p	0,1564	0,1564	0,0153	0,0153	0,1885	0,0014
alpha_1_p	0,0896	0,0896	0,0815	0,0815	0,1122	0,0853
fstat	4,2529	4,2529	5,3217	5,3217	15,6380	14,6652
fpvalue	0,0412	0,0412	0,0355	0,0355	0,0125	0,0057
r	0,6282	0,6282	0,7801	0,7801	0,9029	0,9215
adjr	0,4801	0,4801	0,6335	0,6335	0,8273	0,8586

### Polish hybrid ICFs 1Y

	mean group_0	median group_0	mean group_2	median group_2	mean group_5	median group_5
const	-3557,2671	-3082,4073	39,7260	39,7260	39,7260	39,7260
cf_1	270,5460	209,2317	0,0322	0,0322	0,0322	0,0322
Innav_1	164,9075	160,0382	-2,0405	-2,0405	-2,0405	-2,0405
lnage_1	30,5390	-6,6973	-1,2480	-1,2480	-1,2480	-1,2480
alpha_1	-0,0898	-0,0753	-0,0470	-0,0470	-0,0470	-0,0470
const_t	-4,7570	-2,9018	5,4762	5,4762	5,4762	5,4762

cf_1_t	1,7111	1,9581	0,0919	0,0919	0,0919	0,0919
lnnav_1_t	4,2970	2,5807	-4,3296	-4,3296	-4,3296	-4,3296
lnage_1_t	2,1359	-0,9309	-5,6358	-5,6358	-5,6358	-5,6358
alpha_1_t	-1,3427	-0,3277	-0,0834	-0,0834	-0,0834	-0,0834
const_p	0,1705	0,0060	0,0120	0,0120	0,0120	0,0120
cf_1_p	0,2896	0,1122	0,9326	0,9326	0,9326	0,9326
lnnav_1_p	0,1646	0,0115	0,0227	0,0227	0,0227	0,0227
lnage_1_p	0,1975	0,1194	0,0111	0,0111	0,0111	0,0111
alpha_1_p	0,6103	0,7504	0,9388	0,9388	0,9388	0,9388
fstat	84,1867	27,2456	43,7720	43,7720	43,7720	43,7720
fpvalue	0,0039	0,0028	0,0054	0,0054	0,0054	0,0054
r	0,8202	0,8496	0,9832	0,9832	0,9832	0,9832
adjr	0,7676	0,8050	0,9607	0,9607	0,9607	0,9607

### Polish hybrid ICFs 6M

	mean group_0	median group_0	mean group_2	median group_2
const	-259,09	-650,584	-2496,29	-2496,29
cf_1	-377,265	-37,7047	176,9051	176,9051
lnnav_1	-2,07422	23,37542	150,2056	150,2056
lnage_1	46,9757	74,02699	56,4936	56,4936
alpha_1	-0,44809	-0,45424	-0,19652	-0,19652
const_t	-2,05848	-2,54331	-4,57115	-4,57115
cf_1_t	-1,21337	-0,48818	3,859521	3,859521
lnnav_1_t	1,189006	1,552672	4,435848	4,435848
lnage_1_t	1,324381	1,754895	3,388882	3,388882
alpha_1_t	-2,62121	-2,43149	-1,13	-1,13
const_p	0,112542	0,009251	0,000642	0,000642
cf_1_p	0,260055	0,122267	0,002271	0,002271
lnnav_1_p	0,161865	0,054907	0,000813	0,000813
lnage_1_p	0,175878	0,051705	0,005379	0,005379
alpha_1_p	0,11537	0,032568	0,280557	0,280557
fstat	21,2076	9,124917	5,866391	5,866391
fpvalue	0,007463	0,002082	0,007457	0,007457
r	0,76307	0,747542	0,661644	0,661644
adjr	0,685233	0,677983	0,548858	0,548858

