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Krzysztof Jajuga
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Karsten Staehr *Editors*

Contemporary Trends and Challenges in Finance

Proceedings from the 4th Wroclaw International Conference in Finance

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Editors

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Preface

This volume presents papers from the 4th Wrocław International Conference in Finance held at the Wrocław University of Economics on September 26–27, 2018. We have sought to assemble a set of studies addressing a broad spectrum of recent trends and issues in finance, particularly those concerning markets and institutions in Central and Eastern European countries. In the final selection, we accepted 19 of the papers that were presented at the conference. Each of the submissions has been reviewed by at least two anonymous referees, and the authors have subsequently revised their original manuscripts and incorporated the comments and suggestions of the referees. The selection criteria focused on the contribution of the papers to the modern finance literature and the use of advanced analytical techniques.

The chapters are organized along the major fields and themes in finance: banking, commodity market, corporate finance, financial market, and some other areas of finance.

The section on banking contains four papers. The paper by Ewa Dziwok compares the methods of fund transfer pricing reference yield estimation depending on the goodness of fit methodology. Marta Karaś and Witold Szczepaniak provide a comparative analysis of systemic liquidity, systemic fragility, and risk spill-over (contagion) based on empirical data for Poland spanning from the year 2006 to 2016 and propose a method of aggregated measurement of systemic risk, using the concept of Mahalanobis distance. The paper by Małgorzata Olszak, Iwona Kowalska, and Filip Świtała examines the impact of bank capital ratios on cooperative banks' lending by comparing differences in loan growth to differences in capital ratios at sets of banks that are clustered based on capital ratio size. Agnieszka Wójcik-Mazur in her paper identifies the dependencies between bank liquidity risk and selected group of internal determinants including levels of credit risk, capital ratio, and profitability.

The section on commodity market contains two papers. The paper by Marta Chylińska applies a VECM DCC-MGARCH on the daily sampled data for the nickel 3-month and spot contracts traded on the London Metal Exchange in the period January 2010–December 2017 to show that the futures and spot exhibit a common stochastic trend. Bogdan Włodarczyk and Marek Szturo in their paper determine the scale of the impact of the financial factors on commodity markets. On the basis of the conducted research, it was found that the prices of a relatively small number of commodities are exclusively related to the factor related to the stock market.

The section on corporate finance contains four papers. Anna Białek-Jaworska, Dominika Gadowska-dos Santos, and Robert Faff build a framework for the study of the provision of loans by nonfinancial companies outside business groups. This framework aims to show the role of cash holdings in providing loans by nonfinancial companies. The paper by Patrizia Gazzola, Valentina Beretta, and Piero Mella examines the financial effects of the depreciation produced by the expansion effect known as the Lohmann-Ruchti effect. Julia Koralun-Bereźnicka in her paper verifies whether and how the relation between profitability and corporate financing policy depends on the firm size and its industrial classification. There the relationship between return on equity and selected measures of capital structure for Polish private firms in the period 2005–2015 is explored in two cross sections: across size groups of firms and across industrial sections. The paper by Paweł Mielcarz, Oussama Ben Hmiden, and Dmytro Osiichuk examines the impact of corporate investment and financing policies on operating performance under negative demand-driven shocks.

The section on financial market contains five papers. The paper by Agata Gluzicka uses Rao's quadratic entropy portfolios and the most diversified portfolios to the selected stocks from the Warsaw Stock Exchange. Lesław Markowski in his paper proposes the separate treatment of results received in periods of positive and negative market excess return. The obtained results underline the meaning of analysis of realized return toward the factor risk and confirm usefulness of beta coefficient as proper measures of risk. The paper by Joanna Olbryś explores market-wide commonality in liquidity on three emerging Central and Eastern European stock markets: Poland, Hungary, and the Czech Republic. Anna Rutkowska-Ziarko, Lesław Markowski, and Christopher Pyke in their paper examine whether accounting betas and downside accounting betas have an impact on the average rate of return in a capital market. The paper by Artur A. Trzebiński and Ewa Majerowska examines the dependence of investment risk level on selected fundamental features of funds. The analysis was carried out on 136 Polish equity funds, during the years 2014–2017.

Finally, there are four papers covering the other areas of finance. The paper by Joanna Adamska-Mieruszewska, Urszula Mrzygłód, and Marcin Skurczyński examines the drivers of the overfunding success stories for crowdfunding projects based on a unique dataset of 814 overfunded projects. Anna Jędrzychowska and Ilona Kwiecień in their paper try to create a model combining methods of life valuation for the purpose of correctly managing the risk of a child's death in personal finance. The paper by Paweł Prędkiewicz, Agnieszka Bem, Paulina Ucieklak-Jeż, and Rafał Siedlecki analyzes the relationship between health care system financing and health system efficiency. Anna Wojewnik-Filipkowska, Anna Zamojska, and Krzysztof Szczepaniak in their paper analyze the relationship between GDP (gross domestic product) and GERD (gross domestic expenditures on research and development) and between VAI (value-added industry) and GERD.

We wish to thank the authors for making their studies available for our volume. Their scholarly efforts and research inquiries made this volume possible. We are also

indebted to the anonymous referees for providing insightful reviews with many useful comments and suggestions.

In spite of our intention to address a wide range of problems pertaining to financial theory, there are issues that still need to be researched. We hope that the studies included in our volume will encourage further research and analyses in modern finance.

Wroclaw, Poland	Krzysztof Jajuga
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Tallinn, Estonia	Karsten Staehr
December 22, 2018	

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Krzysztof Jajuga is a professor of finance at the Wrocław University of Economics, Poland. He holds master, doctoral, and habilitation degree from the Wrocław University of Economics, Poland, title of professor given by the President of Poland, honorary doctorate from Cracow University of Economics, and honorary professorship from Warsaw University of Technology. He carries out research within financial markets, risk management, household finance, and multivariate statistics.

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Part I
Banking

The Role of a Reference Yield Fitting Technique in the Fund Transfer Pricing Mechanism

Ewa Dziwok

Abstract The funds transfer pricing (FTP) structure has become a base for the process of asset and liability management (ALM) in a modern bank. According to the supervisory documents, FTP is thus a regulatory constraint and an important tool in the ALM process. What is more institutions should have an adequate internal transfer pricing mechanism based on reference rate delivered from the market in a form of the yield curve. The fragility and sensitivity of the reference yield in time could have huge consequences for the liquidity risk management process.

The aim of the article is to compare the methods of estimating the FTP reference yield depending on the goodness of fit methodology (least square methods based on rates and prices will be taken into account). The data taken into account come from Polish money market and cover the period between 2005–2017 and the results obtained let point out the periods when disturbances on the market affected the goodness of model's fit to real data and—in consequence—have an effect on the fund transfer pricing mechanism.

1 Introduction

The funds transfer pricing (FTP) mechanism has become a base for the process of asset and liability management (ALM) in a modern bank. The significance of pricing liquidity risk derives from the Basel Principles for Sound Liquidity Risk Management and Supervision (BSBC 2008). In September 2009, EU introduced the amendments to Annex V of the CRD and the Committee of European Banking Supervisors (CEBS) published Guidelines on Liquidity Cost Benefit Allocation (CEBS 2010). According to these documents, FTP is thus a regulatory constraint and an important tool in the ALM process. What is more, institutions should have an adequate internal transfer pricing mechanism based on reference rate delivered from the market in a form of the

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yield curve. The role of FTP has been widely described lately by Wyle and Tsaig (2011), Elliot and Lindblom (2015) who emphasized its importance in business unit profitability measurement, interest rate risk and funding liquidity risk management.

Yield curve modeling is a process of building a continuous function from the market data, both securities and interest rate derivatives. The construction uses generally two types of models: parametric ones (evaluated by Nelson-Siegel and Svensson) and based on B-splines (cubic splines). Both types give lots of possibilities for further analysis and forecasting.

The aim of the article is to compare the methods of estimation depending on the goodness of fit methodology (least square methods based on rates and prices will be analyzed). The data taken into account come from Polish money market and cover the period between 2005–2017 and the results obtained let point out the periods when disturbances on the market affected the goodness of model's fit to real data and—in consequence—have an effect on the fund transfer pricing mechanism.

2 A Yield Curve Construction

The idea of fund transfer pricing mechanism is based on the reference rate which is often market determined in a form of a fixing (i.e. WIBOR, bonds' fixing). The first step is a construction of a reference curve (or yield curve) through interest rate term structure model. The next step is to take into account the institutions' own spread as well as bid/ask spread, depending on the side of the transaction. While the above elements are done, liquidity cost components are added (Fig. 1).

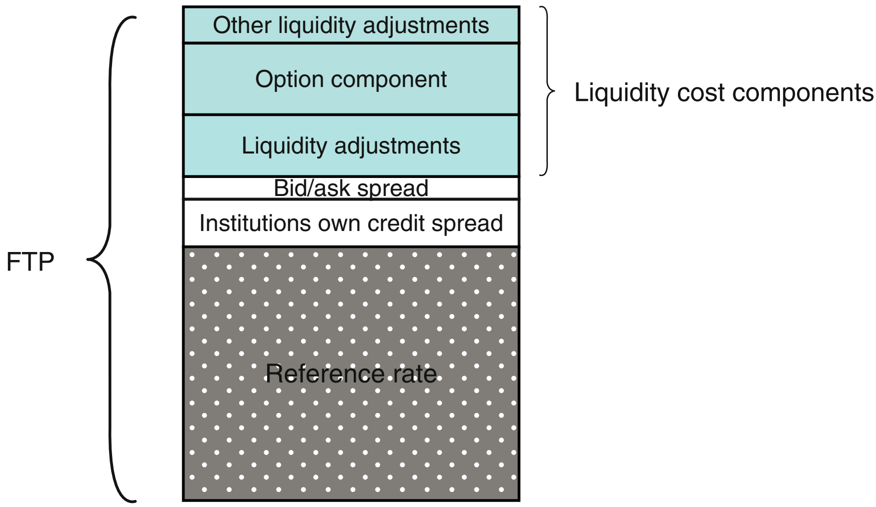

Fig. 1 FTP mechanism—a construction of the yield curve. Source: CEBS, Guidelines on liquidity cost benefit allocation, p. 10

There are plenty of methods, widely described by James and Weber (2000) that let construct the yield curve. To achieve a smoothing yield curve construction, two main groups of models could be taken into account: parametric ones introduced by Nelson and Siegel (1987) and extended by Svensson (1994) as well as cubic splines developed by Fisher et al. (1995) and Waggoner (1997).

An idiosyncrasy of parametric models (which this article focuses on) involves their simplicity and a small number of parameters to be estimated. Additionally the functional form determines three main features (smoothness, flexibility and stability) expected from the correctly estimated curve (Anderson and Sleath 2001).

Following the definition suggested by Nawalkha et al. (2005), the term structure of interest rates gives the relationship between the yield of the investment with the same credit quality but different term to maturity. Classical economic theories described by Fisher (1930), developed by Hicks (1946) and Cox et al. (1981) let define four main shapes of the term structure: positive, negative, flat and humped one that could be constructed under special circumstances.

Generally a term structure is typically built with a set of liquid and common assets; the problem arises in a case of non-liquid market (as in Poland) with a small number of data. One of solutions is to analyze several types of models and then to choose the one, which lets achieve the best approximation.

Definition 1 A zero-coupon bond is an instrument with only two cashflows: first—at the beginning of the investment—called the price; the second one is a cashflow which is paid at maturity.

Suppose the price of the zero-coupon bond is denoted as P, with a cashflow c at maturity τ and yield to maturity $i(\tau)$ understood as a spot rate. If the continuously compound interest is taken into account, the price is the discounted value of a future cashflow c:

$$P(\tau) = c \cdot e^{-i(\tau)\cdot\tau} \tag{1}$$

where: $P(\tau)$—price of the zero-coupon bond with maturity τ
c—cashflow at time τ
$i(\tau)$—spot rate

Following Audley et al. (2002), it is important that under continuous compounding, the spot rate is understood as the continuously compounded instantaneous rate of return. Graphically, the spot rate may be visualized as the yield corresponding to the point at which the spot yield curve intercepts the yield axis.

Definition 2 The function $\delta : \Re_+ \to (0\,;1\,]$ is called the discount function and is expressed as:

$$\delta(\tau) = e^{-i(\tau)\cdot\tau} \tag{2}$$

Lemma: *Every default-free coupon bond can be described as a portfolio of zero-coupon bonds (with the maturities adequate to the payment dates).*

Proof: If P is a coupon bond with a set of future cashflows c_j, observed at time τ_j, $j = 1, 2, \ldots, k$ and let (for simplicity) spot rates $i_j(\tau_j) = i_j$, $j = 1, 2, \ldots, k$, then the price of coupon bond could be expressed as a present value of cashflows:

$$P = c_1 \cdot e^{-i_1\tau_1} + c_2 \cdot e^{-i_2\tau_2} + \ldots + c_k \cdot e^{-i_k\tau_k}$$

According to formula 1, the coupon bond can be described as a linear combination of discount factors δ_j, $j = 1, 2, \ldots, k$:

$$P = c_1 \cdot \delta_1 + c_2 \cdot \delta_2 + \ldots + c_k \cdot \delta_k$$

Definition 3 The instantaneous forward rate $f(\tau) \equiv f_{\tau,\tau+\Delta\tau}$, defined by de La Grandville (2001), is understood as the marginal rate of return implied for infinitesimally short period (length of investment) $\Delta\tau \to 0$.

$$i(\tau) = \frac{1}{\tau} \int_0^\tau f(m)\, dm \tag{3}$$

The existence of inter-relation between discount factor $\delta(\tau)$, spot rate $i(\tau)$ and forward one $f(\tau)$ (in continuous time) could be—after the formulas (1–3) illustrated as below:

$$P(\tau) = \delta(\tau) = e^{-i(\tau)\cdot\tau} = e^{-\int_0^\tau f(m)dm} \tag{4}$$

where: $P(\tau)$—price of a bond
$\delta(\tau)$—discount factor
$i(\tau)$—spot rate
$f(\tau)$—forward rate
τ—term to maturity

The term structure construction begins by gathering the sample of the instrument to be used. In Polish money market, which is analyzed here, there is lack of short term data (apart from money market fixing quotations), that is why all available quotations were taken into account with no quality check.

Suppose that there is a set of k instruments, with market values P_l, $l = 1, 2, \ldots, k$ and cashflows $c_{l,j}$ for bond l at time τ_j, $j = 1, 2, \ldots, k$. Let $C = \{c_{l,j}\}_{l=1,..,k,\, j=1,..,k}$ is a cashflow matrix, generally sparse one with most entries zero and $P = \{P_l\}_{l=1,..,k}$ is the price vector. The knowledge of C and P determines the discount factors:

$$P = C \cdot [\delta(\tau_1)\ \ \delta(\tau_2)\ \ \ldots\ \ \delta(\tau_k)]^T \tag{5}$$

To fit the curve it is necessary to choose an interpolation method, (a form of the theoretical function) which let receive discount factors $\overline{\delta}(\tau)$ for all maturities (between zero and infinity). McCulloch (1971, 1975) used a piecewise polynomial function, but the main problem was the instability of this model and high possibility of unrealistic, negative forward rates (through formula 4).

The utilization of a parametric model (Nelson-Siegel) let calculate forward rates directly (and then via formula 4, receive discount factors). It guarantees different shapes of theoretical term structure.

For the further analysis the Nelson-Siegel model with four parameters $\overline{\delta}(\tau) = \overline{\delta}(\tau \mid \beta_0, \beta_1, \beta_2, v)$ is taken into account:

$$f(\tau) = \beta_0 + \left(\beta_1 + \beta_2 \frac{\tau}{v}\right) \cdot e^{-\frac{\tau}{v}} \tag{6}$$

where: $f(\tau)$—instantaneous forward rate

$[\beta_0, \beta_1, \beta_2, v]$—vector of parameters describing the curve:

β_0—parameter which shows a limit in infinity, $\beta_0 > 0$

β_1—parameter which shows a limit in infinity, $\beta_0 + \beta_1 \geq 0$

β_2—parameter which shows a strength of curvature

υ_1—parameter which shows a place of curvature, $\upsilon_1 > 0$

According to the formula (4) a whole set of discount factors (for all cash-flows) could be calculated from forward rates. Then a vector of theoretical prices $\bar{P} = \left\{\overline{P_l}\right\}_{l=1,..,k}$ can be described as a product of a cash flow matrix C and a vector of discount factors (in a functional form):

$$\bar{P} = C \cdot \left[\overline{\delta}(\tau_1) \quad \overline{\delta}(\tau_2) \quad \ldots \quad \overline{\delta}(\tau_k)\right]^T \tag{7}$$

A set of parameters $[\beta_0, \beta_1, \beta_2, v]$ is estimated by minimizing mean square errors between market prices and theoretical ones (taken from the fitted curve):

$$\frac{\sum_{l=1}^{k} \left(P_l - \overline{P_l}\right)^2}{k} \to \min \tag{8a}$$

and between market and theoretical rates:

$$\frac{\sum_{l=1}^{k} \left(i_l - \overline{i_l}\right)^2}{k} \to \min \tag{8b}$$

where: $P_l - \overline{P_l}$—a price error of l-th asset

$i_l - \overline{i_l}$—a yield error of l-th asset

k—number of bonds

The goodness of fit comparison (for prices and yields respectively) is possible by the calculation of errors through time. A low mean value proves the flexibility of the model and shows its ability to fit the data quite accurately.

3 Data and Results

For the forthcoming research Polish money market rates were taken into account. They are represented by WIBOR (Warsaw InterBank Offer Rate)—a panel of interbank lending rates calculated and published each day around 11.00 a.m. of Warsaw time by ACI Poland (till 30.06.2017) and since then by GPW Benchmark S. A.. Contrary to the LIBOR, the WIBOR rate is an average of quotations provided by chosen banks which received a status of so called Primary Dealers. The maturities of WIBOR rates have been changed last years and nowadays they range from overnight to one year. As a representative of the interbank market, the WIBOR rates reflect default risk affected by a quoting bank's condition (an interbank loan is unsecured) and liquidity of the market. Because the shortest, overnight rate illustrates the demand for liquidity and strongly depends on the obligatory reserve maintenance period, its volatility is very high. For the purposes of following research daily rates from T/N to 1 year were taken (eight in total: T/N, 1-week, 2-weeks, 1-month, 3-, 6-, 9-months, 1 year) from the beginning of 2005 to the end of 2017.

Recall that the vector of theoretical prices $\bar{P}$ could be expressed as a product of a cash flow matrix and a vector of discount factors (formula 7), the process of fitting the term structure starts from the construction of a cash flow matrix. For the money market it forms the square diagonal one (with eight columns and rows in this analysis) because each of these instruments has only one cash flow—the principal to be repaid at maturity.

Considering two different ways of MSE error calculation (8a, 8b) and following Nelson-Siegel parametric model two sets of instantaneous rates can be found. To achieve these results, two macros were written in VBA code that helped to receive theoretical prices for each of analyzed days. As a result, two vectors of MSE were calculated.

The plots of errors for chosen methods let analyze the sensitivity of the model to disturbances in the market (Figs. 2 and 3).

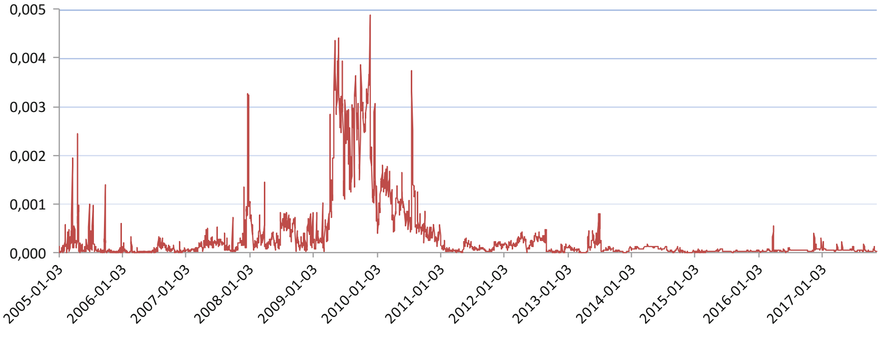

Fig. 2 MSE errors between market and theoretical rates. Source: Own calculations

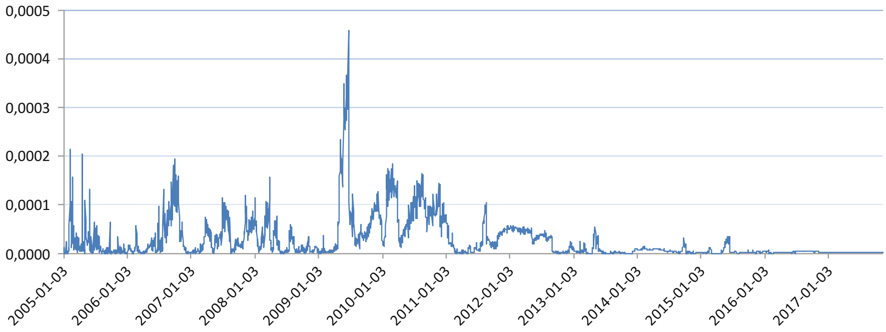

Fig. 3 MSE errors between market and theoretical prices. Source: Own calculations

From the beginning of financial crisis the volatility of assets' rates had become very high which caused problems with the data fitting. The highest value of errors was observed during financial crises and accelerated in 2009–2010 period.

An important conclusion following from the analysis above is the fact that the Nelson-Siegel model can be used to determine the FTP reference curve. The selection problem presented here (how to find the best method of the reference yield construction by adopting a comparison of errors) shows that the best results were achieved by an implementation of the MSE price methodology (through a minimizing of the sum of squared errors of market and theoretical prices). Concerning the fact that differences between both results are not huge, the use of the MSE yield methodology is also acceptable as an additional, supportive method.

4 Summary

The aim of the article was to compare two methods used for FTP reference yield estimation. The comparison concerned the goodness of fit methodology (least square methods based on rates and prices will be taken into account). The research carried out indicates that the better results were achieved by an implementation of the MSE price methodology.

In order for the FTP mechanism to be effective, it must demonstrate neutrality to changes in market rates. In addition, the FTP system must take into account time lag, because the designated curve serves as a reference yield for earlier price decisions. This is why the fragility and sensitivity of the reference yield in time could have a huge consequences for liquidity risk management process.

Two different fitting techniques were applied here (based on price errors and rate errors minimizing procedure) to compare the quality of parametric model and its effectiveness in FTP mechanism. According to the analysis the most flexible and accurate fitting method (represented through a low value for the error) is a procedure which utilizes the parametric Nelson-Siegel model with MSE based on prices.

Additionally, this model is much more resistant to market disturbances especially in the beginning of 2008. It contrasts with the high level of errors during 2009–2010 period when interest rates were unusually volatile.

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Towards a Generalized Measure of Systemic Risk: Systemic Turbulence Measure

Marta Karaś and Witold Szczepaniak

Abstract Systemic risk, a concept closely related to financial system stability, has three major areas of concern: systemic liquidity, systemic fragility and risk spill-over (contagion). In the recent years there were many measures of systemic risk proposed in the literature, however, as can be shown after literature investigation and proven from their theoretical properties, none of these measures truly reflects all three mentioned characteristics of systemic risk. The paper provides a comparative analysis of these characteristics based on empirical data for Poland spanning from the year 2006 to 2016, encompassing the global financial crisis and the European sovereign debt crisis, and proposes a method of combining them into one aggregated measurement, using the concept of Mahalanobis distance, following the concept of financial turbulence measure proposed by Kritzman and Li (Financ Anal J 66:30–41, 2010). The aggregation procedure leads to postulation of a new systemic risk measurement method, called by the authors Systemic Turbulence Measure (STM).

1 Introduction

A search for a "good" systemic risk measure has been the topic of multiple papers over the last decade. Works by Bisias et al. (2012), Hattori et al. (2014), or Benoit et al. (2015) provide the overview of an extensive number of studies aiming at proposing such a measure. Despite a heated dispute, no single golden standard has been so far developed. There are several reasons why this search is so important.

The aim of the paper is to present a proposal of a generalized systemic risk measure which is obtained by aggregating the results of three systemic risk measures whose results are based on three different areas of systemic risk accumulation: systemic liquidity mismatches, fragility of financial institutions and the risk spill-over effect.

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2 Definitions of the Financial System and Systemic Risk

Hattori et al. (2014) point it out that despite the research focused on systemic risk in the last decade, the existing literature does not define the term unequivocally. Hansen (2013) provides an extensive discussion of the types of financial and economic phenomena identified in the literature as systemic risk, relevant for the empirical research presented in this paper. He points to three possible notions of systemic risk: a run which is triggered by liquidity concerns; vulnerability of the financial network where internal shocks spill-over; the insolvency of a major player or market in the financial system. Similarly, a wider literature analysis allows to identify three main areas for systemic risk triggers materialization:

- financial systems liquidity, including, *inter alia*, theoretical works of Brunnermeier and Sannikov (2014), Cespa and Foucault (2014), as well as risk measure proposals of Jobst (2014), Greenwood et al. (2015), Dziwok (2017) or Duarte and Eisenbach (2018);
- fragility of financial institutions, counting theoretical elaborations by Acharya and Yorulmazer (2008), Freixas and Rochet (2013), Adrian and Shin (2014), Martin et al. (2014), Boissay et al. (2016); the empirical studies of e.g. Acharya and Merrouche (2013), Gabrieli and Georg (2014) or Benoit et al. (2016); as well as the fragility-based systemic risk measures proposed, *inter alia*, by Nelson and Perli (2007), Jakubik and Slačík (2013) and Blei and Ergashev (2014);
- risk spill-over, theoretically described in the works of e.g. Koeppl et al. (2012), Acemoglu et al. (2015), Biais et al. (2016) and empirically observed in the works of Iyer and Peydro (2011), Iyer and Puri (2012), Markose et al. (2012) and others; while the measures of systemic risk focused on contagion include, *inter alia*, the proposals of De Nicolo and Lucchetta (2011), Hollo et al. (2012) or Diebold and Yilmaz (2014).

Financial system may be easily defined as a system of interconnected financial institutions, markets and their infrastructure (Matysek-Jędrych 2007, p. 42). In such a system, transmission of the systemic risk triggers happens via Systemically Important Financial Institutions (SIFIs), which are the “institutions whose distress or disorderly failure, because of their size, complexity and systemic interconnectedness, would cause significant disruption to the wider financial system and economic activity” (FSB 2011, p. 1). The presented definitions allow us to model the financial systems as a collective of locally systemically important financial institutions, while modelling systemic risk as the reaction of these collectives to low probability events (i.e. systemic triggers).

3 Selected Partial Risk Measures and the Estimation Methods

Empirical study utilises three risk measures. Two of them are quantile-based risk measures well-established in the literature, one derived from the Value at Risk concept and one from the concept of Expected Shortfall. Based on our previously carried studies (see: Karaś and Szczepaniak 2017; Jajuga et al. 2017), the models selected for the empirical analysis include: Conditional VaR (CoVaR) (Adrian and Brunnermeier 2016; as modified by Karaś and Szczepaniak 2017) and SRISK (Brownlees and Engle 2017). The third measure utilised in this paper, Systemic Liquidity Measure (SLM), was proposed first by Dziwok (2017) uses daily WIBOR data and applying, *inter alia*, the Nelson-Siegel model.

The selection of these measures is purposeful. On the one hand, these measures have an advantage of having been successfully used to measure systemic risk around the time of the global financial crisis both for advanced economies, such as e.g. US or the EU and for Poland (see the afore mentioned empirical studies). Moreover, as extensively explained and confirmed empirically by Karaś (2019), the three measures are complementary in systemic risk measurement.

There also exists literature evidence confirming that the measures are worth of combining. Adrian and Brunnermeier (2016) call CoVaR a measure which is complementary to the high-frequency marginal expected shortfall (MES) based measures, such as SRISK. This is because the measures based on MES answer the question which institutions are most fragile, while CoVaR informs about which institution contributes to systemic risk most. Also, Benoit et al. (2013, p. 17) report the lowest concordance between SRISK and Delta CoVaR for all the measures analysed by them (only 9.9%; with similarities between the other measures of about 50%). Similarly, Kuziak and Piontek (2018) study the properties of CoVaR and confirm that for Poland, Delta CoVaR is not driven by the lack of financial soundness at financial institutions (Kuziak and Piontek 2018, p. 155), confirming the characteristics of the CoVaR measure as a risk spill-over measure and not a measure based on fragility as such.

The third used model, SLM, is neither formally or empirically similar to the two aforementioned methods. It uses different financial system segment (the interbank market) than the other two measures (the banking sector and the stock market). The advantages of this method over other liquidity-focused more traditional approaches consist in the abovementioned focus on the interbank market and the immediate data availability.

From the substantial point of view, the measures selected for the study are expected to produce varying results, as due to their structural properties they measure slightly different aspects of systemic risk. For instance, CoVaR is focused on the risk spill-over—measuring risk conditionally on its co-occurrence in multiple financial institutions, while SRISK is a fragility-type of measure, depending heavily on the financial institutions' leverage. The SLM measure completes the results, allowing to include in the modelling procedure the information form the interbank market.

3.1 Systemic Liquidity Measure: SLM

Systemic Liquidity Measure (SLM) uses the model proposed by Nelson and Siegel (1987), which expresses the instantaneous forward rate $f(s)$, for $s \in [0; t]$ as a function of four parameters:

$$f(s) = \beta_0 + \beta_1 \cdot e^{-\frac{s}{v}} + \beta_2 \cdot \frac{s}{v} \cdot e^{-\frac{s}{v}}$$

In the model, β_0 relates to the longest maturity forward rate, the sum of the parameters $\beta_0 + \beta_1$ relates to the instantaneous spot rate, β_2 determines the shape of the slope of the curve and v determines its peak. Then, it is possible to express the theoretical prices and the vector of the discount factors for maturity t_j as:

$$\overline{\delta}(t_j) = exp\left[-\left(\beta_0 + (\beta_1 + \beta_2) \cdot \frac{1 - e^{-\frac{t_j}{v}}}{\frac{t_j}{v}} - \beta_2 \cdot e^{-\frac{t_j}{v}}\right) \cdot t_j\right]$$

Finding the values of the parameters which would allow to best fit the theoretical curve to real market data has no single analytical solution. The function to minimise the distance between the estimated curve and the real data is selected following the proposal of Dziwok (2012, 2017)—the nonlinear method of mean-root-square error is used:

$$\Psi(P) = \sum_{i=1}^{N} \left(P_i - \overline{P_i}\right)^2 \rightarrow min$$

where P_i is the theoretical price and $\overline{P_i}$ is the market price for the bond i where $i = 1,2, \ldots, N$. In effect of the minimization procedure a set of model residuals are detected, which then are plotted into a time series to obtain the SLM measurement results.

3.2 Fragility Measure: SRISK

The SRISK measure is based on the concept of the Expected Shortfall (ES):

$$ES_{St}(u) = E_{t-1}(R_{St}|R_{St} < u) = \sum\nolimits_{i=1}^{N} w_{it}E_{t-1}(R_{it}|R_{St} < u),$$

where R_{St} is the rate of return of the system, and R_{it} is the rate of return of the institution i for $i = 1,2, \ldots, N$.

Marginal Expected Shortfall (MES) which indicates the system's extreme contribution to systemic risk, i.e. whether the expected shortfall of the system changes if the entity's share in it changes in the extreme, is given as the partial derivative of ES:

$$MES_{it}(u) = \frac{\partial ES_{St}(u)}{\partial w_{it}} = E_{t-1}(R_{it}|R_{St} < u),$$

Of we assume a decline in equity conditional on the equity of the system falling below the assumed marginal threshold within the next 6 months, then we define the Long Run Expected Shortfall (LRMESS):

$$LRMES_{i,t}(C) = 1 + exp(\gamma \cdot MES_{i,t}(C)).$$

The SRISK measure determines the expected shortage of equity (increased quasi-leverage—$[D_{it}; W_{it}]$) in the event of a systemic crisis and is based on the long-term marginal shortfall expected, calculated using the aforementioned Long Run Marginal Expected Shortfall (LRMES). SRISK is thus defined as:

$$SRISK_{it} = max[0; k(D_{it} + (1 - LRMES_{it})W_{it}) - (1 - LRMES_{it})W_{it}].$$

System-level SRISK is obtained by the aggregation of individual institutions" SRISKS.

3.3 Risk Spill over Measure: Delta CoVaR

The third measure used in the study is based on CoVaR, i.e. the Conditional Value at Risk of the system, provided that there is a threat to the financial condition in the analysed institution. This measure is defined by the equation:

$$P\big(R_{St} \le CoVaR_{it|}|C(R_{it})\big) = \alpha.$$

In the study, the measure derived from CoVaR, i.e. Delta CoVaR is used. It is the difference between the system's Value at Risk if the given financial institution is financially at risk and the system's value at risk if the financial position of the given entity is normal (median). This is illustrated by the following formula:

$$\Delta CoVaR_{it}^{q} = (CoVaR_{it}^{q}|R_{it} = VaR_{it}^{q}) - \big(CoVaR_{it}^{q}|R_{it} = VaR_{it}^{0.5}\big).$$

We obtain the system-wide Delta CoVaR by aggregating the individual Delta CoVaRs of all analysed financial institutions.

3.4 Estimation

To estimate the quantile-based systemic risk measures, a two-dimensional process for the rates of return of the system *s* and institution *i* is adopted:

$$r_t = \sqrt{H_t}\upsilon_t,$$

where R_t is a vector (R_{st}, R_{it}) and H_t is a conditional variance-covariance matrix of the form:

$$H_t = \begin{pmatrix} \sigma_{st}^2 & \sigma_{it}\sigma_{st}\rho_{it} \\ \sigma_{it}\sigma_{st}\rho_{it} & \sigma_{it}^2 \end{pmatrix},$$

with a conditional standard deviation of the rate of return of the system σ_{st} and institution σ_{it}, and conditional correlation ρ_{it}. υ_t is a vector (ε_{it}, ε_{st}) of independent equally distributed random variables, such that $E(\upsilon_t) = 0$ and $E(\upsilon_t \upsilon_t') = I_2$ is a 2 by 2 units matrix (cf. Benoit et al. 2013). Conditional volatility of the rates of return of the system σ_{st} *and* institution σ_{it} *was* estimated on the basis of the GJR-GARCH model, while the conditional correlation of the institution and the system ρ_{it} was based on the GJR-GARCH DCC model, whereas the individual conditional expected value for each institution is determined on the basis of the estimator:

$$VaR_{it}^q = \sigma_{it} F_i^{-1}(q)$$

For the institution's contribution to the conditional VaR of the system, is estimated as:

$$\Delta CoVaR_{it}^q = \hat{\gamma}\left(VaR_{it}^q - VaR_{it}^{0.5}\right),$$

where: $\hat{\gamma} = \frac{\hat{\rho}_{i,t}\hat{\sigma}_{s,t}}{\hat{\sigma}_{i,t}}$. The marginal expected shortfall is estimated as:

$$MES_{i,t}\left(VaR_{s,t}^q\right) = \hat{\sigma}_{i,t}\hat{\rho}_{i,t}\hat{E}_{t-1}(\varepsilon_{s,t}|\varepsilon_{s,t} < \kappa) + \hat{\sigma}_{i,t}\sqrt{1 - \hat{\rho}_{i,t}^2}\hat{E}_{t-1}(\varepsilon_{i,t}|\varepsilon_{s,t} < \kappa),$$

where:

$$\hat{E}_{t-1}(\varepsilon_{s,t}|\varepsilon_{s,t} < \kappa) = \frac{\sum_{t=1}^{T} K\left(\frac{\kappa - \varepsilon_{s,t}}{h}\right)\varepsilon_{s,t}}{\sum_{t=1}^{T} K\left(\frac{\kappa - \varepsilon_{s,t}}{h}\right)}$$

and

$$\hat{E}_{t-1}(\varepsilon_{i,t}|\varepsilon_{s,t} < \kappa) = \frac{\sum_{t=1}^{T} K\left(\frac{\kappa - \varepsilon_{s,t}}{h}\right)\varepsilon_{i,t}}{\sum_{t=1}^{T} K\left(\frac{\kappa - \varepsilon_{s,t}}{h}\right)},$$

Table 1 Local SIFIs for the analysed region

Measure	Data and institutions included in the study
SLM	Warsaw Interbank Offered Rate (ON, TN, SW, 2 W, 1 M, 3 M, 6 M, 9 M, 1Y)
SRISK	PKO Bank Polski S.A., Bank Pekao S.A., Bank Zachodni WBK S.A, mBank S.A., ING Bank Śląski S.A., Bank Handlowy w Warszawie S.A., Bank Millennium S.A., Bank BPH S.A., Getin Holding S.A., GTC S.A.
Delta CoVaR	PKO Bank Polski S.A., Bank Pekao S.A., Bank Zachodni WBK S.A, mBank S.A., ING Bank Śląski S.A., Bank Handlowy w Warszawie S.A., Bank Millennium S.A., Bank BPH S.A., Getin Holding S.A., PZU S.A.

Note: Selection of local SIFIs based on KNF (2016), corrected for data availability

for $\kappa = \frac{VaR^q_{s,t}}{\sigma_{s,t}}$, $K(x) = \int_{-\infty}^{\frac{x}{h}} k(u)du$ for the normal distribution density function $k(u)$ and $h = T^{\frac{-1}{5}}$. In turn, the LRMESS is determined on the basis of the following estimator, as proposed by Brownlees and Engle (2017):

$$LRMES_{i,t}(C) \simeq 1 + exp(18 \cdot MES_{i,t}(C)).$$

The choice of institutions for the empirical study follows the suggestions of the regulators who identify "other systemically important institutions" for the analysed region. The set of such biggest and/or most globally interconnected SIFIs, i.e. the banks included in the study, is presented in Table 1, where also the data used in the SLM model calculations is discussed.