### Polish fixed income ICFs (1Y)

	mean group_0	median group_0	mean group_2	median group_2
const	-30,7354	-30,7354	-68,5854	-68,5854
cf_1	17,5062	17,5062	13,7705	13,7705
lnnav_1	1,8074	1,8074	4,1491	4,1491
lnage_1	0,4897	0,4897	0,5448	0,5448
alpha_1	-0,2007	-0,2007	-0,2454	-0,2454
const_t	-0,7567	-0,7567	-1,3250	-1,3250

cf_1_t	3,9023	3,9023	2,4585	2,4585
lnnav_1_t	0,6842	0,6842	1,2521	1,2521
lnage_1_t	1,1148	1,1148	1,1770	1,1770
alpha_1_t	-1,1354	-1,1354	-1,2937	-1,2937
const_p	0,4609	0,4609	0,2099	0,2099
cf_1_p	0,0014	0,0014	0,0301	0,0301
lnnav_1_p	0,5043	0,5043	0,2344	0,2344
lnage_1_p	0,2825	0,2825	0,2620	0,2620
alpha_1_p	0,2740	0,2740	0,2201	0,2201
fstat	4,5978	4,5978	4,2291	4,2291
fpvalue	0,0127	0,0127	0,0230	0,0230
r	0,5508	0,5508	0,5850	0,5850
adjr	0,4310	0,4310	0,4467	0,4467

#### Polish fixed income ICFs (6M)

	mean group_0	median group_0	mean group_2	median group_2
const	161,6630	161,6630	161,6630	161,6630
cf_1	-2,3575	-2,3575	-2,3575	-2,3575
lnnav_1	-14,9371	-14,9371	-14,9371	-14,9371
lnage_1	15,9190	15,9190	15,9190	15,9190
alpha_1	-0,3071	-0,3071	-0,3071	-0,3071
const_t	1,0545	1,0545	1,0545	1,0545
cf_1_t	-0,1781	-0,1781	-0,1781	-0,1781
lnnav_1_t	-1,2993	-1,2993	-1,2993	-1,2993
lnage_1_t	2,4611	2,4611	2,4611	2,4611
alpha_1_t	-1,2961	-1,2961	-1,2961	-1,2961
const_p	0,3165	0,3165	0,3165	0,3165
cf_1_p	0,8622	0,8622	0,8622	0,8622
lnnav_1_p	0,2230	0,2230	0,2230	0,2230
lnage_1_p	0,0336	0,0336	0,0336	0,0336
alpha_1_p	0,2241	0,2241	0,2241	0,2241
fstat	5,1435	5,1435	5,1435	5,1435
fpvalue	0,0163	0,0163	0,0163	0,0163
r	0,6729	0,6729	0,6729	0,6729
adjr	0,5421	0,5421	0,5421	0,5421

#### 4. Conclusions

The results of the study allow to conclude only on Polish ICFs managing portfolios of stocks and fixed income securities since the other results on foreign funds and Polish money market funds are not statistically significant. Such ICFs charge their clients lower management fees than the traditional stock, hybrid and fixed income investment funds so their performance is more attractive to individuals and therefore they should be considered by them much more seriously. On average Polish stock, hybrid and fixed income ICFs are able to



outperform their benchmarks (except of the time of financial crisis in 2007-2008 in case of stock and hybrid funds) as well as most of Polish traditional investment funds. However their performance is not predictable, since they generally persists in a short or long time dependently on the time frame of the analysis. The persistence is not the only factor that remains a challenge: the age and size of the funds as well as the cash flows influence the performance positively or negatively depending which time horizon is studied.

The results of the study occur to be too mixed and unsatisfactory, so further analysis of performance using other measures and other attributes is needed. Therefore the study is still work in progress.