4 Towards Generalized Systemic Risk Measurement: The Aggregation Method, Results and Discussion

If we consider systemic risk as the total risk of the three characteristics analysed in this work, i.e. systemic liquidity, fragility and risk spill-over, then we may interpret systemic risk as the total risk under the highest peak. With such an approach, one can use the concept based on the distance measure. Among the distance-type of measures, Mahalanobis transformation is the only one that allows for normalization of all the variables simultaneously (Jajuga and Walesiak 2000, p. 110), using also the covariance matrix of the variables, i.e. retaining the sensitivity of the aggregation to the changes in risk characteristics synchronicity. Also, the challenge of the different original scales of measurement of the characteristics is overcome by this approach.

4.1 Systemic Turbulence Measure

For aggregation, we use the proposal of Kritzman and Li (2010) to use the Mahalanobis-distance-based turbulence index defined as:

$$MD_t = \sqrt{(\boldsymbol{y}_t - \boldsymbol{\mu})\boldsymbol{C}^{-1}(\boldsymbol{y}_t - \boldsymbol{\mu})'},$$

where
$\boldsymbol{y}_t$—the vector of asset returns for the period t,
$\boldsymbol{\mu}$—sample average vector of historical returns,
$\boldsymbol{C}$—sample covariance matrix of historical returns.

Once an aggregated time series corresponding to the individual peaks of the three risk characteristics and their covariance is obtained, we employ the 25% boundary, following Kritzman and Li who use such threshold to separate "turbulent" from "quiet" observations (2010, p. 32).

4.2 *Empirical Results*

The aim of the following section is to present the proposal of Systemic Turbulence Measure (STM). We propose to combine the information produced by three selected measures into a single time series, as each of the three measures capture different systemic risk characteristics. Before the aggregation procedure, a comparative analysis of the obtained time series is due (see Fig. 1).

All the time series have a mean-reverting property in the long run, which confirms that there exists a certain kind of a balanced state (the "calm" state) typical of the analysed financial system, while in reaction to various kinds of turbulence, they start peaking. Other than this, the time series have a number of individual traits. For

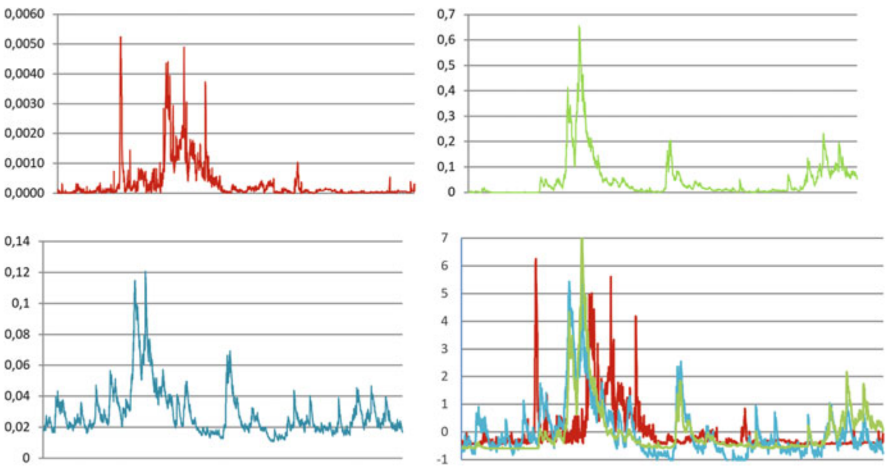

Fig. 1 Comparative view on the three systemic risk characteristics. Note: Upper left panel—Systemic Liquidity Measure; upper-right panel—SRISK; lower left panel—Delta CoVaR; lower right panel—comparative view on the three risk characteristics

Table 2 Descriptive statistics regarding the systemic risk characteristics' time series

Risk characteristic	Mean	Standard dev.	Kurtosis	Skewness
Liquidity	0.000354	0.000809	15.8319	3.632549
Fragility	0.029058	0.084278	13.7175	3.320987
Spill-over	0.049081	0.015787	6.8649	2.312402

instance, each measure peaks at different moments in time, which is consistent with the expectations—the three measures are sensitive to three different characteristics of systemic risk. These observations are confirmed by statistical properties of the analysed time series (see Table 2).

Plotted time series have a sequence of reaction. In the calm times (before the aggravation of the crisis periods), the liquidity characteristic proceeds the fragility characteristic, while both are followed by the spill-over factor. On the other hand, once the financial crisis is in its full (2009–2010), the liquidity characteristic is behind the risk spill-over characteristic, suggesting that each significant turbulence is followed by further worsening of liquidity. This points to a vicious circle that was proven in the literature to exist for the global financial crisis.

Simultaneously, there are periods when all measures show high level of turbulence and these periods correspond to the increased global systemic risk. This provides an argument for introducing aggregation to analyse these risk characteristics jointly: systemic risk may be apparent in each of the analysed categories, but if there is turbulence in two or three of them at the same time, then we observe the realization of systemic risk, or even a financial crisis. From this follows that "the aggregation method should include the information about the co-existence of risk in the three areas and distinguish between the times when only one risk characteristic is increased versus the times when two or three characteristics are increased" (Karaś 2019, p. 257).

The time series obtained show that there was little reaction in the liquidity area to the European sovereign debt crisis in the Polish interbank market. As this crisis was not directly linked to Poland, this is expected. At the same time, both the fragility and the risk spill-over characteristics are increased in this period pointing to materialization of reputational and behavioural aspects of risk, as well as to the somewhat limited exposure of the Polish financial system to sovereign debt instruments which were at risk at that time.

Between the year 2015 and the end of the year 2016 the fragility characteristic again increases together with the spill-over characteristic. It seems that both measures react to the worsening condition of the biggest Polish bank—PKO BP. Reputational consequences affect the prices of stocks of other (unrelated) Polish banks, while the interbank market remains calm, suggesting that these problems do not affect systemic liquidity. We capture the reputational spill-over and related increase in systemic risk. Moreover, as the risk spill-over characteristic precedes the fragility increase, the results suggest that the here the observed system-level fragility is less of a fundamental and more of an irrational nature. All of these observations are well reflected in the aggregate Systemic Turbulence Measure presented by Fig. 2.

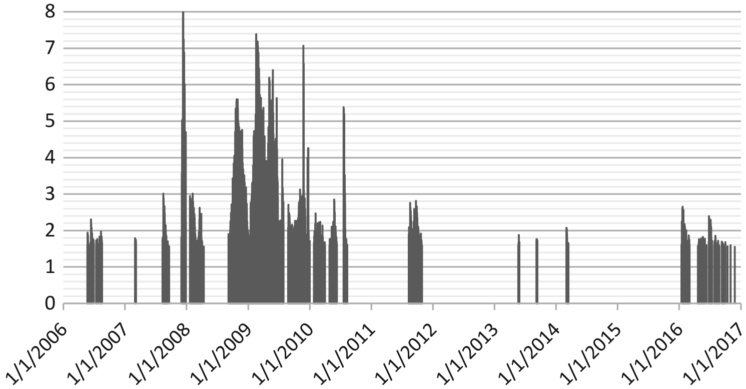

Fig. 2 Systemic Turbulence Measure for Poland for years 2006–2016

It illustrates the joint information from the three analysed systemic risk characteristics. Several peaks are recorded and each of them corresponds to an event that is important for financial stability of the Polish financial system. At the same time, the periods where one risk characteristic is higher are the periods of lower risk than the ones where all three characteristics are increased.[1]

Among the most crucial features of the aggregation method proposed in this paper are the following ones. Above all, aggregation is scale indifferent, meaning that it allows to combine time series of different scales, as long as they share the frequency. Additionally, the applied transformation accounts for the covariance between the three aggregated time series, retaining the information about their co-occurrence. Next advantage of this approach is using the levels of the risk characteristics directly, which means that the measurement (unlike many other proposals from the literature) is theoretically robust to the changes in the properties of the crisis as such. Since it does not draw directly from any observed secondary characteristics of the three obtained time series (like for instance volatility), if such properties were to change (in the next potential crisis to come), the measure is expected to still work relatively well, despite this.

On the other hand, this method does not allow us to interpret the size of risk in any particular scale. This means that although relative size of changes in each risk characteristic is retained, any possible scale of the size of risk is lost. Thus, we can interpret how risk changes over time, but we do not know how high it could possibly go before the system collapses. For Poland, we can only say that the total level of Systemic Turbulence Measure is expected to go higher than it historically has, before we might witness an actual financial system crisis. But how high this would have to be—that is impossible to diagnose based on the currently available data.

[1] For further elaboration on the empirical results please see Karaś and Szczepaniak (2018) or Karaś (2019).

Also, the method uses an arbitrarily set border-line threshold of 75%. The threshold could be calibrated more precisely, but only based on historical information and for the countries where systemic breakdown was actually observed. Given the relatively stable history of the Polish financial system, currently there is no possibility to calibrate such a threshold for Poland.

5 Conclusion

The paper presented a possible method of aggregation for a set of differently focused systemic risk measures, creating the Systemic Turbulence Measure (STM) The method has a set of advantageous characteristics, but also has some limitations. The most important conclusion of the paper is that the aggregation is possible and should be attempted, as none of the currently existing systemic risk measures captures all the facets of systemic risk and an aggregating approach may provide information richer than each of the mentioned measures used separately. This conclusion calls for further elaborative and comparative empirical research with the use of the individual measures versus the aggregate, for a larger set of countries, especially the emerging European countries, for which the results are most scarce in the existing literature.

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Determinants of Loans Growth in Cooperative Banks in Poland: Does Capital Ratio Matter?

Małgorzata Olszak, Iwona Kowalska, and Filip Świtała

Abstract This paper examines the impact of bank capital ratios on cooperative banks' lending by comparing differences in loan growth to differences in capital ratios at sets of banks that are clustered based on capital ratio size. Applying fixed-effects estimator to sample of cooperative banks operating in Poland and using a unique quarterly dataset covering the period of 1999:4–2012:4 we find that loans growth is particularly capital constrained in poorly-capitalized banks, but only in non-recessionary. Lending of poorly capitalized banks is strongly affected by interest rate margin. Interest rate margin is also important in determining loans growth of medium and large cooperative banks. Generally, our results give support for the view that small banks, such as cooperative banks are not capital constrained in recessionary periods, thus their customers do not suffer from capital crunch in unfavourable macroeconomic conditions. However, their lending activity is procyclical, because increases in unemployment rate result in decreases in loans growth of cooperative banks in Poland.

1 Introduction

Many empirical studies have examined the determinants of bank lending and the role of capital ratio on bank lending (see e.g. Hancock and Wilcox 1994; Peek and Rosengren 1995; Beatty and Liao 2011; Carlson et al. 2013; Gambacorta and Marqués-Ibáñez 2011; Kim and Sohn 2017). Most of these studies focus on commercial banks, mainly operating in the United States. These studies find mostly

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positive effect of capital ratio on lending. In this paper we ask whether capital ratio is significant determinant of lending in cooperative banks operating in Poland.

Consistent with capital crunch theory (see Van den Heuvel 2009, 2011) we expect to find that lending depends on the level of capital ratio. However, we are not sure how cooperative bank lending reacts to capital shortages in recessions. We thus investigate whether both poorly-capitalized and well-capitalized banks are capital constrained in recessionary periods?

The rest of the paper is organized as follows. Section 2 provides the regulatory background of our study and develops our hypotheses. We describe our sample and research methodology in Sect. 3. We discuss results and robustness checks in Sect. 4. The last section includes main conlusions.

2 Literature Review and Hypotheses Development

As part of individual banking systems, there are different types of institutions, adopting various organizational forms, business models or ownership structures. In Europe, in many banking sectors there exists cooperative banking, which, despite its sometimes small size, can play an important role in the financial system. We have to bear in mind that cooperative banks are credit institutions, whose members are simultaneously their customers. The rationale behind existence of such institutions should be care of local development and granting credit for small borrowers and depositors (Karafolas 2005).

The main clients of cooperative banks are individual persons as well as small and medium enterprises, and the business model of these banks is approaching the universal bank model. Despite this, cooperative banks still retain a certain specific features that distinguish them from commercial banks. Co-operative banks play an important role in financing local communities. Regardless of the countries in which they operate, cooperative banks should have mechanisms of mutual support so that local communities are supported even in the event of temporary difficulties (Spulbar et al. 2015).

Previous research on the effect of capital ratio on bank lending suggests diversity of this effect which can be attributed to bank size, capital ratio level and the business cycle or crisis events (Berrospide and Edge 2010; Mora and Logan 2012; Beatty and Liao 2011; Gambacorta and Marqués-Ibáñez 2011; Carlson et al. 2013; Kim and Sohn 2017). However, general conclusion of this research is that in commercial banks the effect of capital ratios on lending is positive. Due to the fact that cooperative banks also have to conform to the same capital adequacy rules as commercial banks, we expect that in our sample the a*ssociation between bank lending and regulatory capital ratio is positive.*

Van den Heuvel (2009) shows that capital constrained banks tend to reduce their lending. Previous empirical research also shows that poorly capitalized commercial banks' lending tends to be definitely more sensitive to capital ratio (Carlson et al. 2013) than lending of well-capitalized banks, we therefore expect that *the relative impact of capital ratio on lending in cooperative banks is stronger in poorly-capitalized banks than in well-capitalized banks.*

3 Methodology and Data Applied in the Study

The baseline model reads as, and will be run in subsamples of banks:

$$\begin{aligned}\Delta \mathrm{Loan}_{i,t} = {} & \alpha_o + \alpha_1 \cdot \Delta \mathrm{Loan}_{i,t-1} + \alpha_2 \cdot \mathrm{CAR}_{i,t-2} + \alpha_3 \cdot \mathrm{NIM}_{i,t-1} + \alpha_4 \cdot \mathrm{FDEP}_{i,t-1} \\ & + \alpha_5 \cdot \mathrm{NFDEP}_{i,t-1} + \alpha_6 \cdot \mathrm{WIBOR3M}_t + \alpha_7 \cdot \mathrm{UNEMPL}_{j,t} \\ & + \alpha_8 \cdot \mathrm{recession} + \alpha_9 \cdot \mathrm{recession} \cdot \mathrm{CAR}_{i,t-2} + \varepsilon_t + \vartheta_{i,t} \end{aligned} \tag{1}$$

where:

i—the number of the bank;
j—the number of voisvodeship;
t—the number of observation for the i-th bank;

- ***ΔLoan***—real annual loans growth rate, calculated at a quarterly frequency; to deflate the nominal loans growth rate, we apply the Fisherian formula, i.e. $\Delta Loan = \frac{N\_Loan\ growth\ rate_t - CPI_t}{1+CPI_t}$; where N_Loan growth rate is nominal annual loans growth rate (computed at a quarterly frequency), CPI is annual consumer price index in Poland (also computed at a quarterly frequency to correspond with loans growth rate); following the convention adopted in many studies (e.g. Gambacorta and Mistrulli 2004; Berrospide and Edge 2010; Beatty and Liao 2011; Gambacorta and Marqués-Ibáñez 2011; Carlson et al. 2013; Kim and Sohn 2017), we use the growth rate of the dependent variable instead of levels of the variable to mitigate spurious correlation problems; In contrast to previous research applying quarterly data, instead of using quarterly loans growth rate, we use annual loans growth rate because macroeconomic variables are published at a quarterly frequency and presented as a yearly change in the variable (e.g. the unemployment rate). As in the previous studies (Beatty and Liao 2011; Gambacorta and Marqués-Ibáñez 2011; Carlson et al. 2013; Kim and Sohn 2017) we also apply one quarter lag of loans growth rate as a dependent variable, to capture adjustment costs that constrain complete adjustment to an equilibrium level;
- ***CAR—***the lagged capital adequacy ratio, i.e. total bank capital divided by risk weighted assets, lagged by two quarters; in our study we apply basically total risk-adjusted capital ratio. In the robustness checks we will also use Tier 1 capital adequacy ratio. According to the literature, the coefficients on the capital ratio are expected to be positive, implying that well capitalized banks extend more loans, because they can more effectively absorb the negative effects of risk shocks on bank lending (see, e.g. Bernanke and Lown 1991; Hancock and Wilcox 1994; Peek and Rosengren 1995; Peek et al. 2003; Gambacorta and Mistrulli 2004; Berrospide and Edge 2010; Beatty and Liao 2011; Gambacorta and Marqués-Ibáñez 2011; Carlson et al. 2013; Kim and Sohn 2017). The α2 coefficient measures sensitivity of bank lending to capital ratio during non-recessionary periods (see Beatty and Liao 2011; Carlson et al. 2013). In contrast to previous research (e.g. Kim and Sohn 2017), we apply two quarters lagged capital ratio due

to the specific conditions related to bank reporting. Generally, banks in Poland are obliged to report capital adequacy data for supervisory authority as well as for internal reporting purposes at a quarterly frequency. So the information from the last quarter is reported to the management board of a bank with a lag, e.g. this may be one or two months lag (the data has to be collected, analyzed and included in financial report, and then published in the case of stock-market traded banks);

- ***NIM***—net interest margin on loans lagged by one quarter, i.e. net interest margin divided by average loans (this interest margin is annualized and computed at a quarterly frequency); it proxies profitability of bank lending; banks with high profitability will be eager to extend more loans, thus the relationship between loans growth rate and net interest margin is expected to be positive; however, a high profitability may also imply higher costs on bank loans, thus diminishing the loan demand; in effect, a negative coefficient on net interest margin may also be expected; as is suggested by Kim and Sohn (2017), higher profitability may imply a greater risk on assets; thus, from the perspective of a bank, it may be related with lower lending growth to improve the quality of loans; under this scenario, the association between profitability and lending can be negative;
- ***FDEP***—one quarter lagged deposits from banks divided by total assets; a positive coefficient on this variable suggests that banks with better access to interbank market financing extend more loans; in contrast, a negative coefficient on this ratio may indicate that banks do not need wholesale financing for the development of their lending;
- ***NFDEP***—one quarter lagged deposits from non-financial customers divided by total assets; a positive coefficient on this NIM; we generally expect a positive coefficient on this variable, if banks need access to deposits to extend new lending; the association between loans growth and deposits may also be negative or statistically insignificant if banks do not suffer from the lack of stable funding;
- ***WIBOR3M***—three month Warsaw Interbank Bid Rate; this rate proxies the cost of lending for bank customers (thus higher values may be related with decreased loans growth rate, and the coefficient on WIBOR3M may be negative) or the earnings that banks get from the loan (thus the coefficient on WIBOR3M may be positive); it is calculated as an average for the quarters;
- ***UNEMPL***—annual unemployment rate, calculated at quarterly frequency; this rate is included to account for the effects of macroeconomic conditions and loan demand; it proxies the demand for loans; we expect a negative coefficient on this variable because increases in unemployment rate are associated with a decreased demand for bank lending (and vice-versa);
- ***recession***—dummy variable equal to one during recessionary periods 0 otherwise; we identify four recessionary periods (in 2001q2-2002q2, 2005q1-q4, 2009q1-q3, 2012q2-q4). We predict a negative coefficient on recession if loan supply declines during crisis for reasons other than capital and liquidity constraints (as do Beatty and Liao 2011, p. 7);
- ***recession * CAR***—interaction between Crisis and capital ratio (CAR) was added to the model in order to investigate the effect of CAP depending on the recession (the presence or not of the period of recession); banks which exhibit capital

pressures during recessions will increase their lending if their capital ratio is sufficiently high; we expect the coefficient on this interaction to be positive and statistically significant for banks which suffer from capital shortages (or risk shocks), which affect capital absorption potential.

$\vartheta_{i,t}$ are unobservable bank-specific effects that are not constant over time but vary across banks; ε_t is a white-noise error term.

This study employs the fixed effects panel method, because Judson and Owen (1999) suggest that fixed effects estimators perform well or better when the time dimension of panel data T is greater than 30. Because the time dimension of our datasets is 52 quarters, we adopt the bank fixed effects panel model. The fixed effects method has been extensively used in the literature (see, e.g., Berrospide and Edge 2010; Francis and Osborne 2012; Cornett et al. 2011; Kim and Sohn 2017). As argued by Brei et al. (2013), non-randomly selecting a sample from the population of banks is also consistent with the choice of fixed effects estimations, which is true of our sample.

We use pooled cross-section and time-series quarterly data of individual cooperative banks' balance sheet items and profit-and-loss accounts from Poland over a period from 1999 to 2012. The balance-sheet and profit-and-loss account data are taken directly from the prudential reporting of all banks operating in Poland in the period under analysis. This is a unique set of data, which is gathered by the National Bank of Poland[1] and used in the Polish Financial Supervisory Authority, and covers the financial statements reporting information ("FINREP") and capital adequacy information (bank capital and own funds composition and capital requirements composition) ("COREP").

The macroeconomic data were accessed from the Central Statistical Office of Poland (GUS). We conduct our study for unconsolidated data, to include the effects of capital ratio on bank lending in traditional banking business (i.e. taking deposits and extending loans). We exclude outlier banks from our sample, by eliminating the extreme bank-specific observations. Due to the fact that we are interested in the effect of capital ratio in different business cycle periods, in our study we include only those banks for which we have data covering five consecutive years (and 20 quarters). Based on this selection strategy, the number of banks included in our sample is 237 and the number of observations for the dependent variable is over 12000 observations.

In order to capture both economic upswings (non-recessionary periods) and downturns (recessionary periods) we need to use bank data for a sufficiently long

[1]This data is collected because in accordance with Resolution No. 53/2011 of the Management Board of the National Bank of Poland of September 22, 2011 as amended (NBP Official Journal of 2011 No. 14, 2013 No. 6, No. 47, 2014 No. 40, 2015 No. 38, 2016, No. 2) and pursuant to Regulation of the European Parliament and Council (EU) No 575/2013 of June 26, 2013, (L 176, 06.27.2013 p.1) credit institutions are obliged to provide the NBP with prudential reporting on an individual and consolidated basis.

period. Thus our period covers 1999:4–2012:4 and includes for most banks 52 quarters.

In Table 1 we present descriptive statistics of the key regression variables in the full sample as well as in well-capitalized and poorly-capitalized banks. We find that in well-capitalized banks mean total capital ratio (CAR) is 19.42%, with median value of 17.46%. As for poorly-capitalized banks average CAR is 10.24% with median value of 10.53%. Well-capitalized banks exhibit lower median loans growth of 2.82% relative to poorly-capitalized banks with median loans growth of 3.57%. There is also visible discrepancy between well-capitalized and poorly-capitalized banks in terms of profitability (NIM). Generally, well capitalized banks' average NIM is around 11.94% with median value of 9.51%. In contrast, in poorly-capitalized banks this values are 9.13% and 8.34%, respectively.

Table 1 Descriptive statistics of the data

	Full sample						
	Mean	Std. Dev.	Min	Max	N obs	N banks	Median
ΔLoan	3.71	8.24	−38.92	402.34	12,087	237	3.04
CAR	16.9	7.51	−7.69	80.44	12,112	237	15.03
CAR1	16.37	7.09	0.03	73.11	12,112	237	14.64
NIM	11.16	5.1	0.92	78.84	12,087	237	9.94
NFDEP	74.61	10.25	15.25	95.06	12,056	237	76.06
FDEP	1.21	3.06	0	33.69	12,113	237	0
WIBOR3M	6.86	4.41	3.64	19.19	12,260	237	5.07
UNEMPL	14.39	4.25	5.8	30.6	12,260	237	14
	CAR above 12						
ΔLoan	3.5	7.39	−31.64	141.91	8772	231	2.82
CAR	19.42	7.34	12	80.44	8790	231	17.46
CAR1	18.76	6.88	7.92	73.11	8790	231	17.07
NIM	11.94	5.41	3.67	78.84	8772	231	9.51
NFDEP	73.42	10.48	15.25	91.54	8743	231	75.07
FDEP	0.99	2.82	0	33.69	8790	231	0
WIBOR3M	6.68	4.24	3.64	19.19	8790	231	4.93
UNEMPL	14.23	4.1	5.8	30.6	8790	231	13.9
	CAR below 12						
ΔLoan	4.29	10.1	−38.92	402.34	3314	146	3.57
CAR	10.24	1.46	−7.69	12	3322	146	10.53
CAR1	10.03	1.61	0.03	21.25	3322	146	10.15
NIM	9.13	3.42	3.17	34.07	3314	146	8.34
NFDEP	77.75	8.89	37.84	95.06	3312	146	77.43
FDEP	1.82	3.54	0	31.79	3322	146	0.07
WIBOR3M	7.46	4.85	3.64	19.19	3322	146	5.33
UNEMPL	14.91	4.54	5.8	30.6	3322	146	14.7

Source: Authors' estimations

Notes: N obs—number of observations; N banks—number of banks

4 Research Results

Before discussing the main regression results, we present the baseline regressions which examine the relationship between bank lending and bank-specific variables without including the interaction terms of the capital ratio and measure of cyclicality of LLP as well as of income-smoothing. Table 3 reports these results.

First, looking at the full sample results estimated with FE we find that the coefficients of the capital ratio are positive and statistically significant at the 1% level. The effect of capital ratio on lending is 0.081 in non-recessionary periods (see column 1). The capital ratio in recessionary periods does not seem to induce procyclicality of lending in the full sample, because the coefficient on CAR*recession is positive but not statistically significant (see column 2).

In both regressions in Table 2, the coefficients of all the other control variables are generally significant, with expected signs. Concerning the coefficients of the net interest margin on loans (NIM), the estimated coefficients are positive in the full sample and their effect is always significant. The stable funding effect (proxied by NFDEP) as well as non-stable funding (proxied by FDEP) is negative and significant, suggesting that cooperative banks' lending is not so much dependent of funding constraints (which contradicts the effects obtained by Kim and Sohn 2017 and Olszak et al. 2017, obtained for commercial banks).

Table 2 Determinants of cooperative banks' lending—full sample results

	Full sample			Full sample		
XTREG FE	1	Prob.	T-stat	2	Prob.	T-stat
ΔLoan	0.037	0.00	3.98	0.036	0.00	3.82
CAR(−2)	0.081	0.00	3.60	0.072	0.00	3.14
NIM(−1)	0.134	0.00	4.75	0.145	0.00	5.09
FDEP(−1)	−0.131	0.00	−4.06	−0.131	0.00	−4.07
NFDEP(−1)	−0.039	0.00	−3.10	−0.034	0.01	−2.75
WIBOR3M	0.135	0.00	5.37	0.131	0.00	5.20
UNEMPL	−0.056	0.04	−2.05	−0.048	0.08	−1.75
Recession				−0.821	0.05	−2.00
CAR*recession				0.018	0.42	0.80
Cons	3.585	0.01	2.71	3.352	0.01	2.52
N obs	11,789			11,789		
N groups	237			237		
R-sq within	0.022			0.022		
R-sq between	0.060			0.063		
R-sq overall	0.006			0.007		
F	36.36	0.00		29.45	0.00	
F that all u_i=0	1.42	0.00		1.43	0.00	

Source: Authors' estimations

Notes: Prob.—statistical significance; T-stat—value of t Student statistics; N obs—number of observations; N banks—number of banks

Table 3 Determinants of cooperative banks' lending—the role of capital ratio size

	CAR<12			CAR>12			CAR<12			CAR>12		
XTREG FE	1	Prob.	T-stat	2	Prob.	T-stat	3	Prob.	T-stat	4	Prob.	T-stat
ΔLoan(−1)	0.003	0.86	0.17	0.047	0	4.27	−0.002	0.9	−0.12	0.047	0	4.2
CAR(−2)	0.723	0	6.06	0.06	0.01	2.76	0.823	0	6.12	0.057	0.01	2.51
NIM(−1)	0.631	0	5.68	0.118	0	4.23	0.703	0	6.25	0.126	0	4.46
FDEP(−1)	−0.114	0.12	−1.54	−0.149	0	−4.08	−0.098	0.19	−1.33	−0.151	0	−4.12
NFDEP(−1)	−0.087	0.01	−2.55	−0.023	0.08	−1.77	−0.069	0.04	−2.02	−0.021	0.12	−1.57
WIBOR3M	0.058	0.34	0.95	0.116	0	4.09	0.039	0.52	0.64	0.112	0	3.94
UNEMPL	−0.155	0.02	−2.28	−0.028	0.34	−0.95	−0.13	0.06	−1.91	−0.024	0.42	−0.8
Recession							2.234	0.33	0.97	−0.339	0.49	−0.7
CAR*recession							−0.35	0.11	−1.6	0	0.99	0.02
Cons	−0.34	0.93	−0.09	2.188	0.11	1.58	−3.248	0.4	−0.85	2.046	0.14	1.47
N obs	3220			8568			3220			8568		
N groups	144			231			144			231		
R-sq within	0.039			0.022			0.043			0.022		
R-sq between	0.065			0.002			0.067			0.001		
R-sq overall	0.017			0.011			0.019			0.011		
F	17.63	0.00		26.5	0.00		15.33	0.00		21	0.00	
F that all u_i=0	1.16	0.10		1.17	0.04		1.21	0.05		1.18	0.04	

Source: Authors' estimations
Notes: Prob.—statistical significance; T-stat—value of t Student statistics; N obs—number of observations; N banks—number of banks

Finally, the macroeconomic environment proxied with the market rate (WIBOR3M) and unemployment rate (UNEMPL) and recession dummies exert also expected effect. As for the interbank interest rate, we find that the estimated coefficients are positive in the full sample and their effect is always significant. Such effect suggest that cooperative banks increase their lending when the market rate is increasing. Looking at the full sample estimates of the effect of unemployment rate, we infer the increases in unemployment are associated with decreases in bank's loan growth, thus confirming the notion that cooperative bank lending is procyclical.

The relative level of capital ratio of a bank matters for the effect of capital ratio on lending in non-recessionary, but not in a recessionary periods (see Table 3). Poorly-capitalized banks' lending is definitely more affected by capital ratio in non-recessionary period, because the regression coefficients on CAR is positive and statistically significant (see columns 1 and 4 in Table 3). Based on regression 1, we infer that a 1% decrease (increase) in capital ratio causes poorly-capitalized bank to decrease (increase) its lending by 0.723% in non-recessionary periods (see column 1 in Table 3). In contrast, well-capitalized banks' loans growth is definitely less sensitive to capital ratio in non-recessionary period, because the effect of CAR on loans growth is 0.060 (see column 2 in Table 3).

Cooperative banks' loans' growth is not sensitive to capital ratio in recessionary periods, even if we take into account the size of capital ratio. As we can see from Table 3 (see column 3) in poorly-capitalized cooperative banks the coefficient on CAR*recession is negative and statistically insignificant, suggesting that even banks with relatively higher capital ratio are not able to increased their lending.

Now, we present robustness checks to determine whether our results remain unchanged. To this end we perform regressions with alternate measure for capital ratio, i.e. the tier 1 capital adequacy ratio. Tables 4 and 5 report results for the change in capital ratio.

Looking at the full sample results we find that the coefficients on the capital ratio are positive and statistically significant at the 1% level. The effect of capital ratio on lending is stronger than in Table 2 and equals 0.102 in non-recessionary periods (see column 1 in Table 4). The capital ratio in recessionary periods does not seem to induce procyclicality of lending in the full sample, because the coefficient on CAR*recession is negative and statistically insignificant (see column 2).

The relative level of capital ratio of a bank matters for the effect of CAR1 on lending in non-recessionary, but not in and recessionary periods (see Table 5), we give further supports main results presented in previous section in Table 3. Poorly-capitalized banks' lending is definitely more affected by capital ratio in non-recessionary period, because the regression coefficients on CAR is positive and statistically significant (see columns 1 and 4 in Table 5). Based on regression 1, we infer that a 1% decrease (increase) in capital ratio causes poorly-capitalized bank to decrease (increase) its lending by 0.487% (see column 1 in Table 3) or 0.712 (see column 3 in Table 3) in non-recessionary periods. In contrast, well-capitalized banks' loans growth is definitely less sensitive to capital ratio in non-recessionary period, because the effect of CAR on loans growth is 0.87 (see column 2 in Table 3).

Table 4 Robustness check of determinants of cooperative banks' lending—full sample results

	Full sample			Full sample		
XTREG FE	1	Prob.	T-stat	2	Prob.	T-stat
ΔLoan	0.037	0	3.94	0.036	0	3.81
CAR1(−2)	0.102	0	4.1	0.098	0	3.83
NIM(−1)	0.129	0	4.57	0.143	0	5.01
FDEP(−1)	−0.127	0	−3.95	−0.127	0	−3.96
NFDEP(−1)	−0.035	0.01	−2.79	−0.031	0.01	−2.46
WIBOR3M	0.142	0	5.59	0.136	0	5.33
UNEMPL	−0.06	0.03	−2.19	−0.052	0.06	−1.9
Recession				−0.301	0.47	−0.72
CAR*recession				−0.012	0.6	−0.52
Cons	3.07	0.02	2.28	2.763	0.04	2.04
N obs	11,789			11,789		
N groups	237			237		
R-sq within	0.022			0.023		
R-sq between	0.066			0.068		
R-sq overall	0.006			0.006		
F	36.93	0		29.75	0	
F that all u_i=0	1.43	0		1.43	0	

Source: Authors' estimations
Notes: Prob.—statistical significance; T-stat—value of t Student statistics; N obs—number of observations; N banks—number of banks

We also find further empirical support for the view that cooperative banks' loans' growth is not sensitive to capital ratio in recessionary periods, even if we take into account the size of capital ratio. As we can see from Table 5 (see column 3) in poorly-capitalized cooperative banks the coefficient on CAR*recession is negative and (in contrast to the results obtained in previous section) statistically significant, suggesting that even banks with relatively higher capital ratio are not able to increased their lending.

5 Conclusions

Using the 2000 Q1–2012 Q4 unbalanced quarterly observations of Polish cooperative banks, this study examines whether the effect of bank capital on lending differs depending upon bank capital ratio level. There are two novel contributions of our study relative to the literature.

First, we show that the effect of capital ratio on loans growth in cooperative banks is significant only in non-recessionary periods. Thus, in contrast to commercial banks, in cooperative banks capital ratio does not exert procyclical effects on loans growth.

Table 5 Robustness check of determinants of cooperative banks' lending—the role of capital ratio size

	CAR<12			CAR>12			CAR<12			CAR>12		
XTREG FE	1	Prob.	T-stat	2	Prob.	T-stat	3	Prob.	T-stat	4	Prob.	T-stat
ΔLoan	0.009	0.62	0.49	0.046	0	4.19	0.002	0.91	0.11	0.046	0	4.12
CAR1(−2)	0.487	0	4.1	0.087	0	3.6	0.712	0	4.94	0.092	0	3.68
NIM(−1)	0.559	0	5.01	0.11	0	3.97	0.644	0	5.69	0.121	0	4.28
FDEP(−1)	−0.119	0.11	−1.6	−0.146	0	−3.98	−0.096	0.2	−1.28	−0.146	0	−3.99
NFDEP(−1)	−0.074	0.03	−2.15	−0.019	0.15	−1.45	−0.053	0.12	−1.54	−0.016	0.21	−1.25
WIBOR3M	0.04	0.51	0.66	0.128	0	4.48	0.019	0.76	0.3	0.122	0	4.25
UNEMPL	−0.149	0.03	−2.18	−0.031	0.29	−1.06	−0.121	0.08	−1.78	−0.026	0.38	−0.89
Recession							4.435	0.03	2.24	0.436	0.38	0.88
CAR*recession							−0.571	0	−2.97	−0.04	0.11	−1.59
Cons	1.929	0.61	0.51	1.481	0.29	1.06	−2.65	0.5	−0.67	1.133	0.42	0.8
N obs	3220			8568			3220			8568		
N groups	144			231			144			231		
R-sq within	0.032			0.022			0.038			0.023		
R-sq between	0.048			0			0.05			0		
R-sq overall	0.013			0.01			0.014			0.01		
F	14.7	0		27.28	0		13.61	0		21.83	0	
F that all u_i=0	1.12	0.16		1.2	0.02		1.2	0.05		1.2	0.02	

Source: Authors' estimations

Notes: Prob.—statistical significance; T-stat—value of t Student statistics; N obs—number of observations; N banks—number of banks

Second, we provide evidence that the impact of capital ratio on lending of cooperative banks depends on the banks' capital ratio size. Poorly-capitalized banks' lending is definitely more sensitive to capital ratio in non-recessionary periods. In contrast, well-capitalized banks' loans' growth does not suffer from capital constraints in non-recessionary period. Our research finds also evidence that lending of poorly-capitalized cooperative banks is not immune to recessionary capital crunch.

The implication of our research is that decision-makers implementing new capital adequacy standards, such as Basel III capital buffers or increases in capital ratios, such consider the fact that lending of cooperative banks does not respond to changes in capital ratios as in commercial banks. Therefore attempts to reduce cooperative banks loans' growth through capital ratios may not be effective.

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Analysis of Determinants of Liquidity Risk in Polish Banking Sector

Agnieszka Wójcik-Mazur

Abstract The purpose of this paper is to identify dependences between bank liquidity risk and selected group of internal determinants including levels of credit risk, capital ratio and profitability. The dependence study employed the estimation of correlation coefficient within two groups of banks forming the Polish banking sector, including commercial and cooperative banks. The research revealed the existence of correlation (statistically significant) between financial liquidity level and internal determinants across two groups of banks. However, there were various directions of correlation between liquidity risk and capital ratio evidenced for those two groups of Polish banks. The cooperative banking sector was diagnosed with the existence of strong positive dependence between liquidity and capital ratio, which may suggest the focus in those banks on increasing financial safety regardless the stage of economic cycle as well as on increasing the lending capacity of non-financial sector.

1 Introduction

The crisis and its negative consequences for financial systems and real economy caused the problem of banking systems liquidity risk become more explored research area. The crisis emphasized problems related to banking liquidity risk management (Jajuga 2009) from the level of individual financial institution on global scale and in particular to the issue of quantifying its level. This is primarily associated with the fact that liquidity risk is determined by a series of factors both of internal nature emerging from the classical formula of carrying out the function of financial intermediation as well as coming from macroeconomic effect in particular the market liquidity. The problem of identifying the determinants of bank liquidity risk was not the subject of wide scientific discourse until the outburst of sub-prime crisis. Consequences of the crisis focused the research on the problem of liquidity

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risk in the context of indicating the dependences between liquidity risk and the group of external determinants (GDP, inflation and the ratio of deposits to loans) and internal determinants, i.e. credit risk level or the profitability generated. Nevertheless, the results of the research are not homogeneous, in particular in relation to dependences between liquidity risk and profitability level (Wójcik-Mazur and Szajt 2015). Empirical research identifying the determinants of liquidity risk in Polish commercial banks was done by Vodovà (2013), however it was focused on commercial banks. Given the above, this paper is an attempt to indicate the dependences between the group of internal determinants and liquidity risk in both commercial banks and in the cooperative banking sector operating in Polish banking system. The characteristics of cooperative banks operation and in particular their local nature may result in different type of liquidity policy of those banks. This paper evaluates the existence of dependences between liquidity risk and credit risk level, profitability and the scope of capital ratio (calculated as the share of equity in total assets). Pearson correlation coefficients were used to diagnose those dependences, and they were estimated for the group of commercial and cooperative banks. Based on literature studies, following research hypotheses were formulated:

1. There is a positive linear correlation between liquidity risk and the profitability level of a bank operation, regardless of the type of the bank.
2. Credit risk level is negatively correlated with liquidity risk regardless of the group of banks.
3. Capital ratio is negatively correlated with a bank liquidity risk regardless of the type of the bank analyzed.

2 Liquidity Risk Measurement Methods

According to Basel Committee "liquidity is the ability of a bank to fund increases in assets and meet obligations as they come due, without incurring unacceptable losses" (Basel Committee 2008). It should be noted that liquidity risk is determined by both external factors and internal factors resulting from the nature and characteristics of given financial institution activities. Thus the literature of the subject commonly emphasizes that liquidity risk in commercial banks operation includes two crucial components—funding risk and market risk (Brunnermeier and Pedersen 2009; Nikolaou 2009; Vento and La Ganga 2009). Such specific nature of liquidity risk causes some problems with selecting measures for its analysis. This applies not only to empirical research but also to difficulties associated with the implementation of mandatory standards, on global scale, setting safety thresholds for maintaining liquidity reserves. Only in response to sub-prime crisis consequences Basel Committee introduced the obligation to evaluate liquidity measures in short and long-term, including: Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR), respectively (Dziwok 2015; Zaleska 2016; Basel Committee, January 2013; Basel Committee, October 2014). According to Basel Committee the "objective of the LCR is to promote the short-term resilience of the liquidity risk profile of banks". The LCR ratio should ensure that banks have an adequate amount of unencumbered high-quality liquid assets (HQLA). These assets can be converted easily and immediately in private markets into cash to meet their liquidity needs for a 30 calendar day liquidity stress scenario (Basel Committee, January 2013). The NSFR means that the amount of "available stable funding" should be equal to at least the amount of stable funding required. "Available stable funding" is the proper amount of capital and liabilities expected to over 1 year. The amount of stable funding required consists of various assets held by that institution and those of its off-balance sheet exposures. Their value and level are estimated by allowing for ASF factor, reflecting the funding stability level (Wójcik-Mazur 2012; Basel Committee, October 2014). The effect of the above measures on the banking sector operation in Poland was analyzed in particular by Marcinkowska et al. (2014), Dziwok (2015) and Niedziółka (2014).

The estimation of liquidity levels of individual banking institutions can employ three main measurement methods, including stock approaches, cash-flow and hybrid approaches (Vento and La Ganga 2009). The empirical research, related in particular to the identification of liquidity risk determinants and well as the determinants of effectiveness level estimation, is based on stock approach. The quantitative measurements of bank liquidity risk are being used most often. They include: balance sheet ratios, net cash capital position, maturity mismatches and funding ratios. Problem of calculating these measurements depends on cash-flow timing and its uncertainty level. For that reason space-time analyses treat declared cash flows as certain. Implied balance sheet measures allow for ratios of assets of different liquidity to total assets or selected funding sources including in particular deposits. The most often implied measures of liquidity level are equal to the ratio of liquid assets to total assets (Ferrouchi 2014; Ferrouchi 2014; Alper and Anbar 2011). In parallel those analyses also take into account the ratio of liquid assets to customer deposits and short-term funding (Vodovà 2013; Grant 2012; Deléchat et al. 2012; Mehmet 2014; Maechler et al. 2007; Aspachs et al. 2005; Roman and Sargu 2015). A popular measure of liquidity risk is also the ratio reflecting the share of loans in total assets (Roman and Sargu 2015; Athanasoglu et al. 2006; Vodovà 2011; Abreu and Mendes 2002; Rachdi 2013). Also noted should be the ratio that is widely used in conducted studies and reflects the relation between the value of loans granted and the level of deposits accepted. It enables the estimation of funding risk by indicating the values of stable funding sources, which are considered to be deposits mainly of non-financial sector (Marozva 2015; Bonfim and Kim 2017; Vodovà 2011; Petria et al. 2015). Determinants of individual adopted various liquidity measures do not demonstrate the same directions of dependences and effect strength (Wójcik-Mazur and Szajt 2015). They are also dependent on the specifics of individual banking systems.

The basic element of liquidity risk estimation in cash flow approach is the liquidity gap calculation. Liquidity gap in relation to individual institutions should be based on the estimation of cash flows reflecting the actual inflows and outflows of funds that identify both balance sheet and off-balance sheet items in specific, precisely defined time periods. Many authors emphasize that estimating both funds inflows and outflows should also allow for the process of their materialization which can be enhanced by the approach that takes into account future unexpected changes in cash flows (Matz and Neu 2007; Bessis 2009; Schmaltz 2009; Stopczyński 2016). Therefore it seems that such an approach is similar to the hybrid approach as hybrid approach consists of elements of cash flow and liquid assets approach. In this approach projected cash flows should include the calculation of stochastic cash flows (including those of undefined time profile) that can significantly change the liquidity position of the bank. Nevertheless statistical studies, in particular comparative analyses should be emphasized with the attempts to use balance sheet measures that in such an approach are about to reflect the „idea" of liquidity gap. Few studies undertake the attempts to calculate liquidity risk as liquidity gap that, however, the result of relations between balance sheet elements. In this approach it is treated as the difference between the value of loans granted reduced by the value of deposits accepted and the total value of assets (Chen et al. 2010; Wójcik-Mazur 2012). In the classical approach balance sheet measures or liquidity gap estimation can be used, that may relate both to individual financial institutions and to banking systems of individual countries.

3 Analysis of the Level of Correlation Between Liquidity Risk and Internal Determinants

Therefore, the basis for the research in the field of assessing the effect of liquidity risk determinants is the selection of a measure enabling that assessment. This paper analyzes the level of dependences between liquidity risk and the group of three internal determinants within the group of commercial and cooperative banks in 2009–2016. The source of information is financial data presented on a monthly basis by the Polish Financial Supervision Authority (KNF) for the sector of commercial and cooperative banks operating in Poland. Based on the literature studies, three classical formulas were selected as liquidity measures: loans to deposits ratio, liquid assets to total assets ratio and loans to total assets ratio. These ratio as proxies for liquidity risk are considered by many authors: Vodovà (2011), Bonfim and Kim (2012a, b), Sufian (2011), Kosmidou et al. (2006), Sheefeni (2015) and Roman and Sargu (2015).

When choosing the liquidity level measure from one of the three proposed above, the level of their mutual correlation was evaluated. Tables 1 and 2 present the level of

Table 1 Pearson correlation coefficient of liquidity measures for commercial banks at significance level alpha = 0.05

	Loans/Deposit	Liquid assets/Total assets	Loans/Total assets
Loans/Deposit	1	−0.662358	0.564697
Liquid assets/Total assets		1	−0.774414
Loans/Total assets			1

Table 2 Pearson correlation coefficient of liquidity measures for cooperative banks at significance level alpha = 0.05

	Loans/Deposit	Liquid assets/Total assets	Loans/Total assets
Loans/Deposit	1	−0.556951	0.6393642
Liquid assets/Total assets		1	−0.90794
Loans/Total assets			1

correlation coefficient between liquidity risk measures for the groups of commercial and cooperative banks, respectively. Data presented in Tables 1 and 2 indicate that the lowest level of correlation was observed for loans/deposits measure and loans/ total assets measure for individual types of banks. Therefore it was assumed that the loans/deposits measure was the optimal ratio of liquidity risk for analyzed financial data.

Based on the literature studies and previous research (Wójcik-Mazur 2012; Wójcik-Mazur and Szajt 2015), determinants of liquidity risk include, as mentioned above, in particular credit risk level, return on equity and capital ratio. The value of above ratios were estimated from monthly data published by Polish Financial Supervision Authority (KNF) for the entire group of cooperative and commercial banks. The methodology for calculating the ratios were presented in Table 3.

In the existing empirical literature we can find broad area of research reflects the relationship between profitability in banking activity and group of internal determinants include liquidity risk. These studies have focused on commercial banks in different criteria based on cross-country evidence, country specific, size of banks etc. Many authors (Abreu and Mendes 2002; Kosmidou et al. 2005; Garcia-Herrero et al. 2009; Guru et al. 2002; Graham and Bordelean 2010; Al-Harbi 2017) find the evidence on the relationships between liquidity and profitability. Referring to the impact of bank liquidity is negatively related to the profitability of commercial banks. However Kosmidou et al. (2005) recognize that exists significant positive relationship between these determinants.

We examine the correlation between liquidity of banks and three internal determinants. Table 4 present the results of linear dependences between funding risk and indicated group of measures. Pearson correlation analysis revealed that all relations being analyzed are statistically significant, which suggests the existence of linear dependences between any of profitability ratio (ROE), credit risk level, capital ratio and financial liquidity level measured as funding risk.

Table 3 Internal determinants of liquidity risk

Name of measure	Construction	Source of data
ROE	Net profit/Equity	Polish Financial Supervision Authority (KNF)
Credit risk	Value of past due loans/ Gross loans	Polish Financial Supervision Authority (KNF)
Capital ratio	Equity/Total Assets	Polish Financial Supervision Authority (KNF)

Table 4 Pearson correlation coefficient of liquidity measures for commercial and cooperative banks

Name of measure	ROE	Credit risk	Capital ratio
Loans/deposits (commercial banks)	0.2523664	−0.681624	−0.546792
Loans/deposits (cooperative banks)	0.528535	−0.817615	0.8476575

The research indicates that levels of both operation profitability and credit risk are dependent on the value of maintained liquidity level for commercial banks group as well as for cooperative banks group.

When evaluating the dependence between funding risk and return on equity it is clearly visible that significantly stronger positive dependence occurs in cooperative banks sector. Therefore it seems that it is caused by the fact of maintaining liquidity reserves, which in the event of starting lending activity significantly increase interest revenues while not generating excessive additional increase of interest cost (hypothesis 1). That is because cooperative banks when funding increasing lending activity are not forced to obtain additional, more expensive funding sources originating from financial markets, as they maintain reserves in the form of deposits from non-financial sector. In the group of commercial banks the decrease in liquidity reserves results in increasing profitability ratios, however this dependence is much weaker. The increase in lending activity forces to obtain additional funding sources at a cost higher than from local wholesale market. For that reason the relation is positive but noticeably weaker.

General overview of empirical literature shows a positive relationship between liquidity and credit risk. This is shown by papers such as Diamond and Rajan (2005), Acharya and Viswanathan (2011), Gorton and Metrick (2012) and He and Xiong (2012). But Imbierowicz and Rauch (2014) find an evidence that there is no reliable relationship between liquidity risk and credit risk in banks.

In our paper while evaluating the relation between financial liquidity level and credit risk it should be noticed that there is a strong negative correlation both in commercial and cooperative banks groups (hypothesis 2). It probably results from the specific character of liquidity risk confirming its anticyclical nature (Wójcik-Mazur 2012). As emphasized in current research the significant increase in lending activity is realized by the banking sector in the event of the economic growth. At such circumstances the credit risk level is low and the potential growth of newly-started loans makes the ratio of past due loans to total receivables decrease. This negative correlation is much stronger in case of cooperative banks which are more responsive to economic situation and, as it seems, implement much more restrictive lending policy.

The measure demonstrating the relation between liquidity risk and capital ratio that reflects the ratio of equity share in total assets is observed for a strong correlation, however its direction is different in the discussed groups of banks (hypothesis 3). In commercial banks sector the funding risk level is negatively correlated with the value of that ratio. It means that the increase in liquidity risk is accompanied by the decrease in the share of equity in total assets. The growth in lending activity results in the balance sheet total increase, but it is not accompanied by the proportional progress in equity. It may be caused by the fact that commercial banks are more focused on increasing profitability than on enhancing financial safety. The opposite situation takes place in cooperative banks sector. Those results are not consistent with the expected (hypothesis 3 negatively verified). It should be noticed that cooperative banks hold much higher liquidity buffer in comparison to commercial banks. They invest their free funds in associating banks and in debt instruments. Therefore it seems that the surplus funds held may form a source of newly-started loans, which does not have to be accompanied by a strong increase in deposits obtained from non-financial sector. Positive correlation between funding risk and the share of equity in total assets suggests that banks, when increasing the lending activity (still financed from liquidity surpluses), implement a conservative policy, simultaneously increasing the value of equity. However the policy aimed at the increase of the equity share may not only originate from the desire to enhance financial safety but also attempt to increase the lending potential, especially in the area of business activity financing by acquiring new customers that require more advanced products and in particular higher loans. As it may seem, external limits in relation to equity value in lending activity of particularly cooperative banks limit the possibilities of lending to non-financial sector. Increasing the equity is of key importance for the possibility of financing new ventures and acquiring new customers with higher credit needs, especially given the existing high liquidity buffer in the sector of cooperative banks.

4 Conclusions

The studies on correlation between the liquidity measure and the group of internal determinants evidenced the existing dependences in the sectors of commercial and cooperative banks. It should be noticed that based on financial data presented for cooperative and commercial banks it was possible to prove the existence of the correlation between liquidity risk and the return on equity, credit risk and capital ratio. The direction of diagnosed dependences was identical for ROE and for credit risk. However, the stronger dependences were observed in the group of cooperative banks. The opposite direction of correlation was found in cooperative banks segment in terms of the measure reflecting the relation of equity to total assets ratio and liquidity risk. Pearson correlation estimated revealed that cooperative banks, when decreasing their liquidity reserves, in parallel increase the value of equity, which may suggest that their policy is determinated by capital requirement, but also in particular at increasing lending capacity.

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Part II
Commodity Market

The Post-Crisis Insight into Nickel Pricing on the London Metal Exchange

Marta Chylińska

Abstract This study applies a VECM DCC-MGARCH on the daily sampled data for the nickel 3 month and spot contracts traded on the London Metal Exchange in the period January 2010–December 2017 to show that the futures and spot exhibit a common stochastic trend. Their spread is not co-integrating, however. The hypothesis stating that the price of futures contracts departures from their long run equilibrium relationship do not affect the current price of the contract is rejected for 3 month futures contract. Periods of an increased conditional variances are observed. Volatility of nickel prices has been reacting to the situation on financial markets, especially in May 2010 when European Union announced financial help to Greece which is regarded as one step of financial crisis. Next increase was observed in October 2011, when there was a next step in Greek financial crisis (the agreement to write-off the Greek Debt). At the beginning of 2014, the one of the nickel producing country, Indonesia, stopped the export of minerals. That resulted in significant increase in nickel prices and their volatility. The increase of conditional variances was also observed in 2015 when there was an oversupply in the nickel market as far as the US dollar strengthening. Nevertheless, their conditional correlation coefficient remain almost stable and close to unity.

1 Introduction

Nickel is among six non-ferrous metals traded on the London Metal Exchange (LME). The knowledge of process of price discovery is crucial to the participants of commodity markets. The recent papers put interest on the most liquid markets such as aluminum and copper futures. Less is known about the others, especially the nickel market. Nguyen (2004), Watkins and McAleer (2006), Figuerola-Ferretti and Gonzalo (2010) show that nickel spot and futures prices are non-stationary and co-integrated. Using VEC models, Figuerola-Ferretti and Gonzalo reveal that their

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spread has not co-integrating properties and futures prices do not react significantly to the equilibrium error. They do not reject the hypothesis of co-integrating spreads only for copper futures. McMillan (2005) on daily data discover that non-ferrous returns variances and covariance are time-varying. Nowman and Wang (2001) note that volatility of prices is highly dependent on the level of prices.

Nickel properties result in a variety of its applications in the industry. It is mainly used in the production of stainless steel (66% of world usage) (Crabby 2003, p. 336–443). While mine nickel production is scattered all over the world: Philippines (17% of world nickel production in 2016), Canada (11%), Russia (11%), New Caledonia (10%), Australia (10%), its usage is concentrated in China (55% of world demand in 2017) (USGS, Mineral Commodity Summaries 2018).

The aim of the paper is the analysis of nickel pricing on the London Metal Exchange after the crisis on financial markets in 2007–2009. It is supposed that after the crisis prices are still co-integrated and their increased volatility should be observed. To do this, based on risk premium and cost-of-carry models, vector error correction model is specified on log spot and 3-month nickel futures prices in the period 01/01/2010–30/12/2017 (2086 daily observations). Because of the high volatility of price returns the VEC model is combined with the bivariate GARCH to focus on the evolution of conditional variances and conditional correlation coefficient over the time. Computations are performed using Microfit 5 and Stata 14 SE. The data source is the LME website.

The remainder of the paper proceeds as follows. The next section describes the method. Data and empirical results are reported in Sect. 3. The final section concludes the study.

2 Method

The relationship between spot and futures prices is analyzed on the base of the risk premium model as well as on the cost-of-carry model. In the first, the future price is equal to the expected spot price plus a risk premium. In the second, difference between the current spot and futures price is explained by the price of storage, warehousing costs or convenience yield. While testing the cost-of-carry hypothesis, the hypothesis of the risk premium is verified at the same time (Watkins and McAleer 2006).

In the paper, VEC model is combined with DCC-MGARCH (Johansen 1991; Engle 2002):

$$\Delta lnN3_t = \sum_{k=1}^{p-1} \alpha_k^{(1)} \Delta lnN3_{t-k} + \sum_{k=1}^{p-1} \beta_k^{(1)} \Delta lnN0_{t-k} + \delta^{(1)} e_{t-1} + \xi_t^{(1)} \tag{1a}$$

$$\Delta lnN0_t = \sum_{k=1}^{p-1} \alpha_k^{(2)} \Delta lnN0_{t-k} + \sum_{k=1}^{p-1} \beta_k^{(2)} \Delta lnN3_{t-k} + \delta^{(2)} e_{t-1} + \xi_t^{(2)} \tag{1b}$$

$$e_t = lnN3_t - \phi_0 - \phi_1 lnN0_t \tag{1c}$$

$$\xi_t = H_t^{0,5} v_t \qquad H_t = D_t^{0,5} R_t D_t^{0,5} \tag{2a}$$

$$R_t = diag(Q_t)^{-0,5} Q_t diag(Q_t)^{-0,5} \tag{2b}$$

$$Q_t = (1 - \lambda_1 - \lambda_2)R + \lambda_1 \Psi_{t-1} + \lambda_2 Q_{t-1} \tag{2c}$$

where: $lnN0_t$, $lnN3_t$—log price of spot and 3-month futures contracts, $\xi_t^{(i)}$—error term, H_t—Cholesky factor of the time-varying conditional covariance matrix, v_t—vector of i.i.d innovations, D_t—diagonal matrix of conditional variances in which each element σ_{kt}^2 evolves according to a univariate GARCH(p_k, q_k) processes $\sigma_{kt}^2 = s_i + \sum_{j=1}^{p_k} a_j^{(k)} \xi_{j,t-j}^2 + \sum_{j=1}^{q_k} b_j^{(k)} \sigma_{k,t-j}^2$, R_t—matrix of means to which the dynamic process in Eq. (2c) reverts, Ψ_t—rolling estimator of the correlation matrix $\hat{\xi}_t$, λ_1, λ_2—parameters that govern the dynamics of conditional correlations such that $0 \leq \lambda_1 + \lambda_2 < 1$.

The order of integration of the variables is tested using ADF-GLS and KPSS tests. The model estimation has 2 steps. First, co-integrating vector is identified using the Johansen procedure. Second, the residuals from the co-integrating vectors are used to estimate the model (Eqs. (1a)–(2c)) with the maximum likelihood method. Then it is validated and several hypotheses are tested to analyse the relationship between spot and futures prices.

3 Data and Empirical Results

The Primary Nickel (99.80% purity) is sold in 6 tonnes lots. Price quotation is in US dollars per tonne (USD/t). Settlement is physical. Nickel can be traded on LMEselect from 1 am to 7 pm London time, 24 h a day on the inter-office telephone market and during the Rings. In the paper LME official seller prices are used (last price quoted during the second Ring session).

As demonstrated on Fig. 1., log daily price series of spot and 3-month nickel futures contracts seem to be non-stationary and co-integrated. That assumptions are supported by the results of the ADF-GLS and KPSS tests[1]. Next, the number of lags $p = 11$ in VAR is selected using AIC information criterion. The rank of co-integration in VECM is tested with the maximal eigenvalue and trace tests.

[1]The results are available from the author on the request.

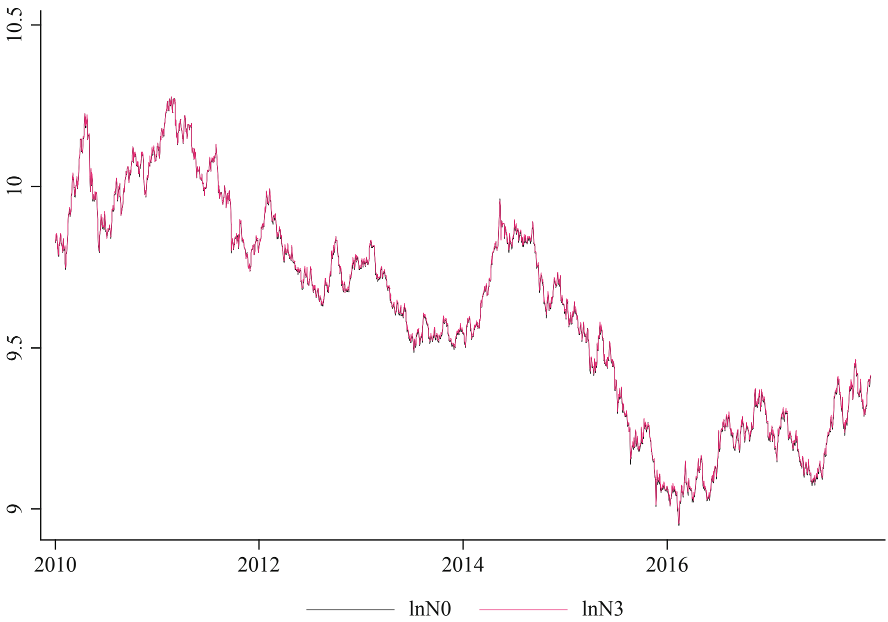

Fig. 1 Daily logs of spot and 3-month futures nickel prices at LME, 01/01/2010–30/12/2017

There exist one co-integrating vector[2]. So, spot and 3-month futures follow a common stochastic trend.

Then, the over-identifying restrictions are set on the parameters of co-integrating vectors. The hypothesis stating that spread has co-integrating properties is rejected ($LR = 23.718$ test statistic is asymptotically distributed as $\chi^2(1)$, 95% bootstrap critical value is 4.177)[3].

Residuals from co-integrating vector $\boldsymbol{e_t = lnN3_t - 0.9967lnN0_t - 0.0360}$ are used to estimate the model with the maximum likelihood method. Because of high volatility of prices, it is necessary to include in the final model 10 lags ($\boldsymbol{p = 11}$) in the mean equations and it is set GARCH(1 5; 1)[4]. The main estimation and validation results are gathered in Table 1. First, considering technical aspects of the models: (1) they are properly specified as in the Ljung Box test null hypothesis is not rejected up to 20th order, (2) the hypothesis of CCC-MGARCH model is rejected (see the estimates of $\boldsymbol{VC_1}$ and $\boldsymbol{VC_2}$ in Table 1.) as far as (3) the hypothesis of integrated multivariate GARCH is (see the estimates of $\boldsymbol{IG}$ and $\boldsymbol{IG_k}$ test statistics in Table 1.).

[2]The results are available from the author on the request. The co-integrating vector is with restricted intercepts and no trends in the VAR.

[3]In previous studies on LME non-ferrous contracts, for example in Figuerola-Ferretti and Gonzalo (2010) or Chylińska (2018), the standard co-integrating vector (1,-1) was not rejected only for copper or aluminum.

[4]The day-of-the-week effects was tested and there were not such effects in variance.

Table 1 Estimation and validation results of the VECM DCC-GARCH model

Variable/Test stat.	Equation			
	ΔlnN3		ΔlnN0	
	Coeff.	Std. err.	Coeff.	Std. error
	Mean			
e_{t-1}	−0.6377	0.3006	−0.4010	0.3015
	Variance			
ξ^2_{t-1}	0.0760	0.0238	0.0798	0.0286
ξ^2_{t-5}	0.0720	0.0316	0.0711	0.0321
σ^2_{t-1}	0.4501	0.1785	0.4309	0.2133
s_i	0.0001	0.0000	0.0001	0.0000
	Validation			
Statistic	Estimate	*p*-value	Estimate	*p*-value
IG_k	7.79	0.01	5.84	0.02
W_{1k}	4.97	0.89	6.11	0.81
W_{2k}	3.82	0.96	6.56	0.77
W_{3k}	4.50	0.03	1.77	0.18
	Residuals			
LB(1)	0.07	0.80	0.07	0.79
LB(5)	4.68	0.46	0.21	1.00
LB(10)	6.23	0.80	1.14	1.00
LB(15)	13.64	0.55	10.97	0.76
LB(20)	21.68	0.36	25.24	0.19
	Sq. of residuals			
LB(1)	0.08	0.78	0.01	0.94
LB(5)	0.19	1.00	3.94	0.56
LB(10)	0.79	1.00	5.92	0.82
LB(15)	11.86	0.69	12.75	0.62
LB(20)	26.74	0.14	20.11	0.45

W_{1k}—Wald test statistic under H_0 distributed as $\chi^2(p-1)$, the price of spot (futures) contract do not Granger cause the price of futures (spot) contract; W_{2k}—Wald test statistic under H_0 distributed as $\chi^2(p-1)$, the past prices of contract do not affect its current price; W_{3k}—Wald test statistics under H_0 distributed as $\chi^2(1)$, the price of futures contracts departures from their long run equilibrium relationship do not affect the current price of the contract ($H_0 : \delta^{(i)} = 0, i = 1, 2$); $W = 44.20$, Wald test statistics under H_0 distributed as $\chi^2(1)$, the price of futures contracts departures from their long run equilibrium relationship equally quickly revert to the long-run equilibrium relationship ($H_0 : \delta^{(1)} = \delta^{(2)}$); $IG = 18.92$, GARCH vs. IGARCH, Wald test statistic under H_0 distributed as $\chi^2(2)$; $VC_1 = 139.59$, VECM CCC-GARCH vs. VECM DCC-GARCH, Wald test statistic under H_0 distributed as $\chi^2(2)$; $VC_2 = 13.34$, no return of conditional variances to their mean levels, $H_0 : \lambda_1 + \lambda_2 = 1$, *t* test statistic under H_0 distributed as $N(0, 1)$ in large samples; *LB*(*k*)—Ljung-Box portmanteau test statistic for autocorrelation of order up to *k*, under H_0 distributed as $\chi^2(k)$

What is more interesting, the hypothesis stating that the price of futures contracts departures from their long run equilibrium relationship do not affect the current price of the contract is rejected only for 3 month futures contracts (see the estimates of $\boldsymbol{W_3}$ test statistics in Table 1.). The hypothesis stating that the past prices of contract do

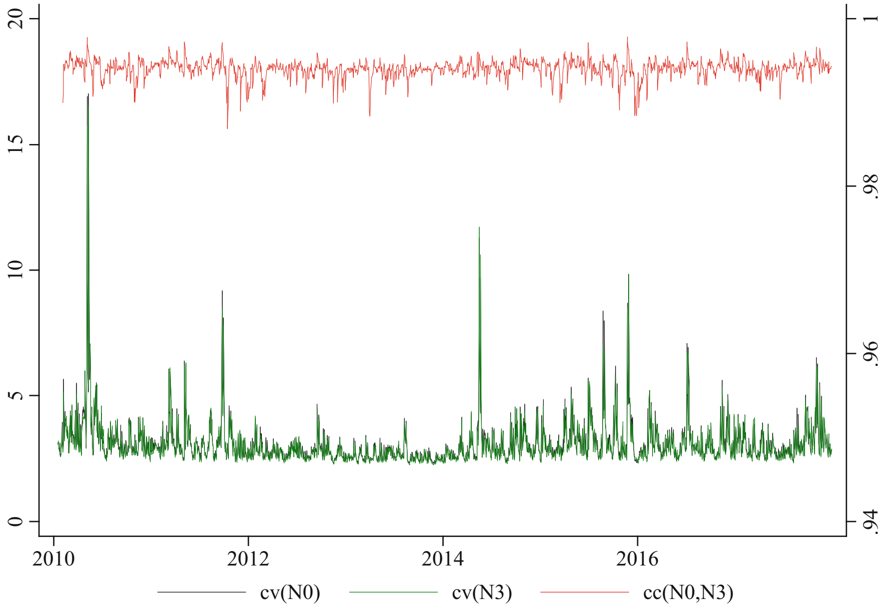

Fig. 2 Conditional correlation, $cc(\cdot,\cdot)$, (right axis) and conditional variances, $cv(\cdot)$, ($\%^2$) (left axis) of the daily log rates of return on spot and 3-month futures nickel prices at LME, 01/01/2010–30/12/2017

not affect its current price is not rejected as far as there is found no Granger causality (see the estimates of $\boldsymbol{W_1}$ and $\boldsymbol{W_2}$ test statistics in Table 1.).

Finally, the behaviour of the conditional correlation coefficient and conditional variances for the log rates of returns on spot and 3-month nickel futures at LME is plotted on Fig. 2. Periods of increased conditional variances are observed. Volatility of nickel prices has been reacting to the situation on financial markets, especially in May 2010 when European Union announced financial help to Greece which is regarded as one step of financial crisis. Next increase was observed in October 2011, when there was a next step in Greek financial crisis (the agreement to write-off the Greek Dept). At the beginning of 2014, the one of the nickel producing country, Indonesia stopped the export of minerals[5]. That resulted in significant increase in nickel prices and their volatility. The increase of conditional variances was also observed in 2015 when there was an oversupply in the nickel market as far as the US dollar strengthening. While increases of nickel conditional variances are relatively high, they return quickly to the previous level. Conditional correlation coefficient remain close to one during the period.

[5]In 2014, nickel production in Indonesia production decreased by 60% compared to the previous year.

4 Conclusion

The aim of this paper is the analysis of nickel pricing on the London Metal Exchange. To do this a VECM DCC-MGARCH is estimated on daily data from January 2010 to December 2017 (2086 observations). Empirical results for nickel markets seem to be close to that for the other commodity markets like copper or aluminum (see Chylińska and Miłobędzki (2017), Chylińska (2018)). Spot and futures prices exhibit a common stochastic trend. However, unlike on the other non-ferrous markets, the hypothesis of co-integrating spread properties is rejected. So, the results of the study are consistent with the pre-crisis knowledge on nickel pricing. Periods of increased conditional variances are observed. Volatility of nickel prices reacts not only to the situation on financial markets (Greek financial crisis, US dollar strengthening) but also reacts to changes in the volume of nickel production (Indonesia's nickel export ban). Nevertheless, conditional correlation coefficient remain close to one during the period.

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Impact of Macroeconomic and Financial Factors on the Commodity Price Indexes in the Context of Financialization

Bogdan Włodarczyk and Marek Szturo

Abstract The most visible feature of the financialization of commodity markets is probably a significant increase in the strength of correlation between market parameters, in relation to commodity and financial markets. Another financial aspect concerns the rates of return and the volatility of spot prices on commodities. In this context, the purpose of the article is to determine the impact of selected macroeconomic and financial factors on the value of price indices of commodity markets. This will allow us to attempt to address the research problem, which is to determine the scale of the impact of the financial factors on commodity markets. On the basis of the conducted research, it was found that the prices of a relatively small number of commodities are exclusively related to the factor related to the stock market. However, the largest group of commodity indexes is associated with both variables representing macroeconomic and financial fields. Considering the above, it can be concluded that the process of financialization of commodity markets has become real, but it has not dominated all commodity markets so far.

1 Introduction

Commodities are generally viewed as real assets. The prices of commodities and raw materials depend on the demand for the means of production and the production capacity of suppliers and producers. A long position in a futures contract for commodities is a gamble on the increase in their price. The vast majority of futures contracts of commodities are closed before the maturity date, so trading in futures contracts does not affect the price of physical commodities (Blackwell et al. 2007). It is a traditional view of the relationship between futures (forward markets) and instant commodities (spot markets). However, this view has been seriously questioned in the last 20 years; mainly by the observed increased presence of financial investors on commodity markets. This phenomenon is now known as the financialization of

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commodity markets. The most visible trait of financialization of commodity markets is probably the significantly increased correlation between market parameters, of commodity and financial markets. Another manifestation of financialization is concerning the rates of return and the volatility of spot prices of commodities. In particular, it seems that the financialization and growing speculation of commodity futures markets has a significant impact on the spot prices of commodities in real transactions. The relationship between speculation and spot prices, however is not fully explained. In this context, the purpose of this article is to determine the impact of selected macroeconomic and financial factors on the value of price indices of commodity markets. This will allow us to attempt to address the stated research problem, which is to determine the impact scale of the financial sphere on commodity markets.

2 Financialization as the Process Influencing Financial Variables on Commodity Markets

The essence of financialization is the growing dominance of the financial sector, in particular capital markets and banks with their multiple subsidiaries, over the non-financial sector. The financial sphere became more important than the macroeconomic sphere. It generates more and more revenues, and financial markets together with financial entities which operate on them trade in financial instruments, significantly influencing the decisions of non-financial entities. Financialization is also distinguished by factors such as the ever-widening range of financial instruments and institutions operating in the most developed countries around the world, the increase in financial assets in the total value of non-financial entities, the increase in the importance of financial instruments in controlling large enterprises, the growth in credit-driven consumption of households and increasing debt of the public sector (Tang and Xiong 2012). One of the most interesting and at the same time most recent manifestations of the financialization process are the changes taking place on the international commodity markets (especially on the stock market). This phenomena refer mainly to determinants affecting prices of commodities, their volatility and the volume and frequency of transactions.

The view, that commodity index investment was a major driver of the spike in commodity futures prices, is called “Masters’ Hypothesis”. It argues that demand from index funds created a bubble in commodity prices, with the result that prices far exceeded fundamental values (Masters and White 2008).

Several researchers support that link between market positions of index funds and commodity futures price movements (UNCTAD 2011). Some of them find significant relationship between index fund trading activity and returns in commodity markets for crude oil, aluminum, copper and food (Gilbert 2009, 2010). There were also findings that index investment flows are an important determinant of price changes along with several other conditioning variables (Singleton 2011).

Brunetti and Büyükşahin (2009) conduct Granger tests and do not find a statistical link between swap dealers positions and subsequent returns or volatility in the crude oil, natural gas, and corn futures markets. Stoll and Whaley (2010), Sanders and Irwin (2010), find no evidence for “Masters’ Hypothesis” in agricultural futures markets. In further researches Büyükşahin and Robe (2011) show that index fund activity is not associated with the increasing correlation between commodity and stock returns.

In some results it occurs that there was a style effect, which replaced the financial crisis effect as the main occurrence of risk spillovers. This was the investment behavior of commodity index traders who tend to sell stocks and commodities simultaneously as a reaction to changes in the market (Adams and Glueck 2015).

The increase in investor activity can be expected to bring benefits in terms of market efficiency but the ongoing financialisation of commodity markets may at times significantly affect market dynamics (Domanski and Heath 2007).

Three basic determinants of commodity prices can be found in the literature. First, resulting from many commodities being used as input in the production process, both the demand for them and their prices increase with the increase in global economic activity (Kilian 2009; Kilian and Murphy 2014; Kilian and Lee 2014; Alquist and Coibion 2014). Second, because commodity prices are denominated in US dollars, the depreciation of the US dollar results in lowering commodity prices in the local currency following an increase in demand for these commodities, which causes the prices of commodities to rise. Therefore, the exchange rate affects the competitiveness of producers and the purchasing power of consumers (Schuh 1974; Frankel 1986; Saghaian et al. 2002; Cho et al. 2002). Thirdly, due to the fact that monetary policy affects commodity prices, lower interest rates reduce the incentive to implement spot transactions, whilst increasing the incentive to maintain inventories, thereby increasing the demand for commodity derivatives, which in turn increases the prices of basic products (Cabrales et al. 2014). In particular, it seems that financialization and large-scale of speculation on future commodity markets have a significant impact on the prices of physical goods. The nature of this relationship however, is a debatable issue. In the literature review, Haase et al. (2016) analyzed 100 articles that have been published on the subject of financialization of commodity markets in the last decade. It was found that the number of articles in which the positive effect of speculation was observed and those in which the negative impact was shown is very similar. Therefore, the nature of the relationship between speculation on the future commodity markets and the prices of basic goods has not been explicitly confirmed. Conflicting results may also come from inadequately designed empirical models and the lack of high quality data (Cheng and Xiong 2014). Based on the above considerations, an attempt was made to study, the results of which in the form of preliminary results are presented in this article.

Financialization of commodity markets means that economic mechanisms that affect financial markets and financial investors may also be relevant for commodity markets. Commodities may respond to the same global macroeconomic risks as equities. Index VIX was accepted as explanatory financial variable due to the results of the researches that stated that commodity strategies are the only that respond well to a rising level of VIX (Munenzon 2012). The other results provide a vivid example of how financial distress experienced by financial traders during the recent financial crisis may cause them to consume rather than provide liquidity in commodity futures markets. By using changes in the VIX to proxy for shocks to financial traders' risk-bearing capacity it was found that during the crisis, but not before it, increases in the VIX led financial traders to reduce their net long positions in 12 agricultural commodities (Cheng et al. 2012).