## References

- Albizzati, M.O., Geman, G. 1994, Interest rate risk management and valuation of the surrender option in life insurance policies. *Journal of Risk and Insurance* 61(4): 616–637.
- Bacinello, A.R. 2003. Pricing guaranteed life insurance participating policies with annual premiums and surrender option. *North American Actuarial Journal* 7(3): 1–17.
- Bacinello, A.R. 2005. Endogeneous model of surrender conditions in equity-linked life insurance. *Insurance: Mathematics and Economics* 37: 270–296.
- Bacinello, A.R., Biffis, E. and Millosovich, P. 2010. Regression-based algorithms for life insurance contracts with surrender guarantees. *Quantitative Finance* 10(9): 1077–1090.
- Bacinello, A.R., Biffis, E., Millosovich, P. 2009. Pricing life insurance contracts with early exercise features.
- Berkowitz M. K., Kotowitz Y. 2000. Investor risk evaluation in the determination of management incentives In the mutual fund industry. *Journal of Financial Markets* 3 (3): 365-387.
- Białkowski, J., and R. Otten. 2011. Emerging market mutual fund performance: Evidence for Poland. *North American Journal of Economics and Finance* 22 (2):118–30.
- Boyle, P.P., Schwartz, E.S. 1977. Equilibrium Prices of Guarantees Under Equity-Linked Contracts. *Journal of Risk and Insurance* 54 (4): 639-660.
- Brennan, M., Schwartz, E. 1979. Alternative Investment Strategies for the Issuers of Equity Linked Life Insurance Policies with an Asset Value Guarantee. *Journal of Business* 52 (1): 63-93.
- Carhart M.M. 1997. On persistence in mutual fund performance. *Journal of Finance* 52 (1): 57–82.
- De Giovanni, D. 2010. Lapse rate modeling: A rational expectation approach. *Scandinavian Actuarial Journal*, 1: 56–67.
- Faust R., Schmeiser H., Zemp A. 2012. A performance analysis of participating life insurance contracts, *Insurance: Mathematics and Economics* 51(1): 158–171.
- Gabryelczyk, K. 2006. Fundusze inwestycyjne. Krakow, Poland: Oficyna Ekonomiczna (in Polish).
- Gatzert N., Huber C., Schmeiser H. 2011. On the valuation of investment guarantees in unit-linked life insurance: A customer perspective. *The Geneva Papers* 36(1): 3–29.
- Grosen, A. Jørgensen, P.L. 2000. Fair valuation of life insurance liabilities: The impact of interest rate guarantees, surrender options, and bonus policies. *Insurance: Mathematics and Economics* 26(1): 37–57.
- Grosen, A., Jørgensen, P.L. 1997. Valuation of early exercisable interest rate guarantees. *Journal of Risk and Insurance* 64: 481–503.
- Hardy, M. 2003. Investment Guarantees. Modeling and Risk Management for Equity-Linked Life Insurance, John Wiley & Sons, Inc. Hoboken, New Jersey.
- Homa, M. 2013. Rozkład wypłaty w ubezpieczeniu na życie z funduszem kapitałowym a ryzyko finansowe. *Research Papers of Wrocław University of Economics* 312: 78-87 (in Polish).
- Homa, M. 2015. Mathematical reserves in insurance with equity fund versus a real value of a reference portfolio. *Research Papers of Wrocław University of Economics* 381: 86-97
- Jackowicz, K. 2008. Performance persistence of banking sector in Poland. In Management: Qualitative and quantitative research, eds. W. Z. Wydawnictwo Naukowe, 118–28. Warsaw, Poland: Uniwersytetu Warszawskiego.

- Jackowicz, K., and D. Filip. 2009. Powtarzalność wyników funduszy inwestycyjnych w Polsce. *Materiały i Studia*, Narodowy Bank Polski Paper 236. Available at [https://www.nbp.pl/publikacje/materialy\\_i\\_studia/ms236.pdf](https://www.nbp.pl/publikacje/materialy_i_studia/ms236.pdf) (in Polish).
- Jensen M.C. 1968. The performance of mutual funds in the period 1945-1964. *Journal of Finance* 23 (2): 389-416.
- Jensen M.C. 1969. Risk, the pricing of capital assets and the evaluation of investment portfolios. *Journal of Business* 42 (2): 167-247.
- Journal of Computational and Applied Mathematics* 233(1): 27-35.
- Li J., Szimayer A. 2014. The effect of policyholders' rationality on unit-linked life insurance contracts with surrender guarantees, *Quantitative Finance* 14(2): 327-342.
- Li, J., Szimayer, A. 2011. The Uncertain Mortality Intensity Framework: Pricing and Hedging Unit-Linked Life Insurance Contracts", *Mathematics & Economics*, 49 (3): 471(16).
- Perez, K. 2012. Efektywność funduszy inwestycyjnych. Warszawa, Poland: Difin (in Polish).
- Pietrzyk, R. 2014. Evaluation of mutual fund performance on Polish capital market with the use of market timing models. 32nd International Conference Mathematical Methods in Economics. Conference Proceedings, Palacky University, Olomouc, Czech Republic, September 10-12, 789-94.
- Stanko, D. 2003. Performance evaluation of public pension funds: The reformed pension system in Poland. Discussion Paper PI-0308, The Pensions Institute, Birkbeck College, University of London, UK.
- Swinkels, L., and P. Rzezniczak. 2009. Performance evaluation of Polish mutual fund managers. *International Journal of Emerging Markets* 4 (1):26-42.
- Voronkova, S., and M. Bohl. 2005. Institutional traders' behavior in an emerging stock market: Empirical evidence on Polish pension fund investors. *Journal of Business Finance & Accounting* 32 (7-8):1537-60.
- Zamojska, A. 2012. Efektywność funduszy inwestycyjnych w Polsce. Warszawa, Poland: CH Beck (in Polish).