REA index, is calculated from cargo ship freight rates. It is regarded as a proxy for global economic activities related to commodities (Kilian 2009)—a proxy of demand for all commodities. Fluctuations in demand can cause fluctuations in commodity prices.

3 Area of Research and Research Methods

The undertaken research problem relates to determining the scale of impact the financial sphere have on commodity markets. The article will present the preliminary results of the study, which aimed to determine the impact of selected macroeconomic and financial variables on the value of price indices of commodity markets. The subject scope of the study included the dependence between two variables (one of which is a variable referring to the macroeconomic processes and the other to the financial field of the economy) and price indexes of future commodity market (31 indexes). The time range of the study looks at the period of time from 1990 to 2018. The first variable adopted for the study regarding the macroeconomic processes is the level of economic activity measured using the REA index—Index of Global Real Economic Activity (Kilian 2009). The second financial variable is the volatility index VIX, expressing the volatility of the S&P500 index expressing the expectations of investors, calculated on the basis of quotations of the S&P500 index option. Time series of commodity market indexes have been taken from the Reuters databases. The analysis is based on monthly closing value of two indexes: REA index and VIX index.

Considering that the VIX index concerns the US economy, in the future an attempt will be made to build its own volatility index related to the global equity market. In order to check for robustness of our results we change the frequency of our explanatory variables, from monthly closing values to quarterly closing values. For robustness check, the results remain qualitatively intact.

Based on the values of specific commodity indexes, their logarithmic growths (monthly) have been selected. Next some normality tests of the logarithmic growth series were conducted. Shapiro-Wilk and Jarque-Bera tests have been used. In every case with the probability of 95%, the null hypothesis was rejected; justified by stating that the examined growth series can be described by using normal distribution. In the following steps the stationary of the studied time series was verified, using an extended version of Dickey-Fuller test (ADF). Based on that the stationary of analyzed time series was concluded.

Time series of accepted variables and selected raw material indexes have been subjected to the Granger causality test in the MATLAB® environment (version R2013a). A numerical experiment was carried out regarding the test of causality in the Granger sense between the selected variables and the indexes from the commodity markets. Before verification of the hypothesis concerning the existence of causality, between the two selected variables (REA index and VIX index) and raw material market indexes, the time series were cleared of missing observations and the so-called outlier detection (Median Absolute Deviation method).

The following futures price indexes time series were used for the following commodities: crude oil (Brent, WTI Oil), gas (US), gasoline, heating oil, cotton, gold, palladium, platinum, silver, copper, wheat, corn, soybean, rice, beef, lean pork, beef livestock, orange juice, cocoa, coffee, sugar and lumber. The above group of raw materials was accepted for research, due to their dominant share in international trade and due to the fact that they became the base instruments for the majority of listed commodity derivatives within the stock market.

The Granger test started of by building an autoregressive equation with delay distribution (ADL—autoregressive distributed lag). Due to the fact that the Granger test is sensitive to number of delays, which can impact the cause direction, only delyas of series 1–4 were tested. The statement that x is the cause of y consists of testing the null hypothesis about the lack of causality, which assumes that the delayed values of x are statistically insignificant. The alternative hypothesis says that some of these variables are statistically significant. The Fisher-Snedecor test was used to verify the null hypothesis.

4 Research Results

Table 1 presents descriptive statistics for the time series adopted for the study. In addition to the basic parameters of the distribution, the percentage of outliers is presented.

The mean values are positive for the vast majority of indexes. The distribution of most time series is negative skewed and leptokurtic.

The synthetic results of the numerical experiment consist of the results of the Granger causality test between the filtered time series of the selected two variables and the raw material market indexes. The following tables present aggregate values of Granger's causality test statistics (values of F-Snedecor). The "Critical Value" column contains the critical values of the tests (the threshold of rejection of the null hypothesis).

The Table 2 presents the results of testing the null hypothesis (lack of causality in the Granger sense) for variables referring to the economic activity (REA index). In respect to 15 commodities indexes, the null hypothesis was rejected (the value of statistics F is greater than the critical value). This means adopting an alternative hypothesis in which there is a causality within the Granger sense between the REA index and the indices of commodities. The percentage of surveyed indices for which

Table 1 Descriptive statistics of time series of values of REA and VIX indexes and monthly log returns of commodity indexes

Time series of indexes	Mean	Std. Dev.	Skewness	Kurtosis	Percentage of outliers
REA index	−0.506	25.773	0.627	2.870	1.8
VIX index	25.482	7.965	1.985	8.865	6.3
Time series of commodity indexes (log returns)	Mean (%)	Std. Dev.	Skewness	Kurtosis	Percentage of outliers
LondonCocoaFuture (CA.F)	0.235	0.856	0.652	4.265	1.2
BrentOilFuture (CB.F)	0.822	7.654	0.674	5.567	0.3
CocoaFuture (CC.F)	0.168	0.423	0.215	4.235	0.4
CrudeOilWTIFuture (CL.F)	0.941	1.362	0.951	6.431	3.6
Cotton#2Future (CT.F)	0.134	2.668	−0.125	0.345	2.5
GoldFuture (GC.F)	0.536	0.522	0.458	6.452	3.3
CopperFuture (HG.F)	0.298	1.458	0.292	1.245	0.3
HeatingOilFuture (HO.F)	1.072	2.458	0.457	2.547	0.3
FeederCattleFuture (GF.F)	0.209	0.902	0.879	2.236	6.9
LeanHogsFuture (HE.F)	0.170	0.623	0.021	1.234	5.1
Coffee’C’Future (KC.F)	−0.025	1.726	0.015	0.587	13.5
WheatKCBTFuture (KE.F)	0.066	0.436	−0.354	0.631	1.5
LiveCattleFuture (LE.F)	0.176	0.514	−0.215	0.154	0.3
WheatSpringFuture (MW.F)	0.122	0.782	−0.359	2.154	2.1
LumberFuture (LS.F)	0.277	0.226	0.231	0.212	0.0
GasOilFuture (LF.F)	1.181	0.961	0.532	1.254	6.9
NaturalGasFuture (NG.F)	0.431	1.021	−0.752	0.812	0.0
OrangeJuiceFuture (OJ.F)	−0.051	0.954	0.016	0.879	0.0
PalladiumFuture (PA.F)	2.327	0.632	0.843	1.214	14.0
PlatinumFuture (PL.F)	0.147	2.215	0.987	6.235	12.0
GasolineFuture (RB.F)	0.659	1.141	0.689	2.231	13.5
LondonCoffeeFuture (RM.F)	−0.801	0.623	0.112	1.563	12.0
Sugar#11Future (SB.F)	0.073	0.932	0.223	0.852	3.2
SilverFuture (SI.F)	0.383	1.263	0.896	4.124	15.2
LondonSugarFuture (SW.F)	0.072	1.532	0.954	2.132	14.1
CornFuture (ZC.F)	0.096	0.687	0.798	1.874	6.9
SoybeanOilFuture (ZL.F)	0.071	0.523	0.235	0.546	3.2
SoybeanMealFuture (ZM.F)	0.074	0.532	0.212	0.752	0.0
RoughRiceFuture (ZR.F)	0.149	0.432	0.113	0.741	0.0
SoybeanFuture (ZS.F)	0.052	0.745	0.132	0.895	0.3
WheatFuture (ZW.F)	0.064	0.476	0.054	0.739	2.1

Source: Own studies

Granger causality was confirmed was 51%. Therefore, it can be concluded that in these cases the fundamental relationship between the level of economic activity and the expectations of changes in commodity prices (futures prices) was confirmed.

Table 2 Results of Granger causality testing for the REA Index, VIX Index and commodity market indexes

Commodity index	Alpha	Index REA (Global Real Economic Activity)		Index VIX (CBOE Volatility Index)	
		F	Critical value	F	Critical value
LondonCocoaFuture (CA.F)	0.05	0.5538	3.8394	0.9661	3.7056
BrentOilFuture (CB.F)	0.05	**14.0873**	**1.8707**	**14.1558**	**2.3029**
CocoaFuture (CC.F)	0.05	**7.4588**	**2.6278**	**7.6823**	**2.5180**
CrudeOilWTIFuture (CL.F)	0.05	**14.4972**	**2.3287**	**14.3061**	**2.6327**
Cotton#2Future (CT.F)	0.05	**8.7994**	**1.9457**	**8.8534**	**2.4458**
GoldFuture (GC.F)	0.05	**8.3137**	**2.1361**	**8.4512**	**1.8511**
CopperFuture (HG.F)	0.05	**7.9406**	**1.7421**	1.8809	2.9306
HeatingOilFuture (HO.F)	0.05	**13.3022**	**2.0012**	0.8370	3.2448
FeederCattleFuture (GF.F)	0.05	1.7237	3.6439	**8.0903**	**1.3839**
LeanHogsFuture (HE.F)	0.05	1.1551	3.6992	**13.0876**	**1.7377**
Coffee'C'Future (KC.F)	0.05	**3.9739**	**3.0396**	**3.4503**	**3.0516**
WheatKCBTFuture (KE.F)	0.05	0.5297	3.2133	1.2118	3.1934
LiveCattleFuture (LE.F)	0.05	2.0520	3.7232	1.7244	3.0246
WheatSpringFuture (MW.F)	0.05	**8.3362**	**2.0533**	**8.1325**	**2.2063**
LumberFuture (LS.F)	0.05	0.7879	3.5597	1.0551	3.6655
GasOilFuture (LF.F)	0.05	0.6028	3.7636	0.4709	3.5144
NaturalGasFuture (NG.F)	0.05	1.5925	3.0711	2.4016	2.9245
OrangeJuiceFuture (OJ.F)	0.05	**4.1796**	**3.7132**	**3.717**	**3.4661**
PalladiumFuture (PA.F)	0.05	**6.8944**	**1.8500**	**6.1083**	**1.3341**
PlatinumFuture (PL.F)	0.05	**8.8309**	**1.5117**	**8.8205**	**2.2010**
GasolineFuture (RB.F)	0.05	**5.7309**	**3.6967**	**6.1265**	**3.6659**
LondonCoffeeFuture (RM.F)	0.05	0.1481	3.7056	0.9440	3.9245
Sugar#11Future (SB.F)	0.05	0.9999	3.6661	0.1270	3.0272
SilverFuture (SI.F)	0.05	**4.7873**	**2.9540**	0.9661	3.7056
LondonSugarFuture (SW.F)	0.05	**7.3321**	**3.9581**	**14.1558**	**2.3029**
CornFuture (ZC.F)	0.05	**5.9129**	**1.7504**	**7.6823**	**2.5180**
SoybeanOilFuture (ZL.F)	0.05	1.4181	3.8520	**14.3061**	**2.6327**
SoybeanMealFuture (ZM.F)	0.05	0.8488	3.5058	**8.8534**	**2.4458**
RoughRiceFuture (ZR.F)	0.05	**6.2510**	**2.3979**	**8.4512**	**1.8511**
SoybeanFuture (ZS.F)	0.05	2.6189	3.7331	1.8809	2.9306
WheatFuture (ZW.F)	0.05	**4.5665**	**2.3170**	0.8370	3.2448

Source: Own studies

This applied mainly to precious metals (gold, platinum, palladium, silver), cereals (wheat, soybean, rice) and energy raw materials (crude oil, gasoline and fuel oil).

The results of testing the null hypothesis (no dependence in the Granger sense) for the adopted financial variable (VIX index originating from the stock market). With regard to 18 commodities indexes, the null hypothesis was rejected, which meant the adoption of an alternative hypothesis about the existence of causality in the Granger sense between the VIX index and the given commodity indexes. The percentage of these indices was 58%. These cases present that the causality between the investor expectations regarding the volatility of the S&P500 index and the investor expectations regarding future prices of commodities was confirmed. This concerned the following commodities groups: soft raw materials (cocoa, coffee, orange juice, sugar, cotton), precious metals, cereals and meat; and the energy resources to somewhat a lesser extent.

Taking into considerations the obtained results, the following groups of commodity indexes have been distinguished, due to the existence of causality in relation to two adopted variables:

Group I—indexes of commodities for which only the causality in the Granger sense was found in relation to the REA index;
Group II—indexes of commodities with Granger causality only with the VIX index;
Group III—indexes of commodities for which Granger causality was found, both with the REA index and the VIX index;
Group IV—indexes of commodities for which no Granger causality was found in relation to any accepted variables.

In the first group there were four indexes (copper, heating oil, silver and wheat). It can be interpreted that the prices of these commodities depend very traditionally on the economic activity in the sphere of non-financial enterprises, and the markets for these commodities do not have any lasting and significant influence of the financing process.

In the second group there were six indexes representing meat, coffee, soybean and soybean oil markets. In these markets, expectations regarding price volatility were related to one of the basic variables regarding the prices of shares (VIX index). Therefore, it can be concluded that these commodity markets have clearly observed the effects of the financialization process. The prices of these commodities are related to the expectations of investors on the capital markets.

In the third group there were 12 indexes from the entire cross-section of the analysed commodity markets. These include soft commodities, precious metals, cereals and energy sources. It can be concluded that in these markets price determinants are both related to the macroeconomic situation as well as to expectations regarding volatility in capital markets (stocks). This means that both motivations of market participants are getting worse and depending on the conditions, the impact of the economic activity or financial markets may be more important amongst these.

In the fourth group, there were nine indexes from the area of soft raw materials (cocoa coffee noted in London, sugar), cereals (wheat, soy), livestock, lumber, gasoline and natural gas. The markets for these commodities with price expectations may be decisive for other factors not included in the present study. For example, these may be, monetary policy, international relations, climate conditions, etc. However, there was no causality in Granger sense with respect to the adopted variables.

5 Conclusions

Commodity prices are one of the main pillars of global economy. In recent decades, the financialization process has expanded the catalog of determinants influencing them not with variables originating from financial markets. The result of such activity may be an increasing risk to the commodity markets.

The purpose of this article was to determine the impact of selected macroeconomic and financial factors on the value of price indices of commodity markets. Based on the research conducted, it was found, that based on Granger's causality, that the prices of a relatively small number of commodities are exclusively related to the factor related to the stock market. The largest group of commodity indexes are related to both variables representing economic activity and financial processes. Considering the above, it can be concluded that the process of financialization of commodity markets has become a fact, but it has not dominated all commodity markets as yet. The increasing impacts of financial variables, in particular related to the expectations of future prices of financial assets (stocks) means that speculative investors who build investment portfolios using commodity derivatives play a significant role on commodity markets. It is possible to regress this process if given time, if supervisory restrictions on speculation on commodity markets are introduced in relation to the range of fluctuations in commodity prices with significant economic significance.

A separate issue seems to be the issue of diversification of impact, with soft commodity markets (cocoa, coffee, sugar) seemingly more susceptible to the financialization process. The markets of precious metals and energy raw materials, although they are also subjected to the processes of financial sphere, are also strongly related to the economic activity, which results from their specificity such as limited production or extraction, the influence of political risk or monopolistic position of producers.

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Part III
Corporate Finance

Conceptual Framework for Lending Money Outside Business Groups: Evidence from Poland

Anna Białek-Jaworska, Dominika Gadowska-dos Santos, and Robert Faff

Abstract This paper builds a framework for the study of the provision of loans by non-financial companies outside business groups. This framework aims to show the role of cash holdings in providing loans by non-financial companies and constitutes the background for future research of this phenomenon. We provide evidence of the use of cash holdings for loans provision outside business group on the basis of Polish case. In this purpose, we apply the General Method of Moments (GMM) approach. Our findings confirm, that non-financial private companies provide loans outside the business groups with the use of cash holdings retrieved from bank loans and cash flows. We contribute to the literature by indicating that in addition to the common use of cash holdings for financial flexibility and the internal capital market created inside business groups—enterprises' access to finance in transition economies could be also improved by loans provided by non-financial companies with the use of cash holdings.

1 Introduction

This paper presents a conceptual framework for the study of the provision of loans by non-financial companies outside their business groups. A conceptual framework represents the synthesis of literature on how to explain a phenomenon and maps out the actions required in the course of the study given his previous knowledge of other researchers' point of view and his observations on the subject of research. The framework aims to show the role of corporate cash holdings in mitigating

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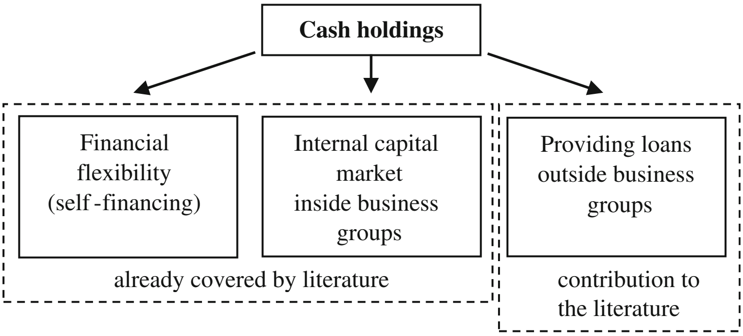

Fig. 1 Business groups members and stand-alone firms usage of cash holdings

SMEs financial constraints by improving the access to finance and constitutes the background for empirical research on non-financial firms lending money outside business groups.

In this paper we analyze the supply side of loans provisions outside the business group. Based on literature review on cash holdings, trade credit and redistribution effect of access to bank loans through trade credit channel we identify potential contribution to the literature. Our conceptual framework shows loans provision outside the business group as an extension to the common use of cash holdings for financial flexibility and an internal capital market within business groups (Fig. 1). We provide some evidence for Polish case to support our predictions. This way, our conceptual framework offers a foundation for future research on the lending practices of non-financial firms outside their business groups.

2 Cash Holdings Motives Recognized in the Literature

Cash holdings are being explained within corporate finance theory framework, using mostly agency theory, pecking order theory, trade-off theory and signaling theory. Moreover, research often relates to economic phenomena resulting from market failures, such as asymmetric information, adverse selection and moral hazard. According to Keynes (1936), there are three main motives, for a company acting rationally, to accumulate cash: transactions motive (so as to avoid costs of external financing or those connected with asset sale) (Miller and Orr 1966; Mulligan 1997), speculative motive (to benefit from favorable changes in prices) (Kaplan et al. 2006) or a precautionary motive (to reduce the risk of failing to raise the necessary funds to finance profitable investment projects or as a cushion against unexpected needs when hedging against insolvency and bankruptcy) (Riddick and Whited 2009).

2.1 Financial Flexibility

The increase in **cash holdings** is closely linked with financial flexibility, i.e. the ability of a company to respond to changes in its cash flows or investment opportunities set by providing cost-effective sources of financing (Denis 2011). Cash holdings are determined by manager's expectations of the prospects for future growth and future financing costs (Frésard 2012).

Managers arrange their liquidity management policies so as to respond flexibly to unexpected changes in the firm's investment opportunity set (Denis 2011). Inside business groups, companies with a diversified firm structure, the cash flows of operating segments with poor growth opportunities can be used to subsidize those segments with good growth opportunities, but poor cash flows. This allows for the reduction of magnitude of financing frictions. Subramaniam et al. (2011) find that diversified firms have lower cash holdings than more specialized counterparties, as diversification might reduce financing frictions. Tong (2011) reports that the value of cash is significantly lower in diversified firms than in single-segment firms because of agency problems associated with the conglomerate structure.

2.2 Internal Capital Market Created by Business Groups

The literature on business groups underlines the role of loans provided within the internal capital market in liquidity management, and in financing investment projects of enterprises having limited access to bank loans. The research on loan provision focuses mostly on public companies (mainly in China and Chile) and the problem of tunneling of minor shareholders for the benefit of major ones who are focused on obtaining a higher and more certain rate of return than the dividend yield (He et al. 2016; Buchuk et al. 2014). Several studies on international corporations focus on analyzing the impact of thin capitalization rules on the transfer of profits and on the internal financing of related or co-related companies in business groups, with parent company in the USA.

Studies of the German market analyze the demand side, i.e. loans from partners as an alternative to bank loans or equity infusion. On the internal capital market, providing loans facilitates the transfer of funds—referred to as „funnel leverage" of business groups (He et al. 2016). Internal capital market may shift the lending from less effective projects to more effective ones. Moreover, the reallocation of intra-group loans is more common and plays a more important role in countries with less developed capital markets (Stein 1997). Buchuk et al. (2014) proved that intra-group loans in Chile improve business investment and their rates of return, due to strict regulations and the information disclosure about provided loans.

3 Redistribution Effect

The literature provides evidence of the "redistribution" effect through a trade credit channel as a mechanism of mitigating limitations in access to finance, particularly in periods of restrictive monetary policy or financial crisis (Love et al. 2007; Garcia-Appendini and Montoriol-Garriga 2013). Due to the redistribution effect, enterprises who have better access to finance provide trade credit to companies with financial constraints. Results of previous research point out that trade credit is a dominant source of finance for enterprises (Petersen and Rajan 1997). According to the redistribution view, firms accumulate cash holdings in periods of loose monetary policy to pass on their savings in the form of trade credit at a time of credit constraints. As a result, trade credit could be used to ensure sales growth.

Firms with a better access to bank financing offer more trade credit, which means that they may act as intermediaries between institutional lenders and firms financially constraint. Short-term bank loans are used for minimising transaction costs. In the periods of restrictive monetary policy, buyers facing bank funding constraints increase their demand for trade credit much more than those who do not experience credit rationing, thereby proving the existence of a strong monetary policy transmission channel (Petersen and Rajan 1997). Larger suppliers, with a broader access to diverse sources of funding (including bank loans), are capable of mitigating the effects of monetary restrictions through the transmission of funds in the form of trade credit. The reason is that, in periods of monetary tightening, small firms will be more likely to substitute bank credit with financing at the cost of their suppliers in the form of trade credit.

Yet, the more important the transactional role of trade credit over its financial role, the less trade credit can be used for mitigating the effects of monetary restrictions (Blasio 2005). Trade credit is a channel through which financing is redistributed between firms and credit is relocated from sellers who enjoy the access to bank financing towards buyers whose access to bank financing is limited (Guariglia and Mateut 2006; Taketa and Udell 2007). Profitable firms lend some part of their bank loan via trade credit, in order to support their business partners, but the size of this credit decreases as the availability of bank loans grows (Cull et al. 2007).

Disturbances in the redistribution mechanism transmitted via trade credit are caused by the worsening financial standing (as a result of the crisis) of traditional providers of this type of credit, i.e., firms with a higher level of short-term debt (Love et al. 2007). Trade credit is found to have a positive impact on the real output, the counter-cyclical pattern of the substitution effect being the spontaneous relaxation of constraints imposed by financial institutions in periods of economic stagnation and a self-triggering mechanism smoothing liberal crediting policies during the rapid growth periods (Huang et al. 2011). We would like to extend this concept into lending money to other companies with the use of loans (the real transfer of money) instead of trade credit (postponing repayment).

We have not found confirmation that banks are aware of lending money by their borrowers to their affiliates (related companies) or other entities (unrelated companies). However, banks are aware of financing potential borrowers by loans granted by their shareholders. Banks respond to this precedent by requiring the signing of a subordinate clause that prevents the repayment of loans from shareholders before the settlement of a bank loan. This allows banks to treat these loans from the shareholders as quasi-equity, thereby improving leverage.

Intra-group loans can be used for managing cash excesses in one firm and cash shortages in another. Almeida et al. (2011) show that groups use internal revenues to set up or acquire capital-intensive firms, which are more likely to be constrained in financial markets (Belenzon et al. 2013). Similarly, Gopalan et al. (2014) find that firm investment is partly financed by the dividends of other firms in the group.

4 Conceptual Framework for Lending Money Outside Business Groups

In the literature, it is well documented that a significant amount of funds available to micro and small firms are provided by owners or households (Yilmazer and Schrank 2006; Seppa 2010; Coleman and Robb 2009; Casey and O'Toole 2014). It is known as "inside-debt" (Seppa 2010) as this is a debt provided by principal owners and households as an alternative capital source to straight equity capital. Inside-debt does not often carry any regular amortization plan. Repayments are made when the firm has sufficient cash available; discipline of inside-debt repayment is similar to dividend payments. Indeed, credit providers consider inside-debt as a quasi-equity, despite the lack of sound empirical evidence.

Conventional equity is adjusted for inside-debt (adjusted equity = book equity + inside-debt). In particular, in Poland, BRE Bank treats loans received from shareholders of the limited liability company in this way, i.e., quasi-equity, but requires the signing of a subordination clause. Seppa (2010) found that inside-debt is positively related to financial leverage, with a positive relationship between leverage and bankruptcy that is well documented in academic literature. Internal debt gives an advantage to the lending firm, as all of the firm's cash can be used to provide a loan. If the controlling shareholder decides to guarantee direct equity financing, he can only contribute with his share of dividends from the firm with excess cash. In this regard, internal debt represents an advantage over indirect equity financing.

The Fig. 2 builds a conceptual framework. In business groups, intra-group loans alleviate financial constraints and allow for an increase in investments, contrary to inter-corporate loans granted to non-related firms that play mainly an emergency financing role and defer their bankruptcy risk. Intra-group loans provided to related firms tend to be higher and are expected to increase the level of borrowers' investments. Therefore, borrowers should be provided with higher availability of bank debt, with a more important role of redistribution effect of a bank loan. Intra-group

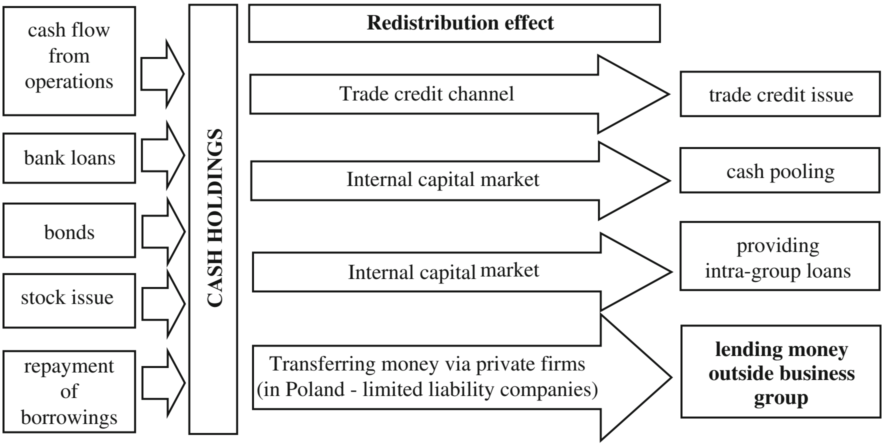

Fig. 2 Conceptual framework—mechanism of providing loans by non-financial companies outside business groups

loans should be provided by larger private firms in capital-intensive industries. Borrowers usually invest more after they receive intra-group loans, which is consistent with the financing advantage hypothesis (Buchuk et al. 2014).

Managers could use excess cash to grant loans not only to related firms but also to unrelated entities, taking into account corporate financial policies in the case of the lender's poor investment opportunities, when the lender misses viable projects and extends loans because of a lack of alternatives). Among the reasons for lending by non-financial companies, there is the possibility that companies providing inter-corporate loans may have the 'informative' advantage over banks when it comes to verifying and monitoring borrowers. Lenders may benefit from inter-corporate loans by lending at a higher interest rate than in the case of alternative investment (e.g. bank deposits). Inter-corporate loans are an alternative source of financing for borrowers with limited access to bank loans, such as small firms not listed on stock exchange.

Białek-Jaworska (2017a) proposes a decomposition of the changes in cash holdings between the beginning and the end of the financial year, using cash flow statement prepared according to the indirect method, to indicate the main sources of non-financial corporate cash holdings. We list the possible sources of cash holdings in Fig. 2: cash flows from operations, bank loans, issue of shares or corporate bonds.

The formal financial sector can allocate credit ineffectively, due to strong asymmetry of information and poor law enforcement. Informal channels of financing, based on reputation and relationships between lenders and borrowers, may fill this gap by ensuring higher level of control, monitoring and execution of receivables due to provided loans (Stiglitz 1990).

Table 1 Lenders distribution by industry in the research sample

PKD code	Industry	Obs.	Share (%)
10–39	Manufacturing	9157	41
68	Real estate	3822	17
69–75	Professional, scientific and technical services	3896	17

Source: Authors' elaboration based on the Bisnode database

5 Evidence from Poland

Based on data of receivables from loans provided to related entities (inside a business group) and separate to un-related entities (outside the business group) retrieved from the Bisnode database, we have identified ca. 4600 lenders in a period of 2003–2014. The share of main industries is listed in the Table 1. The basic regression equation with GMM estimator takes the following form (1):

$$\begin{aligned} CASH\ HOLDINGS_{\mathrm{it}} = {} & \beta_0 + \beta_1\ LOAN\_OTHER_{\mathrm{it}} + \beta_2\ LOAN\_BG_{\mathrm{it}} \\ & + \beta_3\ CASHFLOW_{\mathrm{it}} + \beta_4\ LTBANKLOAN_{\mathrm{it}} \\ & + \beta_5 CONTROLS + \varepsilon_{it} \end{aligned} \tag{1}$$

where *cash holdings*—cash and money at bank/total assets (TA); *loan_other*—receivables from long-term and short-term loans provided to unrelated entities outside the business group/TA; *loan_bg*—receivables from long-term and short-term loans provided to related entities inside the business group/TA; *ltbankloan*—long-term liabilities on account of bank loans/TA; *short_debt_related*—short-term debt to related companies (within the internal capital market of the business group)/TA; *long_debt_related*—long-term debt to related companies/TA; ε_{it}—is the error term.

Our findings confirm that cash holdings is negatively related with loans provided outside the business group. The results show that companies use funds from related companies on the internal capital market, long-term bank debt and cash flow from operations to hoard cash that allows them to provide loans outside the business groups. Private companies that lend money outside the business group hold less cash (see Table 2). This result is contrary to the usage of loans to manage liquidity on the internal capital market in companies listed on the stock exchange in Poland (Białek-Jaworska 2017a, b). This may be caused by redistribution effect of cash hold by private companies.

6 Conclusions and Directions for Future Research

In this paper we propose a framework for the study of the provision of loans by non-financial companies outside their business groups which analyzes the role of corporate cash holdings in mitigating small businesses' financial constraints by

Table 2 Non-financial firms cash holdings sources and usage for loans provision

Variable	Cash holdings	
Cashflow	0.0903***	
	(0.0071)	
loan_other	−**0.5453***	
	(0.0868)	
loan_bg	−0.4302***	
	(0.0269)	
ltbankloan	0.0503***	
	(0.0131)	
long_debt_related	0.0674***	
	(0.0174)	
short_debt_related	0.0488***	
	(0.0137)	
Other control variables	Yes	
Time effects	Yes	
N	23,105	
Sargan's test	59,5424	[0.2498]
Arellano-Bond test for AR(1)	−15,626	[0.0000]
Arellano-Bond test for AR(2)	0.57739	[0.5637]
Arellano-Bond test for AR(3)	−1.078	[0.2810]
Arellano-Bond test for AR(4)	−0.34958	[0.7267]

Source: Own elaboration in STATA ver. 15. The source of data: Bisnode
Bold value indicate key test variable
Calculations are based on data from the years 2003–2014. Regressions include robust standard errors shown in parentheses.
*** denotes significance at the 1% level

improving their access to finance. This constitutes the background for empirical research on non-financial companies lending money outside internal capital markets created by business groups in Poland, as well as in other transition economies.

Transition economies have less developed financial markets, characterized by the absence of institutional investors and by fewer financial instruments. As there are not too many sources of funds for SMEs; these companies tend to rely more on traditional sources of funding, i.e. bank loans (provided by loan-deposit institutions) (Dudic and Mirkovic 2016). Even though banking is shifting towards relationship banking, where long standing relations can serve as a form of collateral, the need to provide some form of security still remains. Again, the fact that most small businesses have poor business practices, non-convincing business plans and weak or non-existent governance system, makes them lose their going-concern attribute. Furthermore, information asymmetry makes them look riskier than they might actually be and therefore unattractive to credit suppliers (Akwaa-Sekyi et al. 2017). SMEs are found to be more likely to apply for non-financial corporate loans as financial pressures increase, either through heightened debt to asset ratios, increasing interest costs, deteriorations in capital position or a worsened credit history. Based on SAFE survey results constrained firms are more likely to use loans from other companies (Casey and O'Toole 2014).

Moreover, it is important to notice that emergency borrowings from other unrelated companies (instead of banks or other financial institutions), used for deferring a default, could introduce credit risk into the business sector, resulting not only in underinvestment but also in liquidity problems and an increase in financial constraints. The redistribution effect of cash holdings and money borrowed from banks by creditworthy companies and later lent to unrelated companies (suffering from financial constraints and lacking creditworthiness) may pose a threat to the stability of the financial system, due to the default risk of these "indirect borrowers" and their inability to repay loans.

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The Lohmann-Ruchti Effect in the Development of Corporate Capital

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Abstract Knowledge of the measure of cash flow and of the dynamics of its creation is indispensable for a thorough understanding of many business phenomena, especially those linked to the growth of a company. Of particular interest are the relations between depreciation and the production of cash flow. This paper will examine the financial effects of the depreciation produced by the expansion effect known as the Lohmann-Ruchti Effect, according to which the systematic re-investment of the cash flow from the annual asset depreciation generates a process of growth in the invested capital without the need to rely on outside funds, debt or equity.

1 Introduction

From an economic point of view, depreciation (and amortization) can be associated with two distinct aspects (Peterson 2002; Hang et al. 2016): the decrease of assets' value (impairment) or the allocation of the assets' costs in the different periods in which the assets are used. Along with this study, depreciation is conceived of from a financial point of view, as the process through which investments (destination of funds) needed to acquire depreciable goods—buildings, equipment, office furniture, vehicles, machinery, plants, factories, etc.—are gradually "recovered" in annual shares which measure the cash flow generated by operations (source of funds). In effect, when included in the income statement, the annual depreciation charges of assets reduce the economic result and produce a Gross Operating Cash Flow:

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$$\text{GOCF (n)} = \text{Net Income (n)} + \text{Depreciation (n)}$$

which becomes a Net Operating Cash Flow after adding/subtracting the decreases and increases in the working capital: current assets, liabilities and inventories.

The GOCF as measured by the depreciation charges can be used in four ways:

1. to reimburse the financing needed for the purchase of those goods;
2. to permit the businessman to recover the risk equity;
3. to renew the multi-year factors at the end of the depreciation period;
4. to reinvest in additional goods and increase the invested capital.

2 The Lohmann-Ruchti Effect

The fourth effect of depreciation, “expansion”, is easy to understand (Mella 2014, Sect. 8.6). This is the case in which previously employed resources are firstly released with the depreciation, and then reinvested to acquire additional goods. In this way, the firm has a new form of internal financing that allows the enlargement of productive capacity without using external financing (Brief and Anton 1987; Hinners-Tobraegel 1997; Caparvi 2000).

This effect has been first described by Karl Marx and Friedrich Engels in 1967, and, subsequently, Nico Jacob Polak is the one who first described the expansion effect through the reinvestment of depreciation (Polak 1926; Ruchti 1942; Lohmann 1949; Bebel and Bernstein 2012). However, it is only with the studies of Lohmann-Ruchti that this effect has been widespread across countries (Ruchti 1942; Lohmann 1949).

If the GOCF is at least equal in amount to the depreciation quotas determined in the Income Statement, and if the Net Income $= \text{NI} \geq 0$, then the company is better off not keeping such monetary resources disinvested, even while it should renew the multi-year factors at the end of their useful life. In fact, by not reinvesting the company, on the one hand, runs the risk of monetary losses from inflation, and on the other cannot benefit from additional positive income components.

Assuming Net income $= \text{NI} = 0$, the company can invest the GOCF = depreciation, in:

1. assets that can produce an independent income;
2. productive factors depreciable over M years.

When invested in depreciable goods, the depreciation of the acquired factors (for example, machinery) produce additional cash flow that can lead to new investment in machinery. In this way, at the end of year M the depreciation of the original machinery acquired in year “0”, the stock of productive factors available to the company in year M, will be greater than that at year “0”. The added stock has been financed without recourse to outside financing, and thus the “self-financing” effect is produced through depreciation.

In the following section, an example is used to demonstrate this effect. Let us assume that the company is formed at moment “0” with an initial capital immediately invested in permanent factors with a value of $C(0)$. The initial balance sheet can thus have the following simplified structure: $C(0) = E(0)$, assuming the provision of equity equal to the amount of the investment in assets. If we assume for simplicity’s sake that $\mathrm{NI}(m) = 0$, then over the following “$1 \leq m \leq M$” years the GOCF will be:

$$\mathrm{GCFO}(m) = q(m) = C(m - 1)/M$$

where $q(m) = C(m-1)/M$ indicates the constant depreciation charge in the mth year of useful life of the machines in existence at year “m-1”, assuming a useful life of M years.

At the end of the first year, assuming there is reinvestment of $\mathrm{GCFO}(1) = q(1) = C(0)/M$ in additional machinery: $C1 = q(1)$, capital becomes:

$$C(0) + C1 = E(0) + \mathrm{q}(1) \tag{1}$$

Given the preceding simplifying assumptions and assuming depreciation by constant quotas during the M years of life of the machinery, Eq. (1) can be also be expressed in the following form:

$$C(0) + C(0)\left(\frac{1}{M}\right) = C(0) + \left(1 + \frac{1}{M}\right) = E(0) + q(1) \tag{2}$$

At the end of the second period, GOCF is still equal to the depreciation quotas calculated in the second period, after the increase in machinery. We can thus write:

$$GOCF(2) = q(2) = \left(C(0) + q(1)\right)\frac{1}{M} = \left[C(0)\left(1 + \frac{1}{M}\right)\right]\frac{1}{M}$$

assuming depreciation has been carried out at constant quotas for period M, even for the additional investments.

After the reinvestment of the additional cash flow, the capital at the end of the second period becomes:

$$C(0)\left(1 + \frac{1}{M}\right)^2 = E(0) + q(1) + q(2)$$

Reiterating: at the end of the Mth period the capital will be:

$$C(0)\left(1 + \frac{1}{M}\right)^M = E(0) + \sum\nolimits_1^M q(m) \tag{3}$$

Nevertheless, at the end of period M, since the depreciation process has ended, it is necessary to eliminate the machinery purchased at time “0”. We thus obtain:

$$C(0)\left(1+\frac{1}{M}\right)^{M}-C(0)=C(0)\left[\left(1+\frac{1}{M}\right)^{M}-1\right]$$
$$=E(0)+\left[\sum\nolimits_{1}^{M}q(m)-C(0)\right] \quad (4)$$

Since:

$$\left[\left(1+\frac{1}{M}\right)^{M}-1\right]>1 \quad (5)$$

it has been demonstrated that the capital in year M, after the complete utilization of the multi-year factor acquired at time “0”, includes a stock of factors available for future operations, indicated by the first expression in Eq. (3), which is greater than the initially available stock:

$$C(0)\left(1+\frac{1}{M}\right)^{2}=E(0)+q(1)+q(2)$$
$$C(0)\left(1+\frac{1}{M}\right)^{M}-C(0)=E(0)+\Delta E(0) \quad (6)$$

The “expansion” of the invested capital has occurred without the company having to obtain additional financing, thanks to the “Lohmann-Ruchti” effect (Takatera 1960; Nakano 1964; Rocchi 2007), whose size is represented by the second expression in Eq. (6).

The Lohmann-Ruchti effect can occur with greater immediacy if we focus on specific types of production companies, for example, manufacturing companies (if we assume an expansion in the “plant and machinery”), the navigation sector, or transportation in general (if we assume we want to observe the expansion in the “fleet of ships” or “fleet of vehicles”), or, above all, leasing companies.

3 The Expansion Rate

The explanation of the expansion effect of depreciation considers only the cash flow from the depreciation of the initial investment (Stopka and Urban 2017). The Lohmann-Ruchti effect is not immediately explainable by considering the totality of the investments in each of the M periods, since the cash flow from the investment depreciation also includes that linked to the additional investments made with the cash flow produced in C(0) from the subsequent depreciations q(m). This combination means that if we observe the amount of overall investment (Eq. 6) in any year "n > M" subsequent to the elimination of the first factor obtained, C(0), we observe rhythms and dynamics of C(n) that are apparently irregular, and it appears impossible to describe the process.

However, this is not the case. In fact, note that, at a given year, $N > M$, the chain of "additional investments/retirement of depreciable investments/substitutions" becomes stabilized around a value that on average remains constant.

At this level of $C(N)$, we can determine the amount of expansion in the initial investment.

Letting:

$$C(M) - C(0) = ESP$$

we can demonstrate that *ESP* is equal to the following amount:

$$ESP = C(0)\frac{1}{M}\left(\frac{M-1}{2}\right) \tag{7}$$

To quantify *ESP* we need, in fact, to consider that the total cash flow produced by $C(0)$ in M years derives from the sum of the following:

(1) the M depreciation shares $q(m) = C(0)/M$ of the initial investment;
(2) the *M-1* depreciation shares of the additional investment, $C1$, deriving from the reinvestment of the first quota, with a depreciation life of M years;
(3) the *M-2* depreciation quotas of the additional investment, $C2$, deriving from the reinvestment of the second quota, with a depreciation life of M years;
...
(M), the depreciation share of the additional investment from the reinvestment of the quota calculated at (M-1).

The cash flow earmarked for the expansion of the capital invested in machinery that depreciates based on the preceding assumptions is obtained from the sum of the partial cash flows indicated in points (2) to (M).

If $q = C(0)/M$ represents the constant depreciation quota of the original investment, we can determine *ESP* as follows:

$$ESP = (M-1)\frac{1}{M}q + (M-2)\frac{1}{M}q + \cdots + \frac{1}{M}q \tag{8}$$

Relation (8) represents the sum of an *arithmetic sequence* of M terms and of a *common difference* equal to "q/M", whose total is:

$$ESP = q\left(\frac{M-1}{2}\right) \tag{9}$$

The assumptions posited now make it possible to calculate a "rate" of global expansion, $e(M)$, of the process of self-financing through depreciation. This indicates by how much the initial investment increases after the chain process (investments/retirement/renewal) becomes stabilized. This can be determined as the ratio between the overall cash flow freed up for expansion, calculated in Eq. (9), and the amount of the original investment, C(0):

$$e(M) = \frac{ESP}{C(0)} \tag{10}$$

Substituting Eq. (9) into Eq. (10) we get (in percentage terms):

$$e(M) = \frac{M-1}{2M}100 \tag{11}$$

Equation (10) shows us that the *expansion rate* does not depend on the "scale" of the initial investment but only on the speed of depreciation (Preinreich 1938). If the depreciation is carried out in 1 year, then the expansion will be zero, as determined by setting $M = 1$ in Eq. (10). If the depreciation takes $M = 2$ years, the expansion rate will be e (2) = 25%; when $M = 5$ we obtain: $e(5) = 40\%$; in general, e(M) is an increasing function of M, but its maximum value, for M that tends toward infinity, is 50%. The expansion can never exceed 50%.

However, since it is not easy to calculate with precision the dynamics of $C(n)$, $n > M$, we can only use specific operational models created for each specific depreciation process, due to the complication caused by the "renewal/retirement" chain connected to the investment made M years earlier. Nevertheless, the overall value of investment when the expansion process has "played out" after year $n > N$ (where n is sufficiently high), that is, when the Lohmann-Ruchti effect has occurred and is stabilized, will be equal approximately to:

$$C(n) = C(0)\left[1 + \frac{e(M)}{100 - e(M)}\right] \tag{12}$$

We can use Eq. (10) to determine the *duration of the depreciation process* needed for a desired expansion rate, given the assumptions required for the expansion effect to take place. Given $e(M)$, from Eq. (11) we immediately obtain:

$$M = \frac{1}{1 - 2e(M)} \tag{13}$$

4 The Expansion Effect: Numerical Examples

Let us assume a company purchases machinery for an overall value of $C(0) = 20{,}000$ (€, $ or £) and depreciates it at a constant rate until the complete retirement of the factors. The expansion effect is illustrated below under the assumption of a depreciation life of 5 and 10 years.

Table 1 shows the trends in investment and in the retirement/renewal chain for a depreciation period of 5 years. The process has "played out" in year $n = 11$ when the machinery has a stable value of C(n) ≈ 33.333. The dynamics of Total Investments and Annual Depreciations of Table 1 are shown in Fig. 1.

Table 2 refers to a depreciation period of 10 years, for which the expansion process "plays out" in year $n = 23$, when the overall value of the machinery is around C(n) ≈ 36.363.

The dynamics of Total Investments and Annual Depreciations of Table 2 are shown in Fig. 2.

Table 1 Expansion effect. C(0) = 20,000; M = 5; %q = 20%

Years	Investments years	Investments total	Depreciations $C(n\text{-}1)/5$	Retirements
(1)	(2)	(3)	(4)	(5)
1	20,000	20,000	4000	–
2	4000	24,000	4800	–
3	4800	28,800	5760	–
4	5760	34,560	6912	–
5	6912	41,472	8294	20,000
6	8294	29,766	5953	4000
7	5953	31,719	6344	4800
8	6344	33,263	6653	5760
9	6653	34,156	6831	6912
10	6831	34,075	6815	8294
11	6815	32,596	6519	5953
12	6519	33,162	6632	6344
13	6632	33,450	6690	6652
14	6690	33,488	6698	6831
15	6698	33,355	6671	6815
16	6671	33,211	6642	6519
17	6642	33,334	6667	6632
18	6667	33,369	6674	6690

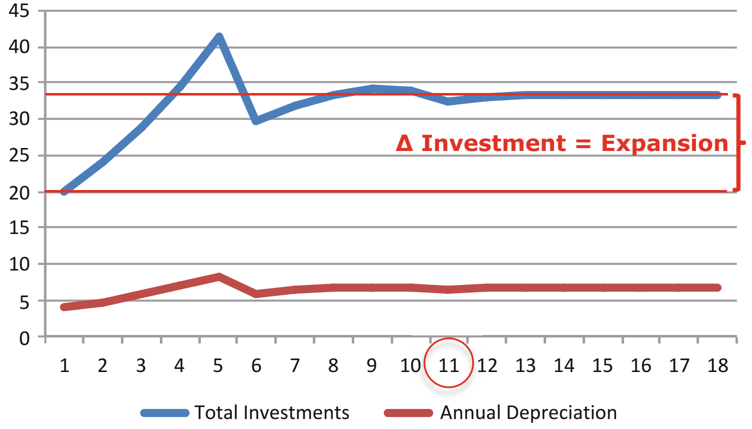

Fig. 1 Lohmann-Ruchti Effect. Depreciation life of 5 years (reference: Table 1)

Table 2 Expansion effect. C(0) = 20,000; M = 10; %q = 10%

Years	Investments years	Investments total	Depreciations$C(n\text{-}1)/10$	Retirements
(1)	(2)	(3)	(4)	(5)
1	20,000	20,000	2000	–
2	2000	22,000	2200	–
3	2200	24,200	2420	–
4	2420	26,620	2662	–
5	2662	29,282	2928	–
6	2928	32,210	3221	–
7	3221	35,431	3543	–
8	3543	38,974	3897	–
9	3897	42,871	4287	–
10	4287	47,158	4716	20,000
11	4716	31,874	3187	2000
12	3187	33,061	3306	2200
13	3306	34,147	3415	2420
14	3415	35,142	3514	2662
15	3514	35,994	3599	2928
16	3599	36,665	3666	3221
17	3666	37,110	3711	3543
18	3711	37,278	3728	3897
19	3728	37,109	3711	4286
20	3711	36,533	3653	4716
21	3653	35,470	3547	3187

(continued)

Table 2 (continued)

Years	Investments years	Investments total	Depreciations$C(n\text{-}1)/10$	Retirements
(1)	(2)	(3)	(4)	(5)
22	3547	35,830	3583	3306
23	3583	36,107	3611	3415
24	3611	36,303	3630	3514
25	3630	36,419	3642	3599
26	3642	36,462	3646	3666
27	3646	36,442	3644	3711
28	3644	36,375	3637	3728
29	3637	36,284	3628	3711
30	3628	36,201	3620	3653
31	3620	36,168	3617	3547
32	3617	36,238	3624	3583
33	3624	36,270	3628	3611
34	3628	36,296	3630	3630
35	3630	36,296	3630	3642
36	3630	36,284	3628	3646
37	3628	36,266	3627	3644
38	3627	36,249	3625	3637
39	3625	36,237	3624	3628
40	3624	36,233	3623	3628

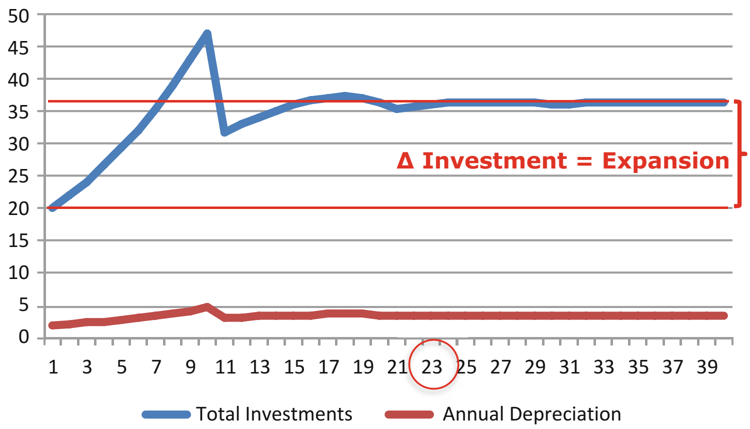

Fig. 2 Lohmann-Ruchti Effect. Depreciation life of 10 years (reference: Table 2)

5 Conclusions: The Assumptions of the Expansion Effect

At the end of this brief presentation and demonstration of the Lohmann-Ruchti effect, one might be led to conclude that the depreciation process—if observed only in its effects on the balance sheet statement—can not only self-finance the *renewal* of multi-year investments but also their expansion. In fact, the depreciation process could "free up" funds that, reinvested in advance, would lead to the desired expansion effect (Wada 1969).

The Lohmann-Ruchti effect is important because it allows companies to invest the "incremental funds" from the depreciation process of the original investment in new factors of production (Takatera 1960).

Nevertheless, it must be noted that the essential condition for the expansion effect is the possibility of investing the cash flow from depreciation in other multi-year factors. However, this possibility depends on the possibility of actually being able to use the new factors. Therefore, the non-saturation of the market must be verified along with the availability of the factors (labor and materials) needed for the functioning of the new factors deriving from the expansion process. Consequently, it is important also to understand whether this effect can be achieved when the firm become loss-making and in which measure.

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Reconsidering the Profitability–Capital Structure Relation: Findings from Poland

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Abstract The aim of the study is to verify whether and how the relation between profitability and corporate financing policy depends on the firm size and its industrial classification. The relationship between return on equity and selected measures of capital structure for Polish private firms in the period 2005–2015 is explored in two cross-sections: across size groups of firms and across industrial sections. The issue is addressed by estimating panel data models with interactions between variables so as to identify the factors responsible for the variability of the considered relationship. The study contributes to the existing literature by capturing the indirect size effect and industry effect in the profitability–capital structure relation. It also takes into account the issue of debt maturity by considering the relationship in question for different debt measures. Findings provide evidence that this relation is more industry- than size-dependent for long-term debt, but that the size effect prevails when short-term debt is considered. The results also suggest greater relevance of the pecking order theory for long-term debt, whilst the trade-off predictions seem more adequate for explaining short-term financing decisions.

1 Introduction

The complexity of corporate financing choices and the factors influencing these decisions has been the subject of academic research for decades. Since the seminal irrelevance theorem by Modigliani and Miller (1958) a remarkable number of competing theories have been developed aiming at solving the capital structure puzzle. However, none of the currently available model seems capable of simultaneously accounting for the whole variety of factors potentially affecting corporate financing policies, which is why the relative importance of these factors remains open to debate (Frank and Goyal 2008). The apparent contradictions between both

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theories and stylised facts make it purposeful to further explore the problem by addressing the issue with yet another approach. This study contributes to the existing academic literature in several ways. Firstly, instead of directly verifying the significance and the direction of the profitability impact on leverage, it searches for the indirect factors potentially affecting this relation, namely the firm size and its industrial classification. Secondly, the issue of debt maturity is covered by considering the impact of profitability separately on short-term and long-term debt. Finally, the analysis includes private firms and not the most commonly explored public companies.

2 Literature Review

Profitability is considered as one of the key factors determining corporate financing choices by the two leading capital structure theories, namely the static trade-off theory (TOT) grown on the debate over the MM irrelevance proposition and the pecking-order theory (POT) by Myers and Majluf (1984). However, the theories remain contradictory in terms of the direction in which financial leverage is affected by profitability.

According to the classic statement of the TOT provided by Kraus and Litzenberger (1973), the optimal leverage reflects a balance between the tax benefits of debt and leverage-related costs, mainly including costs of financial distress. As a result, the TOT predicts a positive relation between profitability and debt level, as profitable companies borrow more to compensate taxes (Frank and Goyal 2003). A positive relationship between profitability and debt is also explained on the grounds of the idea that financial market is reluctant to offer funds to underperforming companies. Moreover, higher leverage indicates greater interest burden for companies with low rates of return for owners, which decreases the valuation of the firm's equity and reduces the possibility of its issuance (Kumar 2007). A positive profitability–leverage relationship was empirically found e.g. by Gill et al. (2011).

According to the POT, developed by Myers (1984), the assumed adverse selection implies that firms prefer internal to external financing and debt to equity if external financing is needed. This ranking stems from such sources as agency conflicts or information asymmetry. Therefore, the POT predicts a negative profitability–leverage relation, as firms generating high returns may have less debt, since retained earnings are used first. The negative relation between profitability and debt has been reported e.g. by Myers (1984), Myers and Majluf (1984), Harris and Raviv (1991), Rajan and Zingales (1995), Hall et al. (2004), Abor (2005) and latterly by González and González (2012).

Another firm-level determinant of leverage considered in this study is the firm size, whose positive relation with debt predicted by TOT is explained by the fact that large firms usually enjoy better reputation in the credit market, bear lower costs of obtaining information, and often have more diversified business. Studies by Frank and Goyal (2003) or Kurshev and Strebulaev (2008) empirically confirm such a relation.

Along with the firm-specific determinants, corporate financial leverage might be affected by external conditions, including industrial classification whose significance in terms of debt is reported e.g. by Harris and Raviv (1991). The industrial characteristics responsible for leverage diversity in this cross-section include such variables as the assets flexibility (Shleifer and Vishny 1992), technological differences (Maksimovic and Zechner 1991) or industrial competition (Leibenstein 1966).

However, it appears that the impact of the firm size or its industry on capital structure may be twofold. Apart from the direct influence of the firm-related or macroeconomic variables on debt, they may also impact corporate financing choices indirectly—by influencing primary factors affecting debt level (Jong de et al. 2008; Koralun-Bereźnicka and Ciołek 2018). Therefore, following the main aim of the study, which is to identify the importance of the firm size and its industrial classification for the relation between profitability and capital structure in Polish private firms, three research hypotheses are formulated: (i) the profitability–capital structure relation is size-dependent, (ii) the profitability–capital structure relation is industry-dependent, (iii) the profitability–capital structure relation varies depending on the debt maturity. The verification of these hypotheses would add to the hitherto research findings by recognizing the indirect effect of firm size and its industrial specifics in the relation between financial leverage and the seemingly well-known determinant of debt.

3 Data and Methodology

The empirical data comes from the BACH-ESD[1] database published by the European Commission (Banque de France 2018). It contains comparable data from financial statements for non-financial incorporated European companies aggregated by industries, firm sizes and years. The study uses data for Polish firms of three size groups of firms: small (SM), medium (ME) and large (LA) in the 11-years' period 2005–2015. The 16 industries included in the analysis cover the following section-level NACE divisions: A, B, C, D, E, F, G, H, I, J, L, N, P, Q, R, S. The ratios used in this study were computed by separately aggregating the data of the numerator and of the denominator.

In order to examine how the profitability–capital structure relation depends on the industrial classification and on the firm size, regressions explaining capital structure measures were estimated. The dependent variable was either long-term debt ratio (LTD) or short-term debt ratio (STD), defined according to the formulas in Table 1. The main explanatory variable in the model was the ROE, defined as a relation of net profit or loss of the year to capital and reserves. In addition to this main covariate,

[1]Bank for the Accounts of Companies Harmonised – European Sectoral references Database.

Table 1 Construction of variables

Variables	Definition
Dependent variables	
Long-term debt to assets (LTD)	Non-current debt/Total assets
Short-term debt to assets (STD)	Current debt/Total assets
Explanatory variables	
Return on equity (ROE)	Net profit or loss for the period/Equity
Size	SM, ME, LA
Industry	A, B, C, D, E, F, G, H, I, J, L, N, P, Q, R, S
Profitability—size interactions	ROE*SM, ROE*ME, ROE*LA
Profitability—industry interactions	ROE*A, ROE*B, . . ., ROE*S

dummy variables representing size groups and industries were included in the regressions in order to reflect the fixed individual effects specific for firm size and industry. Coefficients of these effects can be interpreted as the specific size impact or industry impact on debt. Obviously, because of omitting one of the dummy variables due to perfect collinearity, the effects were interpreted in relation to the omitted size or industry. Moreover, following the aim of the study, which was to evaluate the importance of firm size and industry for the profitability–capital structure relation, the interactions between profitability and size dummies and between profitability and industry dummies were included in the model so as to estimate the different coefficients of profitability impact. The general formula of the estimated models was as follows:

$$\begin{aligned} D_{its} = {} & \beta_0 + \beta_1 ROE_{its} + \gamma_1 D_1 + \ldots + \gamma_{16} D_{16} + \alpha_1 D_S + \alpha_2 D_M + \alpha_3 D_L + \\ & + \delta_1 ROE_{its} D_1 + \ldots + \delta_{16} ROE_{its} D_{16} + \rho_1 ROE_{its} D_s + \rho_2 ROE_{its} D_M + \rho_3 ROE_{its} D_L + \xi_{its}, \\ & i = 1, \ldots, 16;\ t = 1, \ldots, 11;\ s = 1,2,3 \end{aligned} \quad (1)$$

where: D_{its} denotes one of the two debt measures (LTD or STD) for i industry of firm size s in year t, D_1-D_{16} are dummies representing industries, D_S, D_M, D_L—dummies for small, medium and large firms, β, γ, α, δ, ρ are coefficients, and $\xi_{i,t,s}$ is the error term. Mathematically, it means that e.g. the impact of profitability on debt in the industrial section S (16th) in medium firms would be equal to the sum of three parameters: β_1, δ_{16}, and ρ_2. Each regression model type (1) was estimated by OLS with standard errors robust for heteroscedasticity and autocorrelation of error terms (Baltagi 2008). To answer the question whether the profitability impact on debt depends more on the firm size or industry, a joint significance test was applied for groups of interaction parameters. In order to compare the importance of these two types of interactions, additional regressions were estimated with only one group of interactions in each case. Then the Akaike's information criterion (AIC) was applied to decide which group of parameters better explains the variability of the analysed debt measures.

4 Results

The model was first estimated for LTD as the dependent variable. The results are shown in Table 2. Joint tests for interactions reveal the significance of the industry–profitability interactions, as opposed to the size–profitability interactions, which proved insignificant both in the model without industry interactions and with both types of interactions. This indicates that the impact of ROE on long-term debt does vary across industries, but not across size groups of firms. The AIC values also confirm that introducing the industry interactions brings more explanation of long-term debt than size interactions.

The influence of ROE on long-term debt is also illustrated in Fig. 1, which demonstrates that the sign of the relation between ROE and LTD in most cases remains unchanged across size groups for a given industry. The only exceptions from this rule are the sections of information and communication (J), education (P), and other service activities (S), for which the relation is positive for small and medium-sized firms, but negative for large ones.

As for the estimation results for short-term debt, shown in Table 3, it can be seen from joint significance tests that this time the size-profitability interactions cannot be ignored. They proved significant in both models where size interactions were included.

Industry interactions, however, were only significant in the model without size interactions. This suggests that while the industry effect might not be crucial in its impact on profitability–short-term debt relation, the size effect is considerable in this case. It is also clear from Fig. 2 that the relation between ROE and short-term debt is evidently size-dependent in a number of industries. The often repeated pattern here is that the relation is negative for small firms, while positive for medium and large ones. This indicates the greater validity of POT for small firms, which was also reported by González and González (2012) for Spain.

5 Conclusions

The cross-sectional analysis of Polish private firms reveal that the relation between profitability measured by ROE and long-term debt is significantly positive, according to the predictions of trade-off theory. However, the relation proved insignificant for short-term debt. Moreover, the relation between profitability and debt is found to be dependent on the indirect factors, namely industry and firm size. The sign of the profitability–capital structure relation depends significantly on the industrial classification of companies in the case of long-term debt. The size effect is of negligible importance here, although it proves significant when the relation is considered for short-term debt. These results provide partial support for hypotheses (i) and (ii). As stated in hypothesis (i), the profitability–capital structure relation is size-dependent, but only for short-term debt, while—following hypothesis (ii)—the

Table 2 Estimation results of panel regressions for long-term debt

Variable	Long-term debt (LTD)					
Interactions	Size		Industry		Size and industry	
Const.	0.126***	(0.044)	0.024	(0.041)	0.008	(0.045)
ROE	−0.365***	(0.131)	0.645**	(0.328)	0.777**	(0.361)
ME	0.004	(0.025)	0.031**	(0.014)	0.032**	(0.016)
LA	−0.007	(0.025)	0.017	(0.023)	0.037	(0.027)
B	−0.018	(0.043)	0.065	(0.039)	0.076*	(0.045)
C	0.014	(0.043)	0.085**	(0.040)	0.095**	(0.042)
D	−0.011	(0.042)	0.093**	(0.043)	0.107**	(0.047)
E	−0.002	(0.043)	0.044	(0.039)	0.054	(0.043)
F	0.051	(0.043)	0.143***	(0.038)	0.149***	(0.039)
G	−0.012	(0.044)	0.068*	(0.036)	0.083**	(0.040)
H	0.090*	(0.049)	0.203***	(0.049)	0.206***	(0.047)
I	0.178***	(0.066)	0.299***	(0.046)	0.314***	(0.051)
J	0.060	(0.056)	0.124*	(0.065)	0.134**	(0.064)
L	0.023	(0.044)	0.123**	(0.056)	0.142**	(0.059)
N	0.160**	(0.066)	0.100	(0.110)	0.107	(0.110)
P	0.029	(0.051)	0.054	(0.052)	0.069	(0.056)
Q	0.150**	(0.066)	0.161***	(0.059)	0.162***	(0.058)
R	0.083	(0.065)	0.213***	(0.046)	0.239***	(0.055)
S	0.080*	(0.048)	0.120**	(0.047)	0.136***	(0.051)
ROE*ME	0.270	(0.196)			−0.019	(0.092)
ROE*LA	0.191	(0.219)			−0.191	(0.157)
ROE*B			−0.836**	(0.338)	−0.870**	(0.359)
ROE*C			−0.750**	(0.358)	−0.805**	(0.366)
ROE*D			−1.262***	(0.478)	−1.393***	(0.505)
ROE*E			0.188	(0.382)	0.151	(0.402)
ROE*F			−0.918***	(0.315)	−0.974***	(0.331)
ROE*G			−0.823***	(0.316)	−0.937***	(0.343)
ROE*H			−1.219***	(0.363)	−1.225***	(0.352)
ROE*I			−1.455**	(0.677)	−1.584**	(0.694)
ROE*J			−0.684*	(0.375)	−0.740*	(0.381)
ROE*L			−1.419	(0.900)	−1.753*	(0.943)
ROE*N			0.498	(0.711)	0.480	(0.708)
ROE*P			−0.536	(0.332)	−0.654*	(0.362)
ROE*Q			−0.174	(0.346)	−0.154	(0.366)
ROE*R			−1.143***	(0.340)	−1.228***	(0.357)
ROE*S			−0.578*	(0.328)	−0.679*	(0.357)
No. obs.		499		499		499
R^2		0.455		0.577		0.581
Adj. R^2		0.433		0.547		0.549
Heteroscedasticity	417.44 [0.000]		223.13 [0.000]		245.4 [0.000]	
Normality	134.61 [0.000]		70.90 [0.000]		78.16 [0.000]	
AIC	−1130.7		−1230.5		−1231.6	

(continued)

Table 2 (continued)

Variable	Long-term debt (LTD)		
Interactions	Size	Industry	Size and industry
Joint significance for interactions			
Size	1.251 [0.211]		−0.210 [0.234]
Industry		−2.093 [0.037]	−12.36 [0.027]

Notes: (1) Robust standard errors in parentheses. (2) White test for heteroscedasticity. (3) Doornik-Hansen test for normality of residuals. (4) Interpretation of parameters in relation to section A and small firms

*** p < 0.01, ** p < 0.05, * p < 0.1

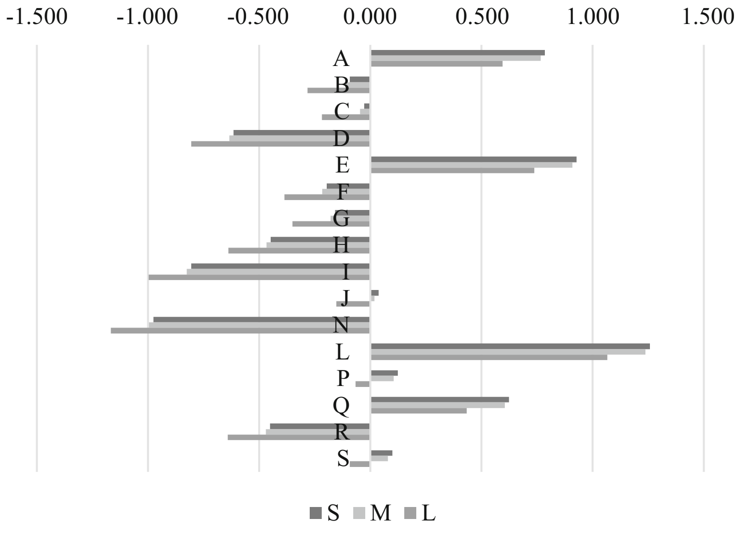

Fig. 1 The impact of profitability on long-term debt across industries and size groups

profitability–capital structure relation is industry-dependent, but mainly for long-term debt. These differences also indicate the likely truthfulness of hypothesis (iii) referring to the differences in profitability–leverage relation resulting from debt maturity. The conclusion resembles the one reached by Degryse et al. (2012), who also found differences between the significance of variables related to debt maturity.

When comparing the considered relation for long-term debt across industries, it appears that companies in industries such as: agriculture (A), water supply (E), administration (L), education (P), healthcare (Q), and other service activities (S) are more in line with the trade-off predictions on positive profitability–debt relation, whereas firms from the remaining industries, i.e. the majority of the analysed sample, provide more support for the pecking order theory by demonstrating mainly negative relation. However, when the other cross-section and the short-term debt is taken into account, it appears that the trade-off is more suitable for medium and large-sized

Table 3 Estimation results of panel regressions for short-term debt

Variable	Short-term debt (STD)					
Interactions	Size		Industry		Size and industry	
const.	0.175***	(0.012)	0.140***	(0.016)	0.167***	(0.019)
ROE	−0.036	(0.048)	0.331***	(0.092)	0.078	(0.124)
ME	−0.016	(0.018)	0.004	(0.011)	−0.016	(0.011)
LA	−0.040***	(0.015)	−0.020	(0.016)	−0.048**	(0.019)
B	0.068***	(0.014)	0.117***	(0.017)	0.109***	(0.018)
C	0.164***	(0.014)	0.177***	(0.024)	0.166***	(0.031)
D	−0.005	(0.015)	0.042**	(0.021)	0.024	(0.020)
E	−0.060***	(0.013)	−0.034**	(0.017)	−0.047*	(0.024)
F	0.194***	(0.011)	0.228***	(0.013)	0.223***	(0.011)
G	0.285***	(0.019)	0.333***	(0.049)	0.316***	(0.048)
H	0.088***	(0.030)	0.093	(0.057)	0.086*	(0.050)
I	−0.029*	(0.015)	0.000	(0.021)	−0.013	(0.019)
J	0.073***	(0.026)	0.119***	(0.032)	0.115***	(0.030)
L	−0.084***	(0.011)	−0.052***	(0.019)	−0.071***	(0.022)
N	0.167***	(0.023)	0.132***	(0.035)	0.126***	(0.038)
P	0.090***	(0.030)	0.158***	(0.048)	0.152***	(0.053)
Q	0.071**	(0.030)	0.097**	(0.039)	0.098***	(0.036)
R	0.079***	(0.018)	0.120***	(0.015)	0.078***	(0.020)
S	0.087	(0.053)	0.072	(0.067)	0.066	(0.069)
ROE*ME	0.269***	(0.097)			0.240***	(0.068)
ROE*LA	0.226**	(0.102)			0.305***	(0.099)
ROE*B			−0.523***	(0.152)	−0.513***	(0.151)
ROE*C			−0.137	(0.218)	−0.055	(0.295)
ROE*D			−0.759***	(0.291)	−0.551**	(0.263)
ROE*E			−0.315	(0.219)	−0.205	(0.312)
ROE*F			−0.303***	(0.089)	−0.253***	(0.071)
ROE*G			−0.394	(0.262)	−0.264	(0.248)
ROE*H			0.023	(0.422)	0.054	(0.368)
ROE*I			−0.308*	(0.172)	−0.220	(0.162)
ROE*J			−0.407**	(0.207)	−0.387**	(0.195)
ROE*L			−0.573	(0.421)	−0.219	(0.460)
ROE*N			0.329	(0.319)	0.339	(0.327)
ROE*P			−0.466***	(0.097)	−0.389***	(0.148)
ROE*Q			−0.281**	(0.143)	−0.291**	(0.118)
ROE*R			−0.166	(0.127)	−0.061	(0.122)
ROE*S			0.027	(0.128)	0.038	(0.149)
No. obs.		499		499		499
R^2		0.773		0.794		0.801
Adj. R^2		0.764		0.779		0.786
Heteroscedasticity	344.5 [0.000]		154.4 [0.000]		169.3 [0.000]	
Normality	95.58 [0.000]		134.1 [0.000]		167.3 [0.000]	
AIC	−1422.9		−1444.3		−1458.7	

(continued)

Table 3 (continued)

Variable	Short-term debt (STD)		
Interactions	Size	Industry	Size and industry
Joint significance for interactions			
size	3.085 [0.002]		3.587 [0.000]
industry		−2.022 [0.044]	−1.339 [0.181]

Notes: (1) Robust standard errors in parentheses. (2) White test for heteroscedasticity. (3) Doornik-Hansen test for normality of residuals. (4) Interpretation of parameters in relation to section A and small firms
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

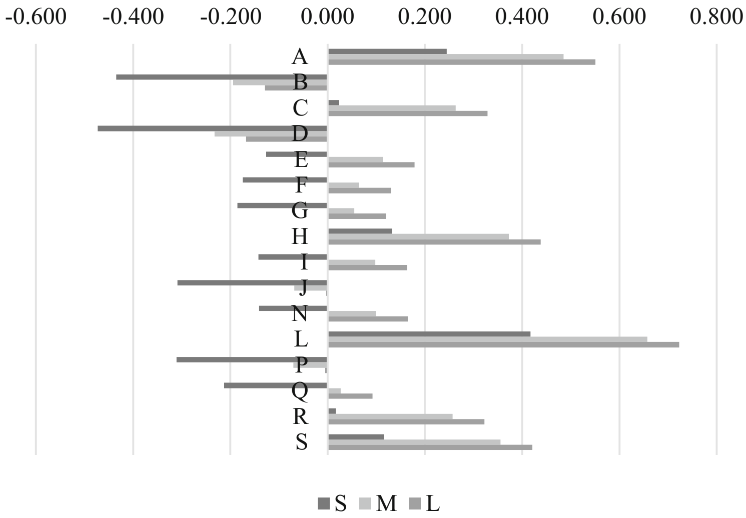

Fig. 2 The impact of profitability on short-term debt across industries and size groups

firms, while small enterprises generally tend to follow the pecking order expectations on the profitability-leverage relation. These results are comparable to prior empirical studies, e.g. for Ghanaian companies (Abor 2005), where long-term debt was found to be negatively correlated with profitability. However, they are in opposition to the findings of Gill et al. (2011), who reported a positive relation between different debt measures and profitability regardless of firm industrial classification, i.e. for both service and manufacturing US public firms. These differences, however, may be attributed to country-related specifics of samples.

Generally, the findings highlight the relevance of the indirect industry and size effect in capital structure. The lack of straightforwardness in the profitability–leverage relation indicated by the study may provide some useful insights for example for lending institutions, which should not only consider firm profitability as a direct determinant of leverage-dependent risk level, but should also, perhaps to greater extent, recognize industrial and size-related firm specifics. The study also contributes additional evidence suggesting that the relative importance of these effects may vary depending on debt maturity. This provides a framework for further exploration of the influence of the indirect factors on capital structure. For example, it would be also valuable to analyse the occurrence of these effects for other economies, which would allow for cross-country comparisons. This is left for future investigation.

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Presaging a Déjà Vu… The Impact of Leverage and Investment on Operating Performance Under Negative Demand-Driven Shocks

Paweł Mielcarz, Oussama Ben Hmiden, and Dmytro Osiichuk

Abstract The early signs of economic slowdown portend a recap of the lessons of major recessions of the past. The paper revisits the impact of corporate investment and financing policies on operating performance under negative demand-driven shocks. Our study based on firm-level panel and cross-sectional data from the French stock market shows, that the outbreak of a recession may significantly alter the relevance of capital expenditures and leverage for the firms' short- and medium-term operating performance. Increased investments at the outbreak of the financial crisis of 2008 appear to have deteriorated the medium-term performance of the French companies, while higher leverage might have alleviated the effects of economic downturn. In order to navigate through the recession and improve their operating performance, companies had to accompany incremental investment outlays with debt reduction and cash accumulation. The revealed patterns appear consistent with the logic of the 'confidence theory', whereby the overleveraged corporate sector makes an attempt to reduce debt burden and grow organically with recurrence to internal resources in order to restore value creating potential under credit crunch and tightening financing constraints.

1 Introduction

As the leading economic indicators and policy modifications in the major economies augur the possible advent of an economic slowdown, the scientific community attempts to presage the possible consequences of a downturn on corporate decision making. A straightforward way to advance the discussion is to revisit the lessons of the preceding crisis.

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Relying on firm-level panel and cross-sectional data from the French stock market, we propose to reexamine the influence of the companies' investment and financing policies on their operating performance under recessionary tendencies. Our findings are expected to shed light on the problems of medium- and long-term financing policy as well as of capital budgeting under the conditions of negative demand shocks. In view of the possible ramifications of financialization of the world economy on the unfolding of the next recession, one may reasonably expect the future decision making patterns and policy actions to remain strongly reminiscent of those observed during the preceding slump.

The remainder of the paper is organized as follows: the next section presents a literature review on the relationships between debt, investment policy and corporate performance. Sections 2 and 3 describe the hypotheses, empirical model and our dataset. In Sect. 4, we present the main results. Section 5 concludes.

2 Background and Literature Review

Theoretical literature on the relationship between firm performance and corporate financing suggests two contradictory effects. On one hand, Jensen and Meckling (1976) underline the disciplinary role of debt. Regular payments of capital and interest reduce the agency costs by controlling and disciplining the managers, and forcing them to act in the interest of shareholders by increasing the risk of liquidation and creating the pressure to generate cash flow (Williams 1987; Baskin 1989). However, under financial distress, an increase in leverage may translate into higher agency costs.

Along with a disciplining managerial effect, debt may generate an overhang problem. The underinvestment problem is particularly important for the highly leveraged firms (Ameer 2014). Myers (1977) points out that the short-term debt might be considered as a possible solution for the overhang problem. Issuing debt, for which the contract terms can be modified, may reduce the debt overhang. However, Douglas et al. (2014) note that the short-term debt does not improve future investment incentives. They report that the debt of shorter maturity may make debt overhang more volatile and eliminate investment opportunities sooner.

A number of empirical studies have explored the impact of debt on firms' financial performance. The positive association was confirmed by Margaritis and Psillaki (2010), who contrasted the efficiency-risk and franchise-value hypotheses. According to the study by Ross (1977), a higher leverage communicates information about the profitable investment projects envisaged by the firm to the market.

At the same time, many research studies find a negative link between leverage and corporate performance. Opler and Titman (1994) argue that the highly leveraged US firms tend to lose market share and generate lower operating profits than their competitors. Based on Swedish data during 2009–2012 period, Yazdanfar and Öhman (2015) report a negative impact of a debt ratio on performance in terms of profitability. They explain that higher leverage seems to increase the agency costs as well as the risk of losing control of the company.

The impact of the financial crisis of 2008 on the economy has been studied extensively. Researchers conclude that companies were affected by the lack of liquidity and by the slowdown of economic activity.

Campello et al. (2010) examine the effect of the crisis on corporate decisions. They conducted a survey among 1050 chief financial officers in 39 countries in December 2008. They find that the credit-constrained companies may have been forced to downscale investment outlays due to encountering difficulties with obtaining the necessary external financing. The investment activity and the opportunities for sales growth were also limited thereby causing the firms to alter their investment and financing decisions (Whited 2006).

The relationship between external finance and corporate performance may have aggravated the industry performance during the crisis (Adjei 2012; Braun and Larrain 2005). Ivashina and Scharfstein (2010) note that because of having aggravated the adverse selection problem on capital markets, the financial crisis caused a substantial credit contraction.

In order to maintain their liquidity during the crisis, companies keep a significant portion of their assets in liquid form. By analyzing a panel data for U.S manufacturing firms, Hu and Schiantarelli (1998) conclude that in recession years, firms with high debt are more sensitive to the availability of internal cash flow. Their liquidity reserves decrease because they deplete them to finance investments. Relying on the firm-level investment data in 12 Asian countries, Australia and New Zealand during the period 1990–2010, Ameer (2014) shows that managers of the financially constrained firms in the developed and emerging countries take different financing decisions in response to the emergence of valuable investment opportunities.

The research presented on the relationship between debt and corporate performance for the French companies has provided different results. Relying on the data for the medium-sized manufacturing companies, Weill (2008) reports a positive relationship between leverage and corporate performance. According to Margaritis and Psillaki (2010), the relationship is more pronounced among the firms with a more concentrated ownership and family management.

3 Hypotheses Development

The aim of the paper is to study the impact of investment and financing policies on the short- and medium-term operating performance of the stock-listed companies in France. In our opinion, the outbreak of financial crisis may have altered the role of the studied factors on the companies' performance record.

Capital expenditures incurred simultaneously with the crisis outbreak may ameliorate (Kivjärvi and Saarinen 1995) or deteriorate (Jackowicz and Mielcarz 2015) the operating KPIs. The positive impact may stem from the modernization effect of investments, whereby the incremental capital expenditures contribute to the strengthening of the company's long-term competitive position and help exploit the firm's growth potential to the maximum possible extent. A negative influence may be caused by an increased cost pressure exercised by cumbersome investment projects accompanied with a weak demand and production downturn. While the first effect is rather long-term and should generally hold in practice, the second one may be critically important for the company's short-term performance and its survival in the turbulent environment.

We argue that at the outbreak of the economic crisis, the cost effect of capital expenditure may outweigh the modernization effect (Jackowicz and Mielcarz 2015). As the financing constraints are being aggravated by the settings of the credit market crunch, the opportunity cost of finance increases and the cash flows are being exhausted by the investment projects, which most probably, will not manage to increase shareholder value because of weak demand. Hence, our first hypothesis can be formulated as follows:

H1 The cost effect of investment outlays incurred at the outbreak of the financial crisis outweigh the modernization effect, causing the short-term operating performance to deteriorate.

At the same time, in the aftermath of the crisis outbreak, the corporate sector is expected to gradually accommodate the credit crunch and demand shrinkage, and scale investment projects appropriately. Hence, the modernization effect is expected to apply in the medium term leading to the second research hypothesis:

H2 In the aftermath of the outbreak of the crisis (2009–2011), the modernization effect of investment expenditures outweighs the cost effect implying its positive impact on the firm's operating performance.

The influence of financing policy on operating performance may also have different transmission mechanisms. On one hand, debt may exercise a disciplining influence on the firm's management, thereby, alleviating the agency problems (Jensen and Meckling 1976). On the other hand, excessive debt may have detrimental consequences on the KPIs (Opler and Titman 1994) due to pre-bankruptcy costs (Elkamhi et al. 2012), increased financing constraints, and impeded access to capital markets (Campello et al. 2010). The more leveraged companies may be assumed to have a better access to external finance, and therefore, may be better positioned to accommodate the repercussions of any turmoil on capital markets.

Hence, companies having more debt at the outbreak of the financial crisis should be more resistant to the negative consequences of a credit crunch due to three key reasons: (1) their debt reduces the scale of the agency problem; (2) as they have a better access to capital markets, they are able to substitute external finance for the deficient internal cash flows; (3) they may be able to avoid undercutting investment financing due to cash flow shortage, as they are able to smooth their investment expenditures with third-party credit. The above line of reasoning is summarized in H3.

H3 Higher leverage at the outbreak of the financial crisis may positively contribute to the company's short- and medium-term performance.

Table 1 Summary of the research hypotheses

Hypothesis	Explained variable	Explanatory variable	Expected sign	Theoretical background
H1	Operating performance	Capital expenditures	–	The cost effect of investment (Jackowicz and Mielcarz 2015)
H2	Operating performance	Capital expenditures	+	Modernization effect of investment (Kivjärvi and Saarinen 1995)
H3	Operating performance	Leverage	+	Financing constraints (Opler and Titman 1994)
H4	Operating performance	Leverage	–	Cost effect of debt (De Fiore and Uhlig 2015)

On the other hand, as the unfavorable conjuncture on the capital markets causes the cost of external capital to rise, excessive debt may exercise a significant negative influence on the firm's bottom line (De Fiore and Uhlig 2015). This negative interrelation may be labelled as the cost effect of debt. If the cost effect prevails, paying down the outstanding interest-bearing debt may constitute a sound managerial solution and may ameliorate the firm's KPIs in the aftermath of the financial shocks.

H4 In the aftermath of the outbreak of the financial crisis, the company's operating performance is negatively correlated with the leverage level, implying that reduction of indebtedness may enhance the performance indicators.

The presented hypotheses are summarized in Table 1.

4 Dataset and Empirical Models

In order to test the described research hypotheses, we have collected a firm-level dataset for 370 companies quoted on the French stock market covering the period from 2005 to 2011. The dataset comprises only non-financial companies including those, which ceased to exist.

The methodological toolkit of the paper features both panel and cross-sectional models. The general specification of the models looks as follows:

$$OP_i = f(Leverage_i; Investments_i; CONTROL_i), \tag{1}$$

where OP_i—explained variable, operating performance indicator; Leverage_i—the leverage indicators; Investments_i—the level of fixed investments undertaken by the company; CONTROL_i—a set of control variables; i—subscript encoding an observation for the i-th company.

Accounting measures of operating performance have been frequently used for this type of research (e.g., Kivjärvi and Saarinen 1995; Lee and Marvel 2009). Hence, we selected Return on Assets (ROA) as the explained variable.

We selected several different proxies for the leverage ratio: (1) Weight of Debt—share of debt in the firm's capital structure based on market values of equity and debt; (2) FNCL LVRG—financial leverage calculated as a ratio of debt to equity; (3) Debt/Assets—an average of the debt-to-assets ratios during the pre-crisis period (2005–2007); (4) TOT DEBT TO TOT ASSETS—contemporaneous debt-to-assets ratio.

The following proxies for investment policy were included into the tested models: (1) Capex/Assets—a ratio of total capital expenditures to total assets; (2) Fixed Asset Sequential Growth—growth of the company's total fixed assets YoY.

The models feature the following control variables: (1) MV/BV—market-to-book value ratio as a proxy for growth opportunities; (2) Dividend payout ratio (DPR) and Equity Dividend Yield (EQY DVD YLD) as proxied for the firm's dividend policy; (3) Current ratio (CUR RATIO) and share of cash in total assets (Cash/Assets) as proxies for the firm's liquidity position; (4) natural logarithm o total assets (LN Assets) as a proxy for the firm's size.

In order to test H1 and H3, which focus on the outbreak of the financial crisis of 2008, we shall use the long-term event study methodology elaborated by Boubakri et al. (2012), which allows to track the influence of the firm-level financial decisions on the dynamics of the chosen parameters over a specified time interval. The explained variable is the difference between the average ROA in the post- (2009–2011) and pre-crisis (2005–2007) periods, while the explanatory variables are the contemporaneous parameters of the firm's financing and investment policies for 2008 described above. 2008 is the year of the crisis outbreak and therefore, serves for splitting the observation period into pre- and post-crisis. The econometric model specification may be presented as follows:

$$\Delta ROA_i = \beta_0 + \beta_1 Leverage_{i,2008} + \beta_2 Investments_{i,2008} + \delta CONTROLS_{i,2008} + \varepsilon_i, \quad (2)$$

where $\Delta ROA_i = \frac{1}{3}\left(\sum_{2009}^{2011} ROA_{i,t} - \sum_{2005}^{2007} ROA_{i,t}\right)$; ε_i—error term.

In order to validate H2 and H4, we use static panel regressions with fixed firm effects. The panel regressions cover only the implied post-crisis period, i.e., 2009–2011. We intend to clarify, how the relevance of the studied explained variables may be altered by the crisis settings. The specification of the tested econometric model is as follows:

$$ROA_{i,t} = \beta_0 + \beta_1 Leverage_{i,t} + \beta_2 Investments_{i,t} + \delta CONTROLS_{i,t} + \varepsilon_i, \quad (3)$$

5 Dataset and Empirical Models

Tables 2 and 3 summarize the results of the empirical tests. All the models possess satisfactory econometrical properties allowing to derive valid conclusions. Part of the regressors are independently and jointly statistically significant at the conventional significance levels.

Table 2 Cross-sectional models. Empirical tests of H1 and H3

Model No	1	2	3	4	5	6	7
No. of observations	278	278	275	278	265	265	265
No. parameters	6	6	6	6	6	6	6
R^2	0,155	0,147	0,136	0,137	0,176	0,160	0,168
F	9,988***	9,419***	8,538***	8,687***	11,11***	9,902***	10,49***
Constant	−1,259	−1,044	−0,662	−0,795	−1,754	−1,098	−1,430
	(0.8822)	(0.8184)	(0.7578)	(0.8359)	(0.7397)	(0.729)	(0.6636)
MV/BV	−0,0028***	−0,0028***	−0,0028***	−0,0027***	−0,0027***	−0,0025***	−0,0027***
	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(0.0002)
CUR RATIO	0,0958***	0,094***	0,091***	0,0911***	0,098***	0,093***	0,096***
	(0.0048)	(0.0045)	(0.0046)	(0.0045)	(0.0045)	(0.0045)	(0.0044)
EQY DVD YLD	−0,241***	−0,271***	−0,239***	−0,240***	−0,259***	−0,255***	−0,281***
	(0.0743)	(0.0789)	(0.0781)	(0.0759)	(0.0817)	(0.0844)	(0.0876)
CAPEX/ASSETS	−22,322**	−21,050**	−19,352**	−22,223**			
	(8.9014)	(8.7743)	(9.0746)	(8.9361)			
Fixed asset sequential growth					−0,0187***	−0,019***	−0,0187***
					(0.0059)	(0.0059)	(0.0058)
Weight of Debt		0,029**					0,021*
		(0.0124)					(0.0126)
FNCL LVRG			0,130**				
			(0.0553)				
Debt/Assets	0,0601***				0,0504**		
	(0.0203)				(0.0216)		

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively
Source: Own elaboration
Notes: This table presents the cross-sectional model estimates. The standard errors are provided in parentheses

Table 3 Results of the panel regression tests of H2 and H4

Model No	8	9	10	11	12
No. of observations	902	904	902	889	891
Wald (joint)	54,5***	43,05***	34,96***	41***	59,65***
R^2	0,83	0,82	0,82	0,82	0,83
AR(1) test	−2,522**	−2,575***	−2,571***	−2,534**	−2,529**
AR(2) test	−5,873***	−5,794***	−5,865***	−5,696***	−5,683***
Constant	10,497***	12,297***	12,438***	12,621***	12,682***
	(1.911)	(1.567)	(1.511)	(1.563)	(1.570)
LN Assets	0,618***	0,349*	0,193	0,226	0,400**
	(0.235)	(0.192)	(0.165)	(0.142)	(0.169)
DPR	−0,0010***	−0,00109***	−0,00107***	−0,00106***	−0,00109***
	(000)	(000)	(000)	(000)	(000)
MV/BV	0,290**	0,195**	0,173*	0,168*	0,173*
	(0.124)	(0.090)	(0.089)	(0.094)	(0.093)
Cash/assets	6,881**	5,790**	6,597**	5,969**	4,703*
	(2.962)	(2.798)	(2.873)	(2.889)	(2.794)
CAPEX/ ASSETS	10,979**	8,891*	10,00*		
	(5.266)	(5.353)	(5.462)		
Fixed asset sequential growth				0,005***	0,005***
				(0.002)	(0.002)
Weight of Debt		−0,051***			−0,062***
		(0.018)			(0.018)
FNCL LVRG			0,073	0,060	
			(0.313)	(0.318)	
TOT DEBT TO TOT ASSET	−0,138***				
	(0.028)				

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively
Source: Own elaboration
Notes: This table presents static panel model estimates. All models are estimated with firm-specific fixed effects. The heteroscedasticity robust standard errors are provided in parentheses

Table 2 shows the results of H1 and H3 tests. The coefficients at the proxies for investment policy are statistically significant and have a persistently negative sign, which speaks in favor of H1: i.e., capital expenditures incurred in 2008 may have had a negative impact on the medium-term performance of the companies in the research sample. Our findings highlight the dominating influence of the cost effect of investment at the outbreak of the financial crisis. Companies, which invested relatively more in 2008 appear to have deteriorated their operating performance in the aftermath of the crisis outbreak. This may have happened due to the fact that most of the investment projects implemented in 2008 were not calibrated for the conditions of the economic downturn and were mostly intended as expansionary projects. Expansionary nature of these projects did not allow the corporate sector to properly adjust their scope to the settings of the plummeting demand.

The coefficients at proxies for leverage are statistically significant at the conventional levels and have a persistently positive influence on the explained variable. We fail to reject H3 and therefore, conclude that a higher leverage ratio at the outbreak of the financial crisis of 2008 (or the higher average leverage ratio during 2005–2007 as implied by the Debt/Assets ratio) may have positively contributed to the operating performance record of the sampled companies. The findings may speak in favor of the theory of capital constraints, whereby financially unconstrained companies are better positioned to accommodate external cash flow shocks. It may also point to the favorable influence of debt in the framework of the agency theory.

The coefficients at control variables in the cross-sectional models allow to derive some additional conclusions. Companies, which recurred to dividend smoothing and refrained from cutting dividend payments appear to have worsened their medium-term performance. Companies, which had a liquidity reserve at the outbreak of the crisis were better positioned to accommodate the economic shocks. Companies with higher growth potential approximated by the MV/BV ratio were more sensitive to the economic conjuncture and suffered a dropdown in operating performance.

Table 3 summarizes the empirical tests of H2 and H4. We tested static panel regressions with fixed effects for the observation period of 2009–2011 (after the outbreak of the crisis).

The coefficients at the variables describing the companies' investment policy are statistically significant at the conventional levels. The positive sign persists despite changes in the model specification, which speaks in favor of H2. In the aftermath of the crisis of 2008, companies appear to have scaled and adjusted their projects to the economic situation, which caused the modernization effect to outweigh the cost effect. Hence, in order to ameliorate their operating performance after the crisis outbreak the firms had to actively invest and restructure their investment projects.

The coefficients at the proxies for capital structure (except for the leverage ratio) are negative and statistically significant, which may point to the impact of the cost effect of debt on the operating performance of the corporate sector. Acute problems with accessing external finance aggravated by the credit market crunch appear to have forced firms to consider paying down debts in search for financing cost optimization. In order to enhance their credibility in the eyes of the creditors, companies may have been induced to cut on external borrowing and finance organic growth predominantly from internal cash flows. Therefore, we fail to reject H4.

In line with previous models, we find that firms with a better liquidity position had a better performance score in the analyzed period. Dividend-paying companies were likely to exhibit lower operating performance, while the growth companies with significant growth opportunities (approximated by MV/BV ratio) had a higher return on assets.

6 Concluding Remarks

The paper re-examines the influence of investment and financing policies on the operating performance of a sample of companies quoted on the French stock market under negative demand-driven shocks. Our findings suggest that at the outbreak of recession in 2008, capital expenditures may have negatively influenced the medium-term operating performance of the sampled firms, while higher leverage ratios appear to have been associated with a better performance record. In the aftermath of the crisis outbreak, the direction of the impact of analyzed variables reversed: capital expenditures positively contributed to the dynamics of ROA, while debt levels were negatively associated with the studied explained variable.

The paper revisits the corporate decision making patterns, which occur under recessionary tendencies. Presaging the potential déjà vu effect upon the advent of future negative demand-driven shocks, the results may serve as a revision of the lessons from the preceding recession.

Our findings may also prompt a discussion over potential improvements in the capital budgeting processes in order to increase their flexibility and allow for contingency planning, for it may help the companies navigate through economic turmoil.

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Part IV
Financial Market

The Application of Two-Stage Diversification to Portfolios from the WSE

Agata Gluzicka

Abstract Diversification is one of the most important elements of the process of investment portfolio management. The special attention is focus on the diversification in the periods of the rapid changes in the financial markets. The numerous empirical research have shown that the lack of the appropriate assumptions in the portfolio construction or the bad stock selection can have catastrophic consequences. One of the important problem is the portfolio diversification. In the recent years a few interesting methods to construct the well-diversified portfolios have been proposed. In the article the models of construction the Rao's Quadratic Entropy portfolios and the Most Diversified Portfolios were described. Also two criteria for selecting stocks to portfolio were presented. These criteria in some sense can improve the well-diversified portfolios. Proposed methods were applied to selected stocks from the Warsaw Stock Exchange. The main goal of these research was analysis of the impact of presented criteria on the risk, rate of return and Sharpe Ratio of diversified portfolios. The research provided that the best results were received when the stocks were selected according to the values of Portfolio Diversification Index and when portfolios were constructed as the Most Diversified Portfolios.

1 Introduction

Diversification is one of the basic elements of modern portfolio theory. The uncertainty which is strictly linked with the financial markets, makes diversification a valuable tool for portfolio management. Numerous empirical research conducted for the world markets have shown that the incorrect assumptions in the portfolio construction process can lead to the catastrophic consequences. Hence, the constant search of the new methods of portfolio construction which can improve the investment process. One of the research trends developed in the recent years is related with

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portfolio selection models, which completely ignore the assumption about the rate of return of portfolio. By using these models we can construct, among others, the Most Diversified Portfolio, the Risk Parity Portfolio or portfolios optimal in the sense of Rao's Quadratic Entropy. All these portfolios can be classified as the well-diversified portfolios. Methods mentioned above allow to avoid excessive concentration of investment in one or more components what is very important for all investments. Moreover the shares of all components of these portfolios are significant.

In the first part of the article two models of well-diversified portfolios construction will be presented: portfolio optimal in the sense of Rao's Quadratic Entropy and the Most Diversified Portfolios. In the next section, two criteria for selecting stocks for portfolios will be presented. These criteria are based on the Principal Component Analysis and on the Portfolio Diversification Index. Applying these criteria to the diversified portfolios construction leads to two-stage diversification. The final part of the article is a presentation of results and conclusions from empirical research carried out for a group of stocks from Warsaw Stock Exchange. The main objective of these research was to analyze the impact of the proposed criteria on the diversified portfolios. The assumption of the research was that the two-stage diversification let to receive a better portfolios (according to the rates of return, risk and effectiveness) than the other classical stock selection criteria.

2 Selected Models of Diversified Portfolios Construction

2.1 Application of the Rao's Quadratic Entropy to Construction the Diversified Portfolios

The important role in the context of diversification plays the entropy. Recently, a new measure of the level of diversification called the Rao's Quadratic Entropy (*RQE*) was introduced (Rao 1982a, b; Carmicheal et al. 2015). This measure is an example of the measure of concentration of information. The Rao's Quadratic Entropy was proposed as the measure of diversity. It was used mainly in statistics and in ecology. However it is possible to apply this entropy as a measure of portfolio diversification. The Rao's Quadratic Entropy is defined as:

$$RQE = 2\sum_{i,j=1}^{N} d_{ij} w_i w_j \tag{1}$$

where $D = \left[d_{ij}\right]_{i,j=1}^{N}$ is the function of dissimilarity. The dissimilarity function measures the differences between any two components of the portfolio. As a function of dissimilarity we can use any function of two arguments which satisfies the following conditions: $d_{ij} \geq 0$ for all $i, j = 1, 2, \ldots, N$, $d_{ij} = d_{ji}$ for all $i, j = 1, 2, \ldots, N$, $d_{ii} = 0$ for all $i = 1, 2, \ldots, N$. In the literature the function of dissimilarity is defined for example for the Kronecker delta, the covariance matrix or the correlation coefficients. In all these cases the Rao's Quadratic Entropy is a generalization of some well-known diversification measures. In the presented research the Rao's Quadratic Entropy was defined for the correlation matrix by the following formula:

$$RQE = 2\sum_{i,j=1}^{N}\left(1-\rho_{ij}\right)w_i w_j \tag{2}$$

In this form the Rao's Quadratic Entropy is a decreasing function dependent on the correlation coefficient ρ_{ij}. Therefore, the *RQE* diversification disappears when all components are perfectly correlated. This is a confirmation of the intuitive explanation for the diversification: low correlation implies a high level of the diversification. We can use the Rao's Quadratic Entropy as an objective function to construct the diversified portfolio. The *RQE* portfolios were constructed by using the following optimization model:

$$\begin{gathered} 2\sum_{i,j=1}^{N}\left(1-\rho_{ij}\right)w_i w_j \rightarrow \max \\ \sum_{i=1}^{N} w_i = 1 \\ w_i \geq 0, \qquad i = 1, 2, \ldots, N \end{gathered} \tag{3}$$

The *RQE* portfolios are a portfolios with minimum concentration of information and they are also interpreted as portfolios with maximum effective number of the independent risk factors. If the function of dissimilarity is defined by the correlation matrix (as is the case in the presented research), the Rao's Quadratic Entropy is en equivalent to the variance of the portfolio.

2.2 The Most Diversified Portfolios

To construct the other type of well-diversified portfolios we can use the Diversification Ratio (*DR*). This ratio was proposed on the assumption that the diversification effect lies in the difference between the weighted sum of the risks of individual components and the total risk of the portfolio (Tasche 2006). This ratio was defined for different measures of risk. However, the most often is used *DR* formulated for the standard deviation (Cheng and Roulac 2007):

$$DR = \frac{\sigma_a}{\sigma_p} = \frac{\sum_{i=1}^{N} w_i \sigma_i}{\sigma_p} \tag{4}$$

where: σ_p—the standard deviation of the portfolio, σ_a—the weighted sum of standard deviations of portfolio components, σ_i—the standard deviation of i-th component of the portfolio, w_i—the share of i-th component in portfolio ($i = 1, 2, \ldots, N$). The values of DR are higher than 1, so on the base of this ratio we cannot determine what part of risk is diversified. We can only compare portfolios according to the diversification level—the higher value of DR, the higher level of the diversification. In the case when all components are perfectly uncorrelated we received a fully diversified portfolio and the DR is equal to the $\sqrt{N}$.

The diversification ratio can be applied as a criterion for selecting investment portfolio. For this purpose the following optimization model can be used (Choueifaty and Coignard 2008):

$$\begin{gathered} DR \to \max \\ \sum_{i=1}^{N} w_i = 1 \\ w_i \geq 0, \quad i = 1, 2, \ldots, N \end{gathered} \tag{5}$$

As a result we receive portfolios called the Most Diversified Portfolios (*MDP*). These portfolios maximize the difference between two definitions of the portfolio volatility—the weighed volatility and the total volatility of portfolio. So far, the most diversified portfolios were compared with the other investment strategies like the naïve portfolio or the minimum variance portfolio. On the base of these research the following properties were formulated:

– if all components of the portfolio have the same value of the Sharpe Ratio, than the Sharpe Ratio of the most diversified portfolio has the highest possible value,
– if all the potential components of the portfolio have the same volatility, than the most diversified portfolio will also be the global minimum variance portfolio.

More properties of both presented diversification measures were described among others in Gluzicka (2017).

3 Stock Selection Criteria

For both types of portfolios presented in the previous section the main problem is how to select the stocks to these portfolios. This is connected with the fact that for the given set of stocks both presented models almost for all stocks assign the non-zero shares. The transformation of the set of correlated rates of return into the set of uncorrelated components is very important process in the portfolio analysis. An example of such method is Principal Component Analysis. Using the assumptions of this methods, we can formulate two criteria for selecting stocks to portfolio.

The first criterion is related to the Portfolio Diversification Index (*PDI*) introduced by Rudin and Morgan (2006). This index was defined by the eigenvalues of the correlation matrix of the rates of returns of portfolio as follows:

$$PDI = 2\sum_{k=1}^{N} ku_k - 1 \tag{6}$$

where $u_k = \frac{\lambda_k}{\sum_{i=1}^{N}\lambda_i}$ for all $k = 1, 2, \ldots, N$ and λ_i, means eigenvalue for $i = 1, 2, \ldots, N$.

The values of the Portfolio Diversification Index are higher than 1. *PDI* value equal 1 means a lack of diversification. For a fully diversified portfolio, the value of *PDI* is equal to the number of components in portfolio ($PDI = N$).

To the initial stock selection we can apply this following procedure:

- for each of any two stocks the value of *PDI* is calculated,
- these two stocks are selected for which the *PDI* is the highest,
- to set of selected stocks the next component is added,
- the value of *PDI* is calculated for each three elements set of stocks
- this stock is selected for which the *PDI* is the highest,
- the procedure is repeated until a fixed number of components are not obtained.

When we apply above procedure (*PDI* criterion) and after that we use one of the presented models of construction the well-diversified portfolios, we received portfolios constructed according to two-stage diversification.

The second stock selection criterion is strictly connected with the application of the *PCA*. In this case the steps are following (*PCA* criterion, Yang et al. 2015):

- the principal component analysis is applied to the correlation matrix of the rates of return for all analyzed stocks,
- for all principal component with the eigenvalues lower than 1 (removal criterion) we select the coefficient of the highest absolute value—the stock corresponding to this coefficient is removed from the further analysis,
- the procedure is repeated until the stop criterion is not reached, eg. if all principal components have the eigenvalues at least on the level 0.7.

It should be noticed that the Principal Component Analysis and the Portfolio Diversification Index are connected with the other type of diversified portfolios called principal portfolios (Meucci 2009; Meucci et al. 2013).

4 The Well-Diversified Portfolios on the Warsaw Stock Exchange: An Empirical Analysis

The methods presented in the previous sections have been applied to selected stocks from the Warsaw Stock Exchange. Two goals were set in these research. Firstly, the impact of proposed criteria for stock selection on the main characteristics of well-diversified portfolios was analyzed. The second goal was to determine which methods of constructing diversified portfolios provided the best results for the proposed criterion for initial selection of companies. For comparative purpose, the following methods were used as a pre-selection criterion: the *PDI* criterion, the *PCA* criterion, the stocks of the highest rates of return, the stocks of the lowest risk (standard deviation), the stocks from the index WIG20. The *PCA* criterion indicated that 13 stocks should be selected to the portfolios. For the rest four criteria 20 stocks were selected to the diversified portfolios.

In the research the daily rates of return of the 198 stocks from the WSE were used. On the base of the data from the 2012 the stock selection was made. The portfolios were constructed for the data from the period 2013–2017. The portfolio construction was made in two ways. First, portfolios were constructed for the data from the entire period 2013–2017 (5-years portfolios). Then, the construction of the diversified portfolios were repeated for the 12-months data. The beginning for each set of data was the next month from the period January 2013–January 2017. As a result, for each criterion 49 diversified portfolios (1-year portfolios) were constructed.

First the 5-years portfolios were analyzed. In the Table 1 the values of risk for all diversified portfolios constructed for the data from the whole period 2013–2017 were presented. For each method of portfolio construction, the best criterion for selecting stocks was the *PDI* criterion. Portfolios for which the stocks were selected based on the value of *PDI* were least risky. The risk analysis of constructed portfolios showed also that for each applied criterion of stock selection, it was better to construct the *MDP* portfolio. These portfolios turned out to be slightly less risky than *RQE* portfolios constructed for stocks selected according to the given criterion. Definitely, the most risky were portfolios constructed for stocks belonging to the WIG20 index.

The values of rates of return for both types of portfolios were presented in the Table 2. Portfolios constructed for stocks with the highest *PDI* was characterized by the highest rate of return. Regardless which criterion of stock selection were used, better method for the construction of diversified portfolios was the *MDP* method. The lowest rates of return of portfolios were received when stocks were selected according to the values of rates of return.

Table 1 Values of risk for 5-years portfolios

Portfolio	PDI	PCA	Rate of return	Risk	WIG 20
RQE	3,1234E-05	5,2700E-05	4,9027E-05	5,2411E-05	0,00011
MDP	2,9329E-05	4,7800E-05	4,2311E-05	3,5301E-05	9,9874E-05

Table 2 Rates of return for 5-years portfolios

Portfolio	PDI	PCA	Rate of return	Risk	WIG 20
RQE	1,00015	0,999829	0,999583	0,999676	0,99950
MDP	1,00019	0,999934	0,999623	0,999823	0,99989

Both types of portfolios are similar according to the number of stocks with non-zero shares in portfolio (Table 3). The *MDP* portfolios were a little bit better (had more non-zero components) when stocks were from the index WIG20 or for stocks selected according to the risk. On the received results we can state that the proposed criteria can be a guarantee that almost all selected stocks will have the non-zero shares in the portfolios constructed by the analyzed models.

In the similar way, 1-year portfolios were compared. First the impact of the stock selection criterion on the rates of return and the risk of portfolios were analyzed. On all graphs presented in this section, the horizontal axis indicates the initial month of the data period for which the portfolio was constructed.

The values of rates of return of diversified portfolios depending on the criterion of stocks selection were presented on the Figs. 1 and 2. For each criterion the highest rates of return for the first 12–13 portfolios were obtained for the *PDI* criterion. However, for portfolios constructed for the further data, it is difficult to determine which criterion is the best when we construct the diversified portfolios. A comparison of the risk values of diversified portfolios showed that for most cases the least risky was portfolio of stocks selected according to *PDI* criterion (Figs. 3 and 4). This dependency is true for most portfolios from the initial and final periods. In the case of

Table 3 Number of stocks with non-zero shares in the 5-years portfolios

Portfolio	PDI	PCA	Rate of return	Risk	WIG 20
RQE	20	13	20	20	16
MDP	20	13	20	19	15

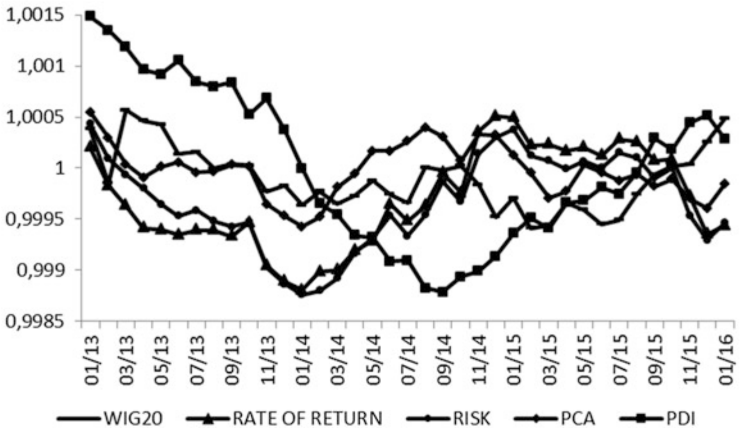

Fig. 1 Rates of return for the most diversified portfolios

Fig. 2 Rates of return for Rao's Quadratic Entropy portfolios

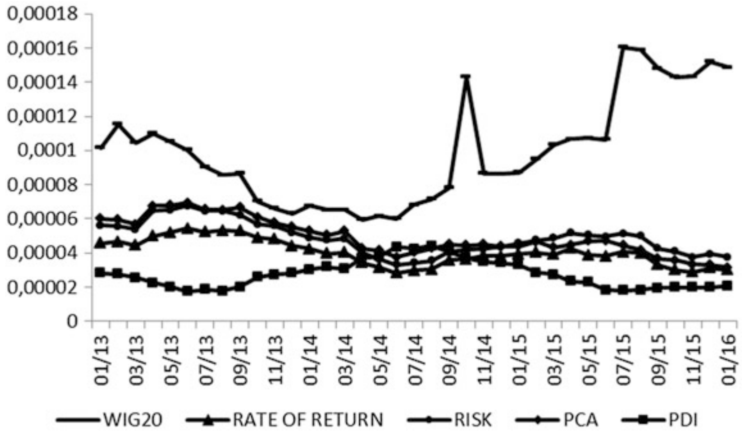

Fig. 3 Risk for the most diversified portfolios

MDP portfolios, for intermediate periods, the least risky were portfolios composed of stocks selected on the base of the rates of return. For *RQE* portfolios, the lowest risk for the intermediate periods was obtained for portfolios constructed for riskless stocks. Unquestionably the most risky were portfolios constructed for stocks from the WIG20 index.

Next, portfolios constructed by different models were compared, but for stocks selected according to one of the proposed criterion. In this part, the well-diversified

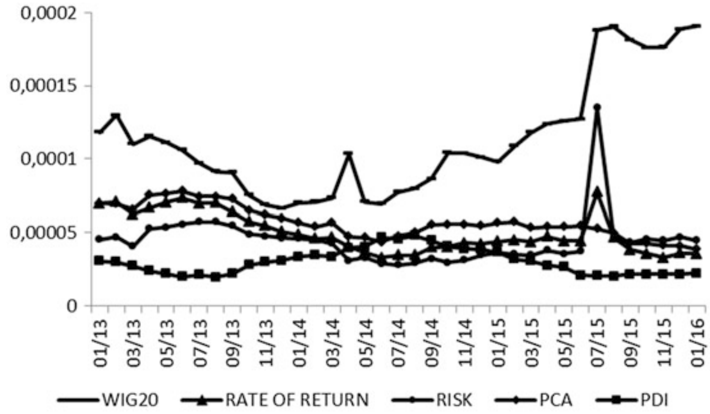

Fig. 4 Risk for Rao's Quadratic Entropy portfolios

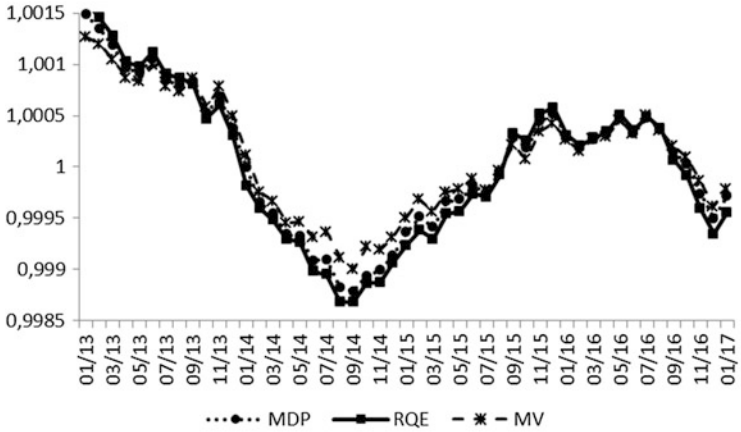

Fig. 5 Rates of return of portfolios constructed for the stocks selected according to *PDI*

portfolios were compared with the minimum variance portfolios (*MV*). Figures 5 and 6 shown the values of rates of return and risk for portfolios constructed for the stocks selected according to *PDI*. For both portfolios the values of rates of return are very similar, so it is difficult to determine which method gave better results for this case. However, according to variance the most risky were portfolios optimal according to the *RQE*. For the stocks selected according to *PCA* the results were

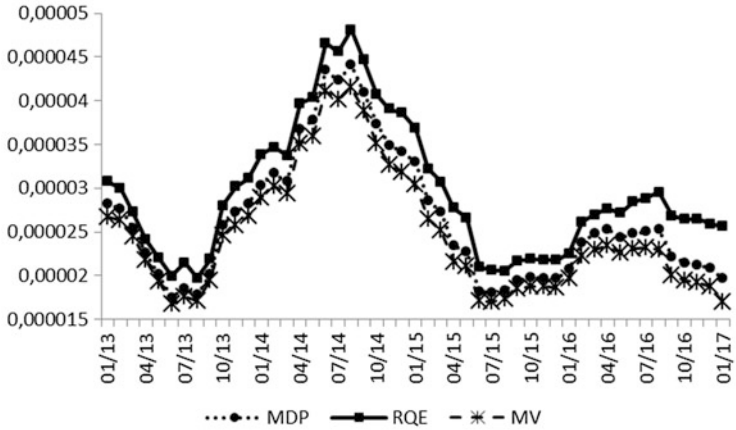

Fig. 6 Risk of diversified portfolios constructed for the stocks selected according to *PDI*

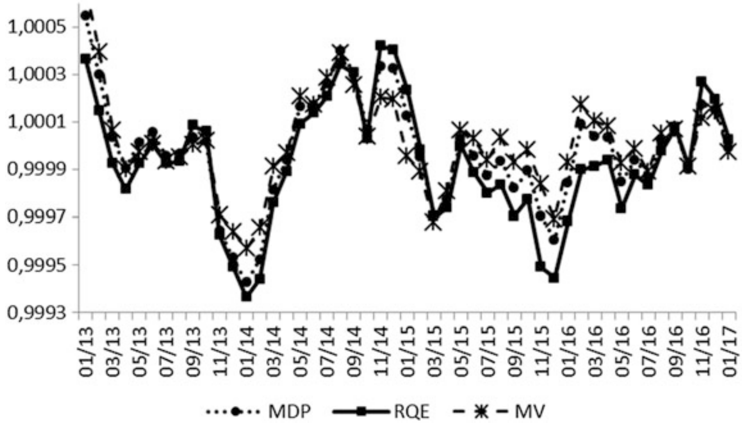

Fig. 7 Rates of return of portfolios constructed for the stocks selected according to *PCA*

similar (Figs. 7 and 8). Additionally, the values of Sharpe Ratio for both diversified portfolios were compared (Figs. 9 and 10). Also, according to this measure both types of portfolios were very similar.

5 Summary

In the article two criteria which can improve the well-diversified portfolios were presented. These criteria were applied to data from the Warsaw Stock Exchange. Based on these research a few conclusions can be formulate:

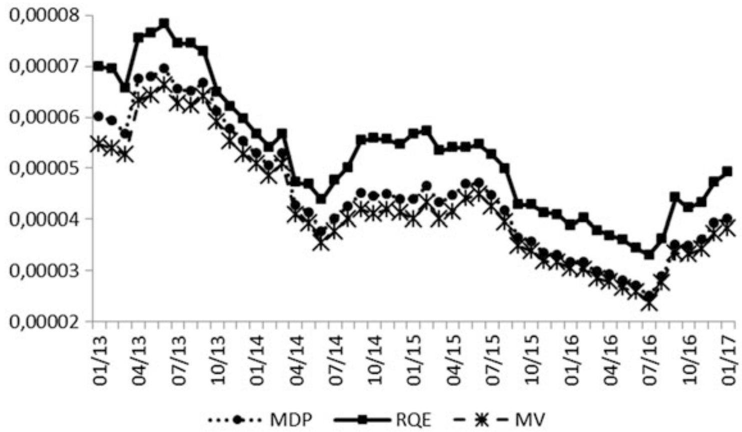

Fig. 8 Risk of portfolios constructed for the stocks selected according to *PCA*

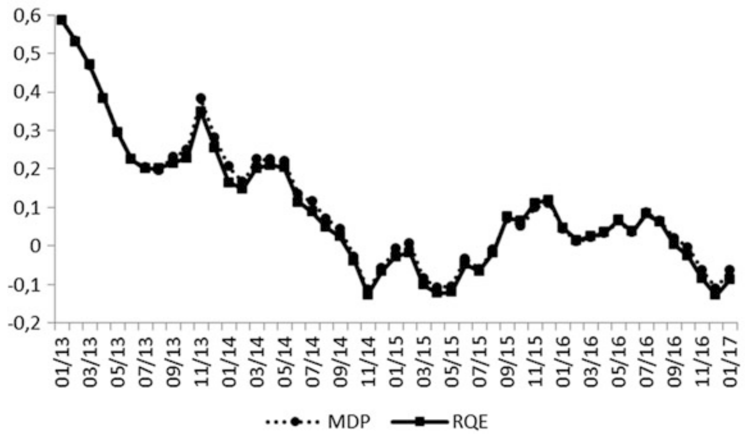

Fig. 9 Sharpe Ratio of portfolios constructed for the stocks selected according to *PCA*

- the selection of stocks according to the *PDI* criterion allows to construct diversified portfolios with lower risk than the selection of stocks according to other analyzed criterions (two-stage diversification),
- for both stock selection criteria, the *MDP* and *RQE* portfolios are very similar according to the rates of return and the values of the Sharpe Ratio
- for proposed criteria of stock selection, the *RQE* portfolios always are more risky,
- all presented methods allow to receive portfolios with a similar number of stocks with non-zero shares in portfolio.

Fig. 10 Sharpe Ratio of portfolios constructed for the stocks selected according to *PCA*

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Verification of the Conditional CAPM: The Example of the Polish Capital Market

Lesław Markowski

Abstract In contrast to the classical approach, this work proposed the separate treatment of results received in periods of positive and negative market excess return. Moreover, this study used rather realised than average returns in cross-sectional regressions. The results indicate that relations between returns and beta coefficients are conditioned the sign of market excess return. The average value of premium for systematic risk is significantly greater than zero in periods of positive market excess return and significantly smaller from zero in periods of negative market excess return. Moreover, conditional relations between average returns and beta are significant in contrast with unconditional relations. The received results underline the meaning of analysis of realised return towards the factor risk (in the case of market risk) and confirm usefulness of beta coefficient as proper measures of risk, that is valid in portfolio management.

1 Introduction

One of the classical capital pricing theories is the capital market equilibrium model also called in the literature as *Capital Asset Pricing Model* (CAPM). Although CAPM is widely used to describe the prices and rates of return of financial instruments, its verification is still an active area of research and the subject of arguments. Many studies accepted its validity Hawawini (1991) and Chan et al. (1991) while others rejected it, or even considered the theory empirically unverifiable Ostermark (1991), Cheung and Wong (1992) and Żarnowski and Rutkowska (2012). Most standard or extended version tests, in which researches used other, apart from market risk, systematic risk factors such as: price to profit Dimson and Musavian (1999), Basu (1977), company size Banz (1981) Brennan et al. (1998), book value per share

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Fama and French (1992), Czapkiewicz and Skalna (2011) were conducted according to the methodology proposed by Fama and MacBeth (1973).

Classical CAPM tests, however, do not allow direct observe the situation in which securities with the high beta achieve lower returns than securities with the low betas. Early tests did not consider the condition that would allow to observe the above case. The solution to this problem may be an approach in witch relationships between the systematic risk and the expected return depend on market conditions. One of the first studies using the above methodology was empirical evidence (Pettengill et al. 1995) where the relationship between rates of return and beta coefficient with high and low levels of this risk measure are conditioned to the relationship between the realized market rate of return and the risk-free rate. They convincingly proved hypothesis about an inverse relationship between beta and returns when excess market return was negative. Note that if $R_{Mt} < R_{ft}$ so $\beta_i(R_{Mt} - R_{ft}) < 0$ and then the expected rate of return is calculated relative to the negative risk premium proportional to the beta coefficient. In other words, if the realized market return is less than the risk-free rate, then there is a negative relationship between the expected return and the beta coefficients. Otherwise, if the realized market return is greater than the risk-free rate, the relationship between the expected return and the beta coefficients is positive. This statement is relevant in the context of testing systematic relations between returns and beta coefficient, especially when the market excess return was negative. That approach to this phenomenon flows from negative attitude investors towards downside risk. This argues the case for greater attention to the need for more CAPM research. Demonstrating the statistical significance of conditional CAPM relationships allow to treat the beta as an important and useful measure of risk. This approach was reflected in many studies that showed positive risk-return relationships consistent with the postulates of the CAPM Fletcher (2000), Jagannathan and Wang (1996), Trzpiot and Krężołek (2006), Theriou et al. (2010) and Bilgin and Basti (2014).

The purpose of the article is to test the validity of estimating CAPM relations between beta coefficient and realised returns for single companies quoted on the Polish capital market. The studies proposed the analysis of unconditional and conditional relationships, considering positive and negative market excess return. In addition to the standard relation defined by the CAPM, extended versions of this model will be verified as well. These augmented versions will consider potential non-linearity and asymmetry of returns distribution.

2 Methodology

2.1 Unconditional Relationships

The study of relations between beta coefficients and realized rates of return was carried out in a two-step procedure. In the first stage, based on all observations of the sample, the beta coefficients of the securities were estimated using the Sharpe's single-index model given as:

$$R_{it} = \alpha_i + \beta_i R_{Mt} + \xi_{it};\ (t = 1, \ldots, T), \tag{1}$$

where: R_{it}, R_{Mt}—rates of return respectively for the i-th asset and the rate of return of the market portfolio; α_i—constant term; β_i—beta coefficient of i-th asset ξ_{it}—random error term of i-th equation.

In the second stage, the regression analysis was based on cross-sectional rows, where the dependent variables were realized excess returns on assets, and the independent variables were the beta coefficients of assets estimated in the first stage of the procedure. The unconditional cross-sectional relationships were estimated for each period of the sample as follows Nurjannah et al. (2012):

$$R_{it} - R_{ft} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_i + \eta_{it};\ (i = 1, \ldots, n; t = 1, \ldots, T), \tag{2}$$

where: R_f—risk-free rate for t-the observation; γ_{0t}, γ_{1t}—parameters of t-th equation; η_{it}—random error term of t-th equation.

Extended versions of the CAPM subjected to empirical verification as shown below:

$$R_{it} - R_{ft} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_i + \gamma_{3t}\hat{A}_i + \eta_{it};\ (i = 1, \ldots, n; t = 1, \ldots, T) \tag{3}$$

$$R_{it} - R_{ft} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_i + \gamma_{2t}\hat{\beta}_i^2 + \gamma_{3t}\hat{A}_i + \eta_{it};\ (i = 1, \ldots, n; t = 1, \ldots, T) \tag{4}$$

where: $\hat{A}_i$—estimate of the skewness in the distribution of *i-th* asset returns.

From the relationships (2–4) some testable implications of the CAPM can be formulated. The average risk premium γ_1 associated with the market risk premium (beta coefficient) for whole study period should take positive values. Because of the assumption of the CAPM equations linearity and preference by investors right-side asymmetry of profitability distributions that allowing to achieve higher rates of return, sets of hypotheses regarding parameters γ_{1t}, γ_{2t} and γ_{3t} are following Tang and Shum (2003):

$$\begin{matrix} H_0 : E(\gamma_1) = 0 & H_0 : E(\gamma_2) = 0 & H_0 : E(\gamma_3) = 0 \\ H_1 : E(\gamma_1) > 0\text{'} & H_1 : E(\gamma_2) \neq 0\text{'} & H_1 : E(\gamma_3) > 0 \end{matrix} \tag{5}$$

Finally, because the asset uncorrelated with the market portfolio has the expected rate of return equal to the risk-free rate, constant term of the relationship (2–4) should be insignificantly differ from zero which means that:

$$\begin{matrix} H_0 : E(\gamma_0) = 0 \\ H_1 : E(\gamma_0) \neq 0 \end{matrix} \tag{6}$$

Bellowed hypotheses were teste using one mean significance test t with a one-sided or two-sided critical area.

2.2 Conditional Relationships

A conditional approach to testing the CAPM was proposed by Pettengill et al. (1995). Conditional, due to the sign of the market excess return, the CAPM equation in the testable version is a form:

$$R_{it} - R_{ft} = \delta\gamma_{0t}^{U} + (1-\delta)\gamma_{0t}^{D} + \delta\gamma_{1t}^{U}\hat{\beta}_i + (1-\delta)\gamma_{1t}^{D}\hat{\beta}_i + \eta_{it}, \tag{7}$$

where δ is a dichotomous variable used to determine the positive and negative market excess return, then $\delta = 1$ if $(R_{Mt} - R_{ft}) > 0$ and $\delta = 0$ if $(R_{Mt} - R_{ft}) < 0$; γ_{0t}^{U}, $\gamma_{0t}^{D}, \gamma_{1t}^{U}, \gamma_{1t}^{D}$—parameters of t-th equation; η_{it}—random error term of t-th equation.

The average estimation of γ_1^U, should be statistically significantly greater than zero, in the periods with positive excess market return and the average estimation of γ_1^D, should be statistically significantly less than zero in the periods with negative excess market return. The set of hypotheses is as follows:

$$\begin{array}{lcl} H_0: E(\gamma_1^U) = 0 & \text{and} & H_0: E(\gamma_1^D) = 0 \\ H_1: E(\gamma_1^U) > 0 & & H_1: E(\gamma_1^D) < 0 \end{array}. \tag{8}$$

Rejection of null hypotheses in both cases will indicate the occurrence of systematic, conditional relations between the beta coefficients and the realized assets returns.

Similarly, to the unconditional approach, the parameters of extended CAPM versions were estimated for each month based on cross-sectional regression of the form:

$$\begin{aligned} R_{it} - R_{ft} = \delta\gamma_{0t}^{U} + (1-\delta)\gamma_{0t}^{D} + \delta\gamma_{1t}^{U}\hat{\beta}_i + (1-\delta)\gamma_{1t}^{D}\hat{\beta}_i + \\ + \delta\gamma_{3t}^{U}\hat{A}_i + (1-\delta)\gamma_{3t}^{D}\hat{A}_i + \eta_{it} \end{aligned} \tag{9}$$

$$\begin{aligned} R_{it} - R_{ft} = \delta\gamma_{0t}^{U} + (1-\delta)\gamma_{0t}^{D} + \delta\gamma_{1t}^{U}\hat{\beta}_i + (1-\delta)\gamma_{1t}^{D}\hat{\beta}_i + \\ + \delta\gamma_{2t}^{U}\hat{\beta}_i^2 + (1-\delta)\gamma_{2t}^{D}\hat{\beta}_i^2 + \delta\gamma_{3t}^{U}\hat{A}_i + (1-\delta)\gamma_{3t}^{D}\hat{A}_i + \eta_{it} \end{aligned} \tag{10}$$

where $\gamma_{0t}^{U}, \gamma_{0t}^{D}, \gamma_{1t}^{U}, \gamma_{1t}^{D}, \gamma_{2t}^{U}, \gamma_{2t}^{D}, \gamma_{3t}^{U}, \gamma_{3t}^{D}$—parameters of t-th equation; η_{it}—random error term of t-th equation.

Expected signs of estimated coefficients in the periods of positive and negative market excess return present the following sets of hypotheses:

$$\begin{array}{lcl} H_0: E(\gamma_1^U) = 0 & \text{and} & H_0: E(\gamma_1^D) = 0 \\ H_1: E(\gamma_1^U) > 0 & & H_1: E(\gamma_1^D) < 0 \end{array}. \tag{11}$$

$$\begin{array}{lcl} H_0: E(\gamma_2^U) = 0 & \text{and} & H_0: E(\gamma_2^D) = 0 \\ H_1: E(\gamma_2^U) \neq 0 & & H_1: E(\gamma_2^D) \neq 0 \end{array}. \tag{12}$$

$$\begin{array}{l} H_0 : E(\gamma_3^U) = 0 \\ H_1 : E(\gamma_3^U) \neq 0 \end{array} \quad \text{and} \quad \begin{array}{l} H_0 : E(\gamma_3^D) = 0 \\ H_1 : E(\gamma_3^D) \neq 0 \end{array}. \tag{13}$$

In the case of rejecting null hypotheses in relation (10) and (9) relationships between rates of return and systematic risk will be non-linear and the asymmetry of returns will be a measure concerned by investors in the context of significant positive or negative premium for bearing this type of risk.

3 Data

A dataset for empirical analyses of the CAPM relationships were a time series of monthly simple returns of individual securities quoted on the Warsaw Stock Exchange, belonging to the all macro sectors. The sample period is from January 2010 to December 2017, what represents 96 observations. The full time series in the analyzed period were characterized by 230 companies. The WIG index is used as the market portfolio approximation and the proxy for the risk-free rate was average-weighted monthly polish T-bill rates. The tested sample period was characterized by symmetry as to the number of positive $(R_{Mt} - R_{ft}) > 0$ and negative $(R_{Mt} - R_{ft}) < 0$ market excess returns, 48 observations of each type.

4 Results

Firstly, the unconditional relations, due to the sign of the market surplus, were analysed the relationships between the beta coefficients and the realized rates of return. The results presented in Table 1 do not allow for the rejection of the null hypothesis with a positive and statistically significant premium for market risk, which it is not consistent with the CAPM postulates. Extended versions of this model also confirm that there is no positive significant market risk premium. The lack of statistical significance of the risk premium is consistent with the results of work on the Polish capital market Żarnowski and Rutkowska (2012).

The average values of parameters γ_{2t} and the test statistics associated with them do not indicate any occurrence of any non-linearity of the risk-return relationship. The results of significance tests regarding the parameter γ_{3t} indicate the significance of the asymmetry of the returns in the capital assets pricing. The values of the average risk premium associated with this measure are positive (0.0034 and 0.0028) and statistically significant at the level of 5%.

In the next study, unlike the above analysis, no periods of positive and negative market excess return were aggregated. Conditional relationships defined by Eqs. (7), (9) and (10), allow test the hypothesis of a positive relation return-beta in periods with a positive market excess return and the hypothesis of a negative relation return-

Table 1 Estimates of unconditional CAPM relations

	Mean	t-Statistic	p-Value
Model: $R_{it} - R_{ft} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_i + \eta_{it}$			
γ_{0t}	0.0027	0.660	0.511
γ_{1t}	0.0032	0.506	0.307
Model: $R_{it} - R_{ft} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_i + \gamma_{3t}\hat{A}_i + \eta_{it}$			
γ_{0t}	0.0026	0.628	0.531
γ_{1t}	−0.0004	−0.066	0.526
γ_{3t}	0.0034	2.203	0.015[a]
Model: $R_{it} - R_{ft} = \gamma_{0t} + \gamma_{1t}\hat{\beta}_i + \gamma_{2t}\hat{\beta}_i^2 + \gamma_{3t}\hat{A}_i + \eta_{it}$			
γ_{0t}	0.0089	1.840	0.069[b]
γ_{1t}	−0.0133	−0.972	0.833
γ_{2t}	0.0058	0.867	0.387
γ_{3t}	0.0028	1.910	0.029[a]

Notes: a, b indicates significance respectively at the 5% and 10%
Source: Own study

beta in periods with a negative market excess return. The results of parameter γ_1 estimated separately in the months of positive and negative market excess return are presented in Table 2.

The results of the basic conditional relations show that the average estimation of the parameter γ_{1t}^U was positive (0.0385) and it turned out to be statistically significant at the level of significance $\alpha = 0.01$, whereas the average estimation of the parameter γ_{1t}^D was negative (−0.0320) and it was statistically significant at the level of significance $\alpha = 0.01$ as well. The results of conditional CAPM relations allow to conclude, that companies with high beta coefficients, in periods with a positive market excess return (with a negative market excess return), achieve higher rates of return (lower rates of return) than companies with relatively lower beta coefficients. The higher relative Student's statistics for this parameter in the bear market mean lower volatility of the negative risk premiums than the premiums in the bull market periods.

Extended CAPM forms confirm in the majority results for the parameter γ_{1t} obtained in standard version of this model. In addition, assuming a level of significance 5% the results of extended conditional models show that there is no indication to rejecting null hypotheses (12–13). There was no observed non-linearity of the return-beta coefficient and a significant pricing of the asymmetry. Only in the model, where regressors were the beta and asymmetry of the returns parameter was statistically significant at the level 10%. This means that skewness is an important factor in explaining the volatility of the cross-sectional rates of return. The obtained results for conditional relationships are consistent with the research like Nurjannah et al. (2012) and Trzpiot and Krężołek (2006).

Unconditional and conditional relationships between beta coefficients and rates of return were also tested in terms of expected values (Table 3).

Conditional relationships explain to a much greater extent the development of expected returns with respect to the risk expressed by beta coefficient than the

Table 2 Estimates of conditional CAPM relations

		Mean	*t*-Statistic	*p-Value*
Model: $R_{it} - R_{ft} = \delta\gamma_{0t}^{U} + (1-\delta)\gamma_{0t}^{D} + \delta\gamma_{1t}^{U}\hat{\beta}_i + (1-\delta)\gamma_{1t}^{D}\hat{\beta}_i + \eta_{it}$				
Up market $\delta = 1$	γ_{0t}^{U}	0.0008	0.112	0.911
	γ_{1t}^{U}	0.0385	3.986	0.000[a]
Down market $\delta = 0$	γ_{0t}^{D}	0.0046	1.214	0.231
	γ_{1t}^{D}	−0.0320	−7.431	0.002[a]
Model: $R_{it} - R_{ft} = \delta\gamma_{0t}^{U} + (1-\delta)\gamma_{0t}^{D} + \delta\gamma_{1t}^{U}\hat{\beta}_i + (1-\delta)\gamma_{1t}^{D}\hat{\beta}_i + \delta\gamma_{3t}^{U}\hat{A}_i + (1-\delta)\gamma_{3t}^{D}\hat{A}_i + \eta_{it}$				
Up market $\delta = 1$	γ_{0t}^{U}	0.0007	0.093	0.925
	γ_{1t}^{U}	0.0344	4.289	0.000[a]
	γ_{3t}^{U}	0.0038	1.405	0.167
Down market $\delta = 0$	γ_{0t}^{D}	0.0045	1.192	0.239
	γ_{1t}^{D}	−0.0352	−7.655	0.000[a]
	γ_{3t}^{D}	0.0030	1.985	0.053[c]
Model: $R_{it} - R_{ft} = \delta\gamma_{0t}^{U} + (1-\delta)\gamma_{0t}^{D} + \delta\gamma_{1t}^{U}\hat{\beta}_i + (1-\delta)\gamma_{1t}^{D}\hat{\beta}_i + \delta\gamma_{2t}^{U}\hat{\beta}_i^2 + (1-\delta)\gamma_{2t}^{D}\hat{\beta}_i^2 + {}$ $+ \delta\gamma_{3t}^{U}\hat{A}_i + (1-\delta)\gamma_{3t}^{D}\hat{A}_i + \eta_{it}$				
Up market $\delta = 1$	γ_{0t}^{U}	0.0058	0.706	0.483
	γ_{1t}^{U}	0.0239	1.000	0.161
	γ_{2t}^{U}	0.0047	0.372	0.711
	γ_{3t}^{U}	0.0033	1.389	0.171
Down market $\delta = 0$	γ_{0t}^{D}	0.0012	2.327	0.024[b]
	γ_{1t}^{D}	−0.0506	−4.381	0.000[a]
	γ_{2t}^{D}	0.0069	1.567	0.123
	γ_{3t}^{D}	0.0023	1.323	0.192

Notes: a, b, c indicates significance respectively at the 1%, 5% and 10%
Source: Own study

Table 3 Estimates of conditional CAPM relations in the expected terms

		Estimate	*t*-Statistic	*p-Value*	*R*	R^2
Model: $\bar{R}_i = \gamma_0 + \gamma_{1t}\hat{\beta}_i + \eta_i$						
Up market $(R_{Mt} - R_{ft}) > 0$	γ_0	0.0008	0.331	0.741	0.717	0.514
	γ_1	0.0385	15.529	0.000[a]		
Down market $(R_{Mt} - R_{ft}) < 0$	γ_0	0.0047	2.208	0.028[b]	−0.713	0.508
	γ_1	−0.0244	−4.003	0.000[a]		
Whole sample	γ_0	0.0027	1.439	0.151	0.113	0.013
	γ_1	0.0032	1.714	0.088[c]		

Notes: a, b, c indicates significance respectively at the 1%, 5% and 10%
Source: Own study

unconditional relationships. The values of determination coefficients are respectively 0.514 and 0.508, in periods of positive and negative market excess return. Acceptance of a greater risk (beta) is associated with achieving high rates of return in periods with a positive market excess return and low rates of return during periods in weak market conditions. Estimates of market risk premiums are consistent with the sign of market excess return and statistically significant at the level 1%. Estimates of the unconditional relationship confirm the lack of statistically significant premium for market risk at the significance level of 5%.

5 Conclusions

The paper presents research showing an alternative to traditional procedures way to test the risk-return relationship in the context of CAPM. Considering the companies listed on the Warsaw Stock Exchange, there was performed a cross-section analysis using the realized rates of return and beta coefficients, separately for periods with a positive and negative market excess return. This approach makes the above study not a classic test of the CAPM and becomes important especially in the situation when indices as a market portfolio takes values below the risk-free rate in a half of the sample periods.

The obtained results of the tested hypotheses are confirmed by earlier studies in the literature and allow to formulate the following conclusions. Unconditional relations indicate that the average value of the systematic risk premium, expressed as a beta coefficient, is statistically not significantly greater than zero. However, these results are probably the defeat to disregard for different market excess return in analysed period. Secondly, the relation between the beta coefficients and realized rates of return is conditioned by the sign of the value of the market excess return. The average value of systematic risk premium is significantly higher than zero in periods of positive market excess return and significantly lower than zero in periods of negative market excess return. The paper showed a significant pricing of the asymmetry of the rates of return distributions and non-linearity between returns and the beta coefficients was unidentified. Additional research has also shown, that the conditional relationship between expected returns and beta coefficients indicates a much more important relationship between expected returns and systematic risk, as opposed to the unconditional relationship.

The analysis of the realized returns on risk factors confirms the fact that the beta factor is an appropriate measure of risk and is therefore a useful tool in portfolio management. The results showed that investors should demand compensation for holding systematic risk associated with beta coefficient.

In next studies, it would be interesting to examining of robustness risk-return relationship conditional on market volatility that require to increase frequency of time series and maybe selected appropriate estimation methods e.g. GARCH.

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Market-Wide Commonality in Liquidity on the CEE-3 Emerging Stock Markets

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Abstract The purpose of this study is to explore market-wide commonality in liquidity on three emerging Central and Eastern European stock markets in Poland, Hungary, and the Czech Republic (the CEE-3). A modified version of the Amihud measure is utilized as daily liquidity proxy for a broad group of stocks. The research sample covers a period from January 2, 2012 to December 30, 2016 (5 years). In the study, the OLS method with the HAC covariance matrix estimation and the GARCH-type models are employed to infer the patterns of intra-market commonality in liquidity on the CEE-3 stock markets. In general, the regression results provide weak evidence of co-movements in liquidity on the investigated markets, considered separately. Therefore, no reason has been found to support market-wide commonality in liquidity on each CEE-3 stock market.

1 Introduction

According to the literature, commonality in liquidity refers to the proposition that an individual security liquidity is at least partially determined by market-wide liquidity. The existence of commonality suggests the assumption, that a common factor exists that simultaneously influences liquidity of all stocks in a market. The first empirical study of commonality in liquidity was conducted by Chordia et al. (2000). Using transactions data for the NYSE during 1992 and five measures of liquidity, they regressed individual stock daily percentage changes in liquidity on market and industry liquidity. Their results revealed that firm-level liquidity was significantly influenced by both a market and an industry-wide liquidity component. Beginning with Chordia et al. (2000), the identification of the common determinants of liquidity, or commonality in liquidity, emerged as a new and fast growing strand of the literature on liquidity, especially for the U.S. stock market, e.g. Kamara et al. (2008),

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Korajczyk and Sadka (2008), Kempf and Mayston (2008) and Kang and Zhang (2013). There are also some empirical studies on commonality in liquidity for other individual stock markets in the world, e.g. Fabre and Frino (2004), Brockman and Chung (2006), Pukthuanthong-Le and Visaltanachoti (2009), Foran et al. (2015) and Narayan et al. (2015).

However, a limited number of studies concerns commonality in liquidity for a group of equity markets. For example, Brockman et al. (2009) apply methodology of Chordia et al. (2000) to 47 stock exchanges. They document the pervasive role of commonality in liquidity within individual exchanges and they find evidence of a distinct, global component in bid/ask spreads and depths across exchanges. Karolyi et al. (2012) investigate cross-country commonality in liquidity based on daily data for individual stocks from 40 developed and emerging countries. Bai and Qin (2015) analyse commonality in liquidity on 18 emerging markets. The authors point out that liquidity co-movements across emerging markets have a strong geographic component.

Bekaert et al. (2007) stress that liquidity is more critical for emerging than developed markets. The CEE-3 stock exchanges are good example of markets that are sensitive to changes in liquidity. Moreover, the related literature indicates that the CEE-3 stock markets are financially integrated. The empirical results reveal that the dynamics of integration increased significantly following the CEE-3's accession to the European Union on May 1, 2004 (Majewska and Olbryś 2017). A relatively high degree of financial integration is usually coupled with high cross-market correlations and therefore it might produce a substantial drop in cross-border portfolio diversification benefits. The empirical findings confirm significant and high cross-market contemporaneous correlations during the common Global Financial Crisis period October 2007–February 2009 (Olbryś and Majewska 2015). In general, the CEE-3 markets are interesting in many aspects. Therefore, the aim of this paper is to investigate market-wide commonality in liquidity on the CEE-3 stock markets in Poland, Hungary, and the Czech Republic.

In this research, modified version of the Amihud (2002) measure is employed as a daily liquidity proxy, in the period from January 2, 2012 to December 30, 2016 (5 years). In general, this study utilizes the research design of Chordia et al. (2000). However, we employ the OLS method with the HAC covariance matrix estimator (Newey and West 1987) and the GARCH-type models to infer the patterns of commonality in liquidity. The regression results provide rather weak evidence of co-movements in liquidity on the CEE-3 stock markets considered separately, because positive and statistically significant coefficients are scarce. Only in the case of the Polish stock market, one can observe considerably more positive coefficients, but they are predominantly insignificant. Therefore, no reason has been found to support market-wide commonality in liquidity on these markets.

To the best of the author's knowledge, the empirical results concerning commonality in liquidity on the CEE-3 stock exchanges presented here are novel and have not been reported in the literature thus far.

The remainder of the study is organized as follows. Section 2 specifies the methodological background concerning the measurement of commonality in liquidity. Section 3 describes the data and discusses the empirical results on the CEE-3 stock markets. The last section summarizes the main findings with the conclusion.

Nomenclature

WSE	Warsaw Stock Exchange
BSE	Budapest Stock Exchange
PSE	Prague Stock Exchange
CEE-3	Central and Eastern European markets in Poland, Hungary, and the Czech Republic

2 Investigation of Commonality in Liquidity

The literature contains a number of methods for assessing commonality in liquidity. To identify common determinants of liquidity, the classical market model of liquidity, or the market and industry model of liquidity introduced by Chordia et al. (2000) have been most frequently used. In this research, the modified version of classical market model of liquidity, including the Dimson (1979) correction for daily data is applied:

$$DL_{i,t} = \alpha_i + \beta_{i,-1} \cdot DL_{M,t-1} + \beta_{i,0} \cdot DL_{M,t} + \beta_{i,+1} \cdot DL_{M,t+1} + \varepsilon_{i,t}, \qquad (1)$$

where $DL_{i,\,t}$ for stock i is the change in liquidity variable L from trading day $t-1$ to t, i.e. $DL_t = \frac{L_t - L_{t-1}}{L_{t-1}}$. According to the Dimson procedure, the $DL_{M,t-1}$, $DL_{M,t}$, and $DL_{M,t+1}$ are the lagged, concurrent, and leading changes is a cross-sectional average of the liquidity variable L, respectively. The Dimson correction enables us to accommodate the problem of nonsynchronous trading effects (Campbell et al. 1997).

In computing the 'market' liquidity proxy L_M, stock i is excluded, so the explanatory variables in model (1) are slightly different for each stock's time series regression. Chordia et al. (2000) stress that changes are examined rather than levels because the interest is fundamentally in discovering whether liquidity moves. Based on model (1), positive and statistically significant slope coefficients are especially desired, as they indicate intra-market co-movements in liquidity and therefore confirm commonality in liquidity. In other words, they inform about liquidity co-movements in the same direction.

In this study, a modified version of the Amihud (2002) measure, $MAmih_{i,d}$ given by Eq. (2), is utilized as liquidity/illiquidity proxy:

$$MAmih_{i,d} = \begin{cases} log\left(1 + \frac{|r_{i,d}|}{V_{i,d}}\right), when\ V_{i,d} \neq 0 \\ 0, when\ V_{i,d} = 0 \end{cases}, \qquad (2)$$

where $r_{i,d}$ is the simple rate of return of stock i on day d, and $V_{i,d}$ is the trading volume of stock i on day d. We follow Karolyi et al. (2012), but our method is slightly different, because they use return and volume in local currency, and finally multiply the result by negative one to obtain a variable that is increasing alongside with liquidity of individual stock. Moreover, the value of daily Amihud measure (2) is defined to be equal to zero when the total volume of daily trading, in the denominator, is equal to zero. The second condition in Eq. (2) is consistent with analogous conditions for other daily liquidity/illiquidity proxies, e.g. Olbrys and Mursztyn (2018). Finally, to avoid numerical problems, the daily values of the estimator (2) are rescaled by multiplying by 10^2. In the literature, the Amihud measure is usually calculated for stock i for each month, e.g. Goyenko et al. (2009), Olbryś (2014), Foran et al. (2015), Fong et al. (2017) and Będowska-Sójka (2018). In this paper, we estimate daily time series of the Amihud proxy (2).

For each stock, the model (1) is initially estimated by using the OLS method and the robust HAC estimates (Newey and West 1987). However, the Newey and West method may not fully correct for the influence problems introduced by the ARCH effect. For this reason, the estimation of the model (1) as a GARCH-type model is appropriate. To test for the ARCH effect, the test of Engle (1982) with the Lagrange Multiplier (LM) statistic is employed. In this research, the GARCH(p, q) model is utilized. According to the literature, the lower order GARCH(p, q), $p,\ q = 1, 2$, models are used in most applications (Tsay 2010). The GARCH(p, q) models are compared and selected by the Akaike (AIC) and Schwarz (SC) information criteria.

The GARCH(p, q) model is given by Eq. (3):

$$\begin{gathered} DL_{i,t} = \alpha_i + \beta_{i,-1} \cdot DL_{M,t-1} + \beta_{i,0} \cdot DL_{M,t} + \beta_{i,+1} \cdot DL_{M,t+1} + \varepsilon_{i,t}, \\ \varepsilon_{i,t} = z_{i,t}\sqrt{\mathrm{h}_{\mathrm{i,t}}}, \quad z_{i,t} \sim N(0,1), \\ \mathrm{h}_{\mathrm{i,t}} = a_{i,0} + \sum_{k=1}^{q} a_{i,k}\varepsilon_{i,t-k}^2 + \sum_{l=1}^{p} b_{i,l}\mathrm{h}_{\mathrm{i,t-1}}, \end{gathered} \tag{3}$$

where $a_{i,0} > 0, a_{i,k} \geq 0, k = 1, \ldots, q, q > 0, b_{i,l} \geq 0, l = , \ldots, p, p \geq 0$. Moreover, $\varepsilon_{i,t}$ is the innovation in a linear regression with $V(\varepsilon) = \sigma^2$, $h_{i,\ t}$ is the variance function, and remaining notation like in Eq. (1). The parameters of GARCH(p, q) models are almost invariably estimated via Maximum Likelihood (ML) or Quasi-Maximum Likelihood (QML) (Bollerslev and Wooldridge 1992) methods, which bring up the subject of a suitable choice for the conditional distribution of innovation. Hamilton (2008) stresses that even if the researcher's primary interest is in estimating the conditional mean, having a correct description of the conditional variance can still be quite important. By incorporating the observed features of the heteroskedasticity into the estimation of the conditional mean, substantially more efficient estimates of the conditional mean can be obtained.

3 Data Description and Empirical Results on the CCE-3 Stock Markets

In this study, daily data for three CEE stock markets are used. Data is coming from Bloomberg under the license agreement between Bloomberg and Bialystok University of Technology (the grant No. 2016/21/B/HS4/02004). The data set contains the opening, high, low, and closing prices, as well as volume for a security over each trading day, in the period from January 2, 2012 to December 30, 2016. Specifically, the database holds 1247 (for the WSE), 1240 (for the BSE), and 1252 (for the PSE) trading days, respectively. The WSE is large compared to the BSE and PSE stock exchanges. The total number of listed stocks (in April 2018) is equal to 881 (WSE), 41 (BSE), and 23 (PSE). Therefore, we choose only these Polish companies that were entered into the WIG20 index at least once during the investigated period. The WIG20 index consists of 20 major and most liquid companies in the WSE Main List. The choice of companies was based on historical WIG20 index portfolios. Moreover, we excluded the stocks that were removed from the WSE in the period from January 2012 to June 2018.

It is commonly known fact that a large number of the CEE-3 stock market listed companies reveal a substantial non-trading problem. Therefore, to mitigate this problem, we excluded the stocks that exhibited extraordinarily many non-traded days during the whole sample period, precisely, above 125 zeros in daily volume, which constituted about 10% of all trading days. Finally, 25 (WSE), 13 (BSE), and 10 (PSE) companies were contained in the data set. Table 1 presents information about all of them in an alphabetical order according to the company's name.

In the first step, we detected with the ADF-GLS test (Elliott et al. 1996) or ADF test (Dickey and Fuller 1981) whether the analysed daily time series are stationary. Using daily data, we utilized a maximum lag equal to five and then removed lags until the last one was statistically significant (Adkins 2014). The critical values of the ADF-GLS or ADF τ-statistics for the rejection of the null hypothesis of a unit root are presented in e.g. Elliott et al. (1996), Cook and Manning (2004). We proved that the unit-root hypothesis can be rejected at the 5% significance level for all time series utilized in the study. In order to reduce the effects of possibly spurious outliers, we 'winsorized' the data by using the first and 99th percentiles for each time series, e.g. Korajczyk and Sadka (2008), Kamara et al. (2008).

Table 1 Companies contained in the database (January 2012–December 2016)

Stock exchange	Companies
The Warsaw Stock Exchange	ASSECOPOL, BOGDANKA, BORYSZEW, BZWBK, CCC, CYFRPLSAT, ENEA, EUROCASH, GTC, HANDLOWY, JSW, KERNEL, KGHM, LOTOS, LPP, MBANK, ORANGEPL, PBG, PEKAO, PGE, PGNIG, PKNORLEN, PKOBP, PZU, TAURONPE
The Budapest Stock Exchange	ANY, APPENINN, ESTMEDIA, FHB, MOL, MTELEKOM, OPIMUS, OTP, PANNERGY, PANNONIA, RABA, RICHT, ZWACK
The Prague Stock Exchange	CETV, CEZ, FOREG, KOMB, PEGAS, RBAG, TABAK, TELEC, UNIPE, VIG

In the next step, we employed the OLS method with the HAC covariance matrix estimator to estimate the parameters of the model (1). In total, 48 models for three stock markets were estimated, comprising 25 models for the WSE, 13 models for the BSE, and 10 models for the PSE. For each stock, daily proportional changes in individual stock liquidity variables were regressed in time-series on the changes of an equally weighted cross-sectional average of the liquidity variable for all stocks in the sample, excluding the dependent variable stock.

Empirical results revealed that the OLS-HAC method turned out to be appropriate for the estimation of model (1) in the case of all companies from the Polish stock market. Barely for four companies from the BSE (namely MTELEKOM, PANNONIA, ESTMEDIA, and ZWACK) and one company from the PSE (namely FOREG), the ARCH effect in residuals was detected. Therefore, for these companies the GARCH(p, q), $p, q = 1, 2$, models (3) were estimated. The number of lags p, q was selected on the basis of the Akaike (AIC) and Schwarz (SC) information criteria. The summarized cross-sectional estimation results of the models (1) and (3) are presented in Table 2. This table contains basic statistics and the proportion of positive significant, positive insignificant, negative significant, and negative insignificant coefficients (at 10% significance level), for each stock market, separately.

The overall cross-sectional findings reported in Table 2 are worth special comments. There is some evidence of market-wide co-movements in liquidity, but it is definitely less significant and less pervasive than that presented by Chordia et al. (2000) in their seminal work for the U.S. stock market. The regressions provide weak evidence of commonality in liquidity on the WSE, BSE, and PSE, because positive and statistically significant coefficients are scarce. For example, the positive and statistically significant concurrent coefficients constitute 4/25, 0/13, and 2/10 of all concurrent coefficients for the WSE, BSE, and PSE models, respectively. By analogy, the positive and statistically significant lag coefficients represent 1/25, 1/13, and 0/10 of all lag coefficients for the WSE, BSE, and PSE models, respectively. The evidence concerning lead coefficients is very similar. In the case of the Polish stock market, one can observe considerably more positive coefficients, but they are predominantly insignificant.

4 Conclusion

The aim of this paper was to explore market-wide commonality in liquidity on three emerging Central and Eastern European stock markets in Poland, Hungary, and the Czech Republic. A modified version of the Amihud measure was utilized as daily liquidity proxy for stocks. The sample covered a period from January 2, 2012 to December 30, 2016. The OLS method with the HAC covariance matrix estimation and the GARCH-type models were employed to infer the patterns of intra-market commonality in liquidity on the CEE-3 stock markets. According to the literature, positive and statistically significant slope coefficients in the estimated models are especially desired, as they indicate intra-market co-movements in liquidity in the

Table 2 Testing for market-wide commonality in liquidity on the WSE, BSE, and PSE in the whole sample period from January 2, 2012 to December 30, 2016

	WSE (25 models)		BSE (13 models)		PSE (10 models)	
	OLS-HAC 25 models	GARCH Conditional mean equation 0 models	OLS-HAC 9 models	GARCH Conditional mean equation 4 models	OLS-HAC 9 models	GARCH Conditional mean equation 1 model
Intercept α_i *Significant*	All	–	All	All	All	All
Mean	1.652		1.652		2.424	
Median	1.598		1.307		2.129	
Concurrent $\beta_{i,\,0}$						
Mean	0.090		−0.004		0.043	
Median	0.012		−0.003		0.011	
Positive significant	4/25	–	0/9	0/4	2/9	0/1
Positive insignificant	16/25	–	2/9	0/4	3/9	0/1
Negative significant	0/25	–	3/9	1/4	2/9	0/1
Negative insignificant	5/25	–	4/9	3/4	2/9	1/1
Lag $\beta_{i,\,-1}$						
Mean	−0.001		−0.001		−0.007	
Median	−0.009		−0.002		−0.020	
Positive significant	1/25	–	1/9	0/4	0/9	0/1
Positive insignificant	7/25	–	1/9	3/4	4/9	0/1
Negative significant	6/25	–	3/9	0/4	2/9	0/1
Negative insignificant	11/25	–	4/9	1/4	3/9	1/1
Lead $\beta_{i,\,+1}$						
Mean	0.014		0.004		−0.019	
Median	−0.015		0.001		−0.032	
Positive significant	1/25	–	1/9	0/4	0/9	1/1
Positive insignificant	7/25	–	5/9	1/4	2/9	0/1
Negative significant	4/25	–	0/9	1/4	2/9	0/1
Negative insignificant	13/25	–	3/9	2/4	5/9	0/1

same direction, and therefore confirm commonality in liquidity. In general, our estimation results provide rather weak evidence of commonality in liquidity on the WSE, BSE, and PSE, because positive and statistically significant coefficients are scarce. Only for the Polish stock market we observe considerably more positive coefficients, but they are predominantly insignificant.

We are aware that our analysis cannot provide definitive conclusions as to commonality in liquidity on the CEE-3 stock markets. Therefore, a possible direction for further investigation would be to study market-wide co-movements in liquidity by utilizing different daily liquidity proxy. Moreover, another possible direction could be to identify components of liquidity on the CEE-3 stock markets by using methods based on principal component approach. To the best of the author's knowledge, no such research has been undertaken so far.

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Accounting Beta in the Extended Version of CAPM

Anna Rutkowska-Ziarko, Lesław Markowski, and Christopher Pyke

Abstract This paper examines whether accounting betas and downside accounting betas have an impact on the average rate of return in a capital market. It also examines whether investors receive a positive risk premium using accounting betas and secondly, if investors receive a positive risk premium for the downside risk. An analysis was undertaken using data from a sample of 27 Polish construction companies currently listed on the Warsaw stock market.

The results show that for the Polish construction company sector investors receive a positive risk premium, associated with *Accounting Betas* and investors receive a positive risk premium for downside risk.

1 Introduction

The article combines the idea of extended version of CAPM with accounting betas (Hill and Stone 1980) in the context of downside risk. The value of a company is created by its operating, investing and financing activities, therefore it is reasonable to measure risk directly from these fundamentals (Nekrasov and Shroff 2009). The empirical research on accounting betas is not common in the empirical asset pricing field. There is no empirical evidence of accounting betas being used as systematic risk measures on the Warsaw Stock Exchange. In addition, a downside risk approach is not a mainstream measure used in the Polish capital market.

In a previous paper it was proposed downside accounting beta (DAB) is new measure of systematic risk that developed the concept of accounting beta (Rutkowska-Ziarko and Pyke 2017). It was found that there are significant similarities

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between market betas and accounting betas, for both food and construction companies listed on the Warsaw Stock Exchange. The correlation was positive and stronger for the downside risk approach than the mean-variance approach (Rutkowska-Ziarko and Pyke 2017, 2018). This paper is a continuation of that research. Accounting betas in variance and downside approach were applied in extended version of CAPM.

In view of the pricing of capital assets, it is appropriate to examine the existence of a systematic risk premium for acceptance of risk connected with classical and downside accounting betas. The analysed conventional betas and accounting betas can be treated as risk sources in the classical version of the CAPM and the extended version of that model. The application of beta coefficient within a group of accounting risk measures means that the proposed version of the model may be considered as an alternative to the three-factor and four-factor CAPM models (Kraus and Litzenberger 1976). These models use measures such as skewness, co-skewness and co-kurtosis. The extended version of CAPM has been explored in many other studies; Fama and French (1993) confirmed the pricing of a book-to-market and the firm size effect; Asparouhova et al. (2010) and Chelley-Steeley and Lambertides (2016) and also Fama's variables supported illiquidity factor as a price risk characteristic.

The aim of this paper is to examine whether the accounting betas and downside accounting betas have an impact on an average rate of return on a capital market. This aim is linked to the following research questions: firstly, does the investor receive a positive risk premium, connected with *Accounting Betas*? Secondly, does the investor receive a positive risk premium for downside risk?

2 Market and Accounting Betas

The classical measure of systematic risk are the beta coefficients (β_i) used in Sharpe's CAPM model, which are usually calculated as follows:

$$\beta_i = \frac{COV_{iM}}{S_M^2}, \tag{1}$$

where: COV_{iM} is the covariance of the rate of return for stock i and market portfolio rates of return, S_M^2 is the variance of market portfolio rates of return.

In this approach, it is assumed that investors display mean–variance behaviour (Estrada 2002). If investors treat risk as the possibility of losing, or not earning enough, compared to a given target point, then the appropriate measure of systematic risk should be downside beta (β_i^{LPM}), calculated as follows (see: Price et al. 1982):

$$\beta_i^{LPM} = \frac{CLPM_i^2}{dS_M^2(f)}, \tag{2}$$

where: $CLPM_i^2$ is the asymmetric mixed lower partial moment of second degree for stock exchange listed company $i, dS_M^2(f)$ is the semi-variance of the market portfolio determined in relation to the risk-free rate of return.

In this paper, it is assumed that when determining both semi-variance and the lower partial moment, that the reference point is the risk-free rate (R_{ft}) when changing its value from one period to another.

The asymmetric mixed lower partial moment of second degree is calculated as follows (Price et al. 1982):

$$CLPM_i^2 = \frac{1}{T-1} \sum_{t=1}^{T} \left(R_{it} - R_{ft}\right) * lpm_{Mt}, \tag{3}$$

where:

$$lpm_{Mt} = \begin{cases} 0 & for \quad R_{Mt} \geq R_{ft} \\ R_{Mt} - R_{ft} & for \quad R_{Mt} < R_{ft} \end{cases},$$

and R_{Mt} is the market portfolio rate of return in the period t.

In a similar way, the semi-variance of the market portfolio is calculated:

$$dS_M^2(f) = \frac{\sum_{t=1}^{T} lpm_{Mt}^2}{T-1}. \tag{4}$$

Both kinds of betas could be regarded as the "market beta" since the market rate of return is used to calculate the systematic risk.

To calculate accounting beta, one of the profitability ratios can be used instead of market rate of return. The accounting beta coefficient for Return on Assets $\beta_i(ROA)$ could be calculated as follows (Hill and Stone 1980):

$$\beta_i(ROA) = \frac{COV_{iM}(ROA)}{S_M^2(ROA)}, \tag{5}$$

where $COV_{iM}(ROA)$ is the covariance of the profitability ratio of company i and market portfolio ratios (market indices of profitability ratios), $S_M^2(ROA)$ is the variance of market profitability ratios.

In this way, we can calculate the accounting beta for different profitability ratios such as Return on Assets (ROA), Return on Equity (ROE), Return on Sales (ROS), as well for other accounting ratios.

The methodology from our previous work is used to calculate the downside accounting beta, (Rutkowska-Ziarko and Pyke 2017). Let us try to define downside accounting beta for ROA:

$$\beta_i^{LPM}(ROA) = \frac{CLPM_i^2(ROA)}{dS_M^2\left(\overline{ROA_M}\right)} \tag{6}$$

where: $\overline{ROA_M} = \frac{1}{T}\sum_{t=1}^{T} ROA_{Mt}$ is the average level of ROA for all analysed companies in the sector and $ROA_{Mt} = \sum_{i=1}^{k} w_i{}^*ROA_{it}$, $w_i = MV_i \Big/ \sum_{i=1}^{k} MV_i$, MV_i is the market value of company i.

The expression of $dS_M^2\left(\overline{ROA_M}\right)$ denotes semi-variance of the market portfolio determined in relation to the average level of ROA.

The asymmetric mixed lower partial moment of second degree for profitability ratios is calculated as follows:

$$CLPM_i^2(ROA) = \frac{1}{T-1}\sum_{t=1}^{T}\left(ROA_{it} - \overline{ROA_M}\right) * lpm_{Mt}(ROA), \tag{7}$$

where:

$$lpm_{Mt}(ROA) = \begin{cases} 0 & for \quad ROA_{Mt} \geq \overline{ROA_M} \\ ROA_{Mt} - \overline{ROA_M} & for \quad ROA_{Mt} < \overline{ROA_M} \end{cases}.$$

Similarly, the semi-variance of the ROA for the whole sector is calculated:

$$dS_M^2\left(\overline{ROA_M}\right) = \frac{\sum_{t=1}^{T} lpm_{Mt}(ROA)}{T-1}. \tag{8}$$

The downside accounting beta (DAB) for a profitability ratio could also be defined in a similar way.

3 Risk Premium in a Classical and Downside Framework

The methodology in this paper is based on the fundamental equilibrium relationship of Sharpe-Lintner-Mossin CAPM:

$$E(R_i) = R_f + RM_i\left[E(R_M) - R_f\right] \tag{9}$$

where RM_i is the systematic risk measure. The structure of this model is retained when semi-variance and co-semi-variance are substituted for a standard counterpart of these measures and that model is then called downside CAPM (D-CAPM) (Estrada 2002).

The verification of CAPM equations was executed according to a two-stage classic procedure. During the first stage, the conventional and accounting betas in classical and downside framework were estimated separately for the individual securities according to the formulas shown in a previous section (Galagedera and Brooks 2007). In the second stage, average security returns are cross-sectionally regressed on the estimated systematic risk to examine if the linear regression is significant (the risk variable is priced). The cross-section estimation equations of the standard CAPM form and the extended version of CAPM, where the regressions are a mixed pair of conventional beta and accounting beta, can be written as (Estrada 2007):

$$\bar{R}_i = \lambda_0 + \lambda_1 R\hat{M}_i + \varepsilon_i \tag{10}$$

$$\bar{R}_i = \lambda_0 + \lambda_1 R\hat{M}_{i1} + \lambda_2 R\hat{M}_{i2} + \varepsilon_i \tag{11}$$

where $\bar{R}_i$—means rates of return for the security i; $R\hat{M}_{i1}, R\hat{M}_{i2}$—is the estimate of risk measures in the form of β_i, β_i^{LPM}, $\beta_i(ROS)$, $\beta_i(ROA)$, $\beta_i(ROE)$, $\beta_i^{LPM}(ROS)$, $\beta_i^{LPM}(ROA)$, $\beta_i^{LPM}(ROE)$; λ_0, λ_1—structural parameters, ε_i—random variable term.

4 Empirical Results

The data for 27 Polish construction companies listed on the Warsaw Stock Exchange was collected and analysed during the period 1 January 2012–30 June 2017. A single sector sample was chosen for ease of comparison. In addition, the construction sector is the largest sector in terms of the number of listed companies in the Polish capital market. As the data was only from one sector the cross-sectional analysis was based on individual assets and not on portfolios (Teplova and Shutova 2011). The application of accounting fundamentals for determining accounting betas for individual companies is presented in the work of (Sarmiento-Sabogal and Sadeghi 2015).

In addition, quarterly financial statements during the period between Quarter 4 2011 and Quarter 1 2017 were also analysed for the same 27 construction companies. The quarterly financial reports used by investors always refer to a company's performance in the previous quarter. Therefore, in this study, a quarter back-shift is applied to the financial data so that it matches the market share prices. A time series of quarterly rates of return and profitability ratios: ROA, ROE and ROS were determined for every company. In this study, we decided to use the sector index (WIG-construction) instead of the wide market index WIG. The Warsaw Interbank Offer Rate (WIBOR 3 M) for 3-month investment was used as the risk-free rate.

A time series of quarterly rates of return and profitability ratios: ROA, ROE and ROS was calculated for every company. For each construction company, the market betas and accounting betas were calculated using two different approaches: the risk measured by variance and downside risk.

The market betas were calculated on quarterly rates of return. The rates of return were computed as relative increases in the prices of stocks according to the formula:

$$R_{it} = (N_{i,t+s} - N_{it})/N_{it} \cdot 100\%, \tag{12}$$

where R_{it} is the rate of return on security i at time t, s is the length of the investment process expressed in days, N_{it} is the listed value (close price) of security i at time t, $N_{i,t+s}$ is the listed value of security i after s days of investing started at time t.

The results comparing the relationship between risk measures and mean returns across securities were considered from regression analysis. Table 1 shows the estimates of the parameters of cross-sectional single regressions according to the relation (10).

Estimations of parameters λ_0 are statistically significant for all models at a different significance level. The estimated results of this parameter for six regressions are positive and ranged within 0.022–0.060% per quarter which, to a large extent, corresponds with the actual risk-free rate. In two cases where the regressions are classical beta and downside accounting beta of ROE, the estimations of parameter λ_0 are negative (which may correspond with the actual level of percentage rate), or a lower inflation in the market, or even deflation in some periods of the time period.

The results of estimates λ_1 (market risk premium) coefficients show the classical CAPM beta and accounting betas, with respect to construction market indices of profitability ratios ROS, ROA and all downside accounting betas, are potential explanatory variables of mean returns of construction companies in the Polish stock market. The estimates of these parameters are positive and statistically significantly different from zero at the 1% level. The investors are compensated with a market premium for the downside risk that causes an increase in the expected rate of return, on average, from 0.021% to 0.151%, for each unit of the risk measure. Except for the $\beta_i^{LPM}(ROE)$ coefficient, the estimated risk premium for classical coefficients are, on average, higher than the premium generated by the downside coefficient.

Table 1 Cross-sectional single regressions of mean returns and the betas for individual assets

Variable	λ_0	*t*-stat	λ_1	*t*-stat	Adj. R^2
β_i	−0.059	−2.53**	0.152	6.08***	0.58
$\beta_i(ROS)$	0.052	3.21***	0.030	3.77***	0.34
$\beta_i(ROA)$	0.058	3.81***	0.042	4.43***	0.42
$\beta_i(ROE)$	0.060	3.13***	0.055	1.65	0.06
β_i^{LPM}	0.022	0.56	0.068	1.11	0.01
$\beta_i^{LPM}(ROS)$	0.045	2.68**	0.021	3.63***	0.32
$\beta_i^{LPM}(ROA)$	0.036	2.27**	0.027	4.54***	0.43
$\beta_i^{LPM}(ROE)$	−0.081	−1.91*	0.112	3.61***	0.31

Source: Own work

Notes: ***, **, * indicates significance respectively at the 1%, 5%, 10% level

Models with significant slope parameters describe the mean rates of return in the range 31–58%, similarly for the classic and downside CAPM models.

In Tables 2, 3 and 4 are the results of multiple cross-sectional regressions. Tables 2 and 3 gives the estimated results with classical beta and all accounting betas. As can be seen, when beta and accounting betas are considered together, almost every regression parameter is significant. It is therefore reasonable to use extended versions of the classic and downside CAPM. The explanatory power of these models significantly outperforms the power of single factor models. The explanatory power in terms of R^2 with classical accounting betas is slightly higher than models with downside accounting betas, except for models where explanatory

Table 2 Cross-sectional multiple regressions of mean returns and the classical and accounting betas for individual assets

Model: $\bar{R}_i = \lambda_0 + \lambda_1\beta_i + \lambda_2\beta_i(ROS) + \varepsilon_i$					
Statistics	λ_0	λ_1	λ_2	Adj. R^2	F
Estimate	−0.046	0.128	0.020	0.73	35.34***
t-stat	−2.35**	6.03***	3.77***		
Model: $\bar{R}_i = \lambda_0 + \lambda_1\beta_i + \lambda_2\beta_i(ROA) + \varepsilon_i$					
Statistics	λ_0	λ_1	λ_2	Adj. R^2	F
Estimate	−0.035	0.120	0.028	0.74	37.96***
t-stat	−1.83*	5.65***	4.04***		
Model: $\bar{R}_i = \lambda_0 + \lambda_1\beta_i + \lambda_2\beta_i(ROE) + \varepsilon_i$					
Statistics	λ_0	λ_1	λ_2	Adj. R^2	F
Estimate	−0.054	0.145	0.033	0.60	20.52***
t-stat	−2.34**	5.88***	1.50		

Source: Authors' calculations
Notes: ***, **, * indicates significance respectively at the 1%, 5%, 10% level

Table 3 Cross-sectional multiple regressions of mean returns and the classical and downside accounting betas for individual assets

Model: $\bar{R}_i = \lambda_0 + \lambda_1\beta_i + \lambda_2\beta_i^{LPM}(ROS) + \varepsilon_i$					
Statistics	λ_0	λ_1	λ_2	Adj. R^2	F
Estimate	−0.047	0.125	0.011	0.65	25.58***
t-stat	−2.12**	5.02***	2.51**		
Model: $\bar{R}_i = \lambda_0 + \lambda_1\beta_i + \lambda_2\beta_i^{LPM}(ROA) + \varepsilon_i$					
Statistics	λ_0	λ_1	λ_2	Adj. R^2	F
Estimate	−0.043	0.114	0.015	0.67	27.60***
t-stat	−1.98*	4.41***	2.82***		
Model: $\bar{R}_i = \lambda_0 + \lambda_1\beta_i + \lambda_2\beta_i^{LPM}(ROE) + \varepsilon_i$					
Statistics	λ_0	λ_1	λ_2	Adj. R^2	F
Estimate	−0.114	0.126	0.060	0.65	25.11***
t-stat	−3.68***	4.98***	2.44**		

Source: Authors' calculations
Notes: ***, **, * indicates significance respectively at the 1%, 5%, 10% level

Table 4 Cross-sectional multiple regressions of mean returns and the accounting betas for individual assets

Model: $\bar{R}_i = \lambda_0 + \lambda_1\beta_i(ROS) + \lambda_2\beta_i^{LPM}(ROS) + \varepsilon_i$					
Statistics	λ_0	λ_1	λ_2	Adj. R^2	F
Estimate	0.046	0.020	0.013	0.41	9.92***
t-stat	2.92***	2.17**	1.98*		
Model: $\bar{R}_i = \lambda_0 + \lambda_1\beta_i(ROA) + \lambda_2\beta_i^{LPM}(ROA) + \varepsilon_i$					
Statistics	λ_0	λ_1	λ_2	Adj. R^2	F
Estimate	0.045	0.023	0.016	0.48	12.99***
t-stat	2.81***	1.84*	1.99*		
Model: $\bar{R}_i = \lambda_0 + \lambda_1\beta_i(ROE) + \lambda_2\beta_i^{LPM}(ROE) + \varepsilon_i$					
Statistics	λ_0	λ_1	λ_2	Adj. R^2	F
Estimate	−0.073	0.042	0.106	0.35	7.89***
t-stat	−1.73*	1.47	3.44***		

Source: Authors' calculations

Notes: ***, **, * indicates significance respectively at the 1%, 5%, 10% level

variables were β_i and $\beta_i^{LPM}(ROE)$. The values of statistics F confirm the significance of the used risk factors explaining the average rates of return.

The last cross-sectional regressions (Table 4) are a proposal for two-factor CAPM models based on only the accounting coefficient betas. These models investigate whether accounting sensitivity measures are priced and whether downside coefficients represent an additional significant source of risk in asset pricing.

The results in Table 4 demonstrate that, as hypothesized, the accounting exposure in both the classical and downside frameworks is significant at the different 1%, 5%, 10% levels of positive risk premium. The premium associated with $\beta_i(ROE)$ came out positive but not significant. The equations explain 35–48% of the volatility of the average companies' returns. To sum up, the results indicate that accounting betas of profitability ratios ROS and ROA have more explanatory power than accounting beta of profitability ratios ROE.

5 Conclusions

The single cross-sectional regressions showed that the risk premium associated with accounting betas were statistically significantly positive for five out of six proposed accounting betas. The classical and downside accounting betas for ROA explained more than 40% of the return variability. For ROS it was only a little more 30% and similarly for the downside beta for ROE. But the accounting beta for ROE in the variance approach had no impact on the average rate of return in the Polish construction company sector. The accounting betas based on the profitability ratios ROA and ROE had higher explanatory power of mean returns for downside approach compared to the classical approach. The multiple cross-sectional analysis supports an extended version of CAPM, especially when the beta coefficient is included in the pricing model together with accounting beta. In these models, accounting betas from the downside framework are equally good as standard framework measures.

In all forms of multiple cross-sectional regressions, the highest explanatory power of mean returns produce models with both accounting beta or downside accounting beta for ROA in the group of independent variables. Konchitchki et al. (2016) found that accounting beta for ROA was a significant risk factor for a sample of US listed firms.

We expected to find a connection between market downside beta with average returns like in the previous studies of Estrada (2002), Post and Van Vliet (2006), Pedersen and Hwang (2007), Artavanis et al. (2010), Alles and Murray (2013). However, we did not find a risk premium for downside beta, but we did find a risk premium for all kinds of DAB in every single and multiple regression analysis.

To conclude, we can confirm that for the Polish construction company sector investors receive a positive risk premium, associated with accounting betas and downside risk.

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The Impact of Fundamental Investment Fund Features on the Level of Risk

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Abstract The aim of the article is to examine the dependence of investment risk level on selected fundamental features of funds. The analysis was carried out on 136 Polish equity funds, during the years 2014–2017. The study involved two different approaches to investment risk. The risk has been expressed symmetrically (by a standard deviation of the return rates) and asymmetrically (by a semi-standard deviation). The fundamental fund features were as follows: the size, the age and the capital inflow. As a result of applying the panel-data least squares method and fixed effects models, it was determined that the level of the semi-standard deviation is statistically significantly dependent on selected fund features. Contrastingly, in the case of the standard deviation, only two characteristics have statistically significant impact: lnAge and Fund Flow. The second part of the analysis focuses on checking whether there is a relationship between the size of the funds and the level of risk. The estimation results of linear panel-data regression models indicate existence of a statistically significant, positive relation of the funds whose net asset value (NAV) is below the median within the researched group of funds. Contrarily, in terms of such funds with the NAV above the median, no such relation was observed.

1 Introduction

The majority of studies on investment funds focus primarily on external determinants of fund risk. At the same time, internal risk factors are contained in the return rates of risk-weighted funds, most commonly expressed as a standard deviation or a standard semi-deviation (e.g. Cuthbertson et al. 2010; Ferreira et al. 2013).

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Nevertheless, attempts have already been made to determine the impact of fund features on the level of investment risk.

Golec (1996), using a sample of 350 funds, indicated that in the years 1988–1990, the age and the size of funds reduced the level of risk (standard deviation) taken by managers.

Vijayakumar et al. (2012), using an example of 14 open-ended funds (2004–2008 study period), indicated a strong dependency between the return rates and the level of risk (standard deviation), the fund size and the cost index.

Filip (2017), using panel data of 69 Polish open-ended funds (equity funds and mixed funds) from the period of 2000–2015, investigated the relations between the level of risk, the fund size and the fund flow. Investment risk has been defined as standard deviation and semi-standard deviation. The results of the analysis indicate a positive dependency between the level of risk and the fund size as well as a negative dependency between the level of risk and the fund's age. New capital turned out to be an insignificant variable.

In turn, Chan et al. (2017) pointed out the possibility for managers to choose (within a family of funds) strategies of various risk levels (standard deviation), in response to the activity of competitive funds. They noticed that the families of funds that obtain average return rates tend to increase the level of investment risk. The second important conclusion from the study indicates a strong negative dependency between the fund flow and the level of risk. The researchers also showed that the largest families of funds change the risk level only when they want to keep its leading position. This conclusion coincides with the results of the studies by Huang et al. (2011) as well as those by Vidal-García and Vidal (2014). The funds that increased the level of risk (standard deviation), achieved worse investment results than the funds that maintained a stable level of risk.

The aim of this study is to determine the dependency of the risk level on selected fundamental features of Polish investment funds. In the study, standard deviations and semi-standard deviations of monthly return rates were adopted as the risk. From the fundamental features, the NAV, the age and the capital inflow were used.

2 Data and Models

The study used the data on 136 Polish equity funds from the years 2014–2017. The values of the selected fund features were determined at the end of each month. In turn, the level of risk (a standard deviation and a semi-standard deviation) were calculated for each month t as an average of the $< t_{-1}; t_{-6} >$ period. The selected monthly delay in the values of fund features results from the attempt to indicate how managers react in the t period. The selected fund features indicate a low (and generally a negative) level of correlation, with an exception of lnNAV, lnAge (an average and positive level of correlation) (Table 1).

Table 1 The summarizing statistics and the correlation between the variables

Fund features	Mean	Median	Minimum	Maximum
Return (%)	−1.42	0.27	−11.72	9.75
NAV (in mln PLN)	197.07	64.10	2.59	4495.05
Age (months)	126	119	41	264
Fund flow (%)	−1.66	−0.75	−29.26	27.78
Standard deviation (%)	3.34	3.23	0.1	11.55
Semi-standard deviation (%)	7.78	7.43	0.18	26.73

	SemiSD	SD	Return	lnNAV	lnAge	Fund flow
SemiSD	1	0.830*	−0.200*	−0.108*	−0.053*	−0.027*
SD		1	−0.014	−0.121*	0.011	−0.005
Return			1	0.016	0.023*	0.058*
lnNAV				1	0.320*	−0.029*
lnAge					1	−0.093*
Fund flow						1

To determine the level of the return rate deviation from average, a standard deviation was used:

$$SD_{it} = \frac{\sqrt{\sum_{i=1}^{n} \left(r_{it} - \overline{r_i}\right)^2}}{n - 1}. \quad (1)$$

where SD_{it}—a standard deviation of the fund's return rates i, r_{it}—the fund's return rate i in period t, $\overline{r_i}$—the fund's average return rate i, n—number of periods.

To measure adverse (negative) deviations from the expected return rates, a semi-standard deviation was used:

$$semiSD_{it} = \frac{\sqrt{\sum_{i=1}^{n} \left(r_{it} - \overline{r_i}\right)_{-}^2}}{n-1}, \quad (2)$$
$$r_{it} - \overline{r_i} = \begin{cases} 0 \, for \; r_{it} - \overline{r_i} \geq 0 \\ r_{it} - \overline{r_i} \, for \; r_{it} - \overline{r_i} < 0 \end{cases}$$

where $semiSD_{it}$—semi-standard deviation of the fund's return rates i, $\left(r_{it} - \overline{r_i}\right)_{-}^2$—a negative deviation from the fund's expected return rate i.

In order to investigate the relations between the level of risk and the investment fund features, a model was applied, which was estimated using the panel-data least squares method:

$$RISK_{it} = \beta_0 + \beta_1 SIZE_{it-1} + \beta_2 AGE_{it-1} + \beta_3 FUND\ FLOW_{it-1} + \xi_{it-1}. \quad (3)$$

where $RISK_{it}$—the fund's investment risk i in a month t, when $i = 1,\ldots,136$ and $t = 1,\ldots,48$, $SIZE_{it-1}$—the size of the fund i calculated as a natural logarithm, from the net asset value, AGE_{it-1}—the fund's age i calculated as a natural algorithm of the number of months from the moment of the first fund price estimation i, $FUND\ FLOW_{it-1}$—fund flow of the fund i, β_0, β_1, β_2, β_3—structural parameters and ξ_{it-1}—the model's random component.

Return rates were purposely eliminated from the analysis, due to the poor quality of the estimated models (Eq. 3).

3 Empirical Results

In the first step of the analysis, the risk, measured via a semi-standard deviation and a standard deviation of the return rates for all funds was modelled. Next, accuracy of the models was evaluated using diagnostic tests. Taking a significance level of 0.05, the significance test statistic indicates the need to reject the null hypothesis assuming the accuracy of the estimation method application (the panel-data least squares method), in favor of an alternative (a fixed-effects model), indicating that a model with fixed effects is more appropriate for risk-level modelling. Based on the obtained Breusch-Pagan test statistic, the null hypothesis, which assumes the panel-data least squares method to be more sufficient for modelling the risk level than the model with seasonal effects, should also be rejected. Ultimately, the Hausman test statistic indicates rejection of the null hypothesis, that is, in this case, the fixed-effects model turned out to be most sufficient, when the risk is measured by a semi-standard deviation and a standard deviation of the return rates (Table 2 and Fig. 1).

In the case of the standard deviation model, only two factors showed statistically significant impact (lnAge and Fund Flow). The dependency between those features is also negative, thus an increase in the value of each factor will cause a decrease

Table 2 Estimations of the risk level for the entire sample using a panel-data linear regression model

	SD		semiSD	
	Pooled OLS	Fixed effects	Pooled OLS	Fixed effects
Const	0.049***	0.053***	0.129***	0.209***
Size (lnNAV)	−0.001***	0.0002	−0.002***	0.002**
Age (lnAge)	0.002***	−0.005***	−0.002*	−0.037***
Fund flow	−0.0003	−0.0006*	−0.003**	−0.005***
Joint sign. test	34.206[a]		60.716[a]	
Breusch-Pagan test	200,854.700[a]		43,718.200[a]	
Hausman test	78.130[a]		18.440[a]	
R-squared	0.018	0.578	0.013	0.435

*, **, ***Statistically significant at 0.1, 0.05 and 0.01 significance level
[a]At the 0.05 significance level, the null hypothesis should be rejected

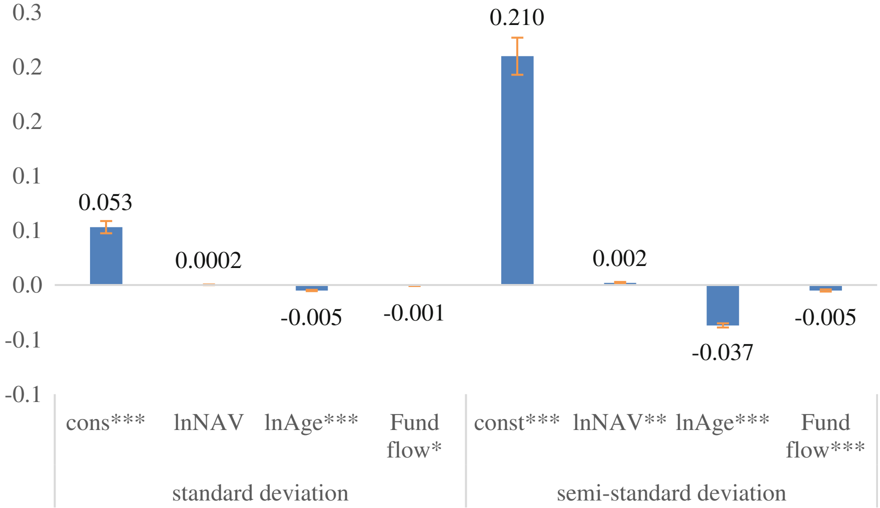

Fig. 1 The β-coefficients and standard errors for the entire sample

in the risk level measured by a standard deviation. In terms of the semi-standard deviation model, it can be stated that its level is statistically significantly dependent on selected explanatory factors. It means that a change in each of these factors (lnNAV, lnAge and Fund Flow) causes a change in the level of risk. Additionally, a constancy test of the model's absolute term indicated the need to reject the null hypothesis, which means that the risk level changed over time. At the same time, it also differed for each of the analyzed funds.

In the second step of the study, attention was focused on the funds' size, the only feature that showed a positive relation with the risk level. The sample was divided into two sub-samples, taking the lnNAV median, calculated for December 31, 2017, as the division criterion. As a result, two samples were created: small funds (the values below the median level) and large funds (the values above the median). Regression equations were estimated for each sample (Tables 3 and 4).

Similarly to the results on entire sample, the values of the Breusch-Pagan he and the Hausman's statistical significance tests, at the significance level of 0.05, indicate the need to reject the null hypothesis, in favor of an alternative hypothesis. This means that the fixed-effects model is appropriate for modelling the risk level measured as a semi-standard deviation and a standard deviation of the return rates (Figs. 2 and 3).

Only one feature—lnAge—showed negative and similar impact on the standard deviation of small funds respectively. Contrarily, other features have statistically significant impact on the level of semi-standard deviation of performance of small funds. In the case of small funds, all the investigated features have impact, while only two features impact large funds: lnAge and Fund Flow. At the same time, an increase in the level of the semi-standard deviation decrease is visible, along with the increase of the funds' size.

Table 3 Estimations of the risk level for small funds using a panel-data linear regression model

	SD			SemiSD	
	Pooled OLS	Fixed effects		Pooled OLS	Fixed effects
Const	0.029***	0.052***	0.061***	0.080***	0.146***
Size (lnNAV)	0.0002	0.0005		0.001	0.004***
Age (lnAge)	0.0008	−0.006***	−0.006***	−0.004***	−0.031***
Fund flow	−0.0003	−0.0006		−0.002	−0.004***
Joint sign. test	57.582[a]			35.179[a]	
Breusch-Pagan test	20,969.400[a]			11,524.500[a]	
Hausman test	7.170			21.293[a]	
R-squared	0.0009	0.558	0.558	0.004	0.437

*, **, ***Statistically significant at 0.1, 0.05 and 0.01 significance level
[a]At the 0.05 significance level the null hypothesis should be rejected

Table 4 Estimations of the risk level for large funds using a panel-data linear regression model

	SD			SemiSD		
	Pooled OLS	Fixed effects		Pooled OLS	Fixed effects	
Const	0.050***	0.055***	0.050***	0.138***	0.274***	0.299***
Size (lnNAV)	−0.002***	−0.0003		−0.004***	0.002	
Age (lnAge)	0.003***	−0.004***	−0.004***	0.002	−0.050***	−0.048***
Fund flow	0.0004	−0.0005		−0.009**	−0.012***	−0.012***
Joint sign. test	64.319[a]			33.144[a]		
Breusch-Pagan test	22,937.200[a]			8955.210[a]		
Hausman test	7.685[a]			77.631[a]		
R-squared	0.021	0.590	0.590	0.013	0.424	0.424

*, **, ***Statistically significant at 0.1; 0.05 and 0.01 significance level
[a]At the 0.05 significance level the null hypothesis should be rejected

4 Conclusions

To investigate the dependency between the risk level and the fundamental features of funds (the size, the age and fund flow), a sample of equity funds was chosen, due to their highest risk volatility among this type of funds. As a result of the analysis carried out, it has been determined that, in terms of the entire sample, the only feature impacting the risk level (the standard deviation) is the age of a fund. Considering the risk as a semi-standard deviation, all three features impact its level. The results obtained are partially consistent with the results shown for the funds on various European markets (Vidal-García et al. 2016) and those on the Polish market (Filip 2017). Similar results of the impact of fund features on the standard deviation have been observed for the funds divided according to size.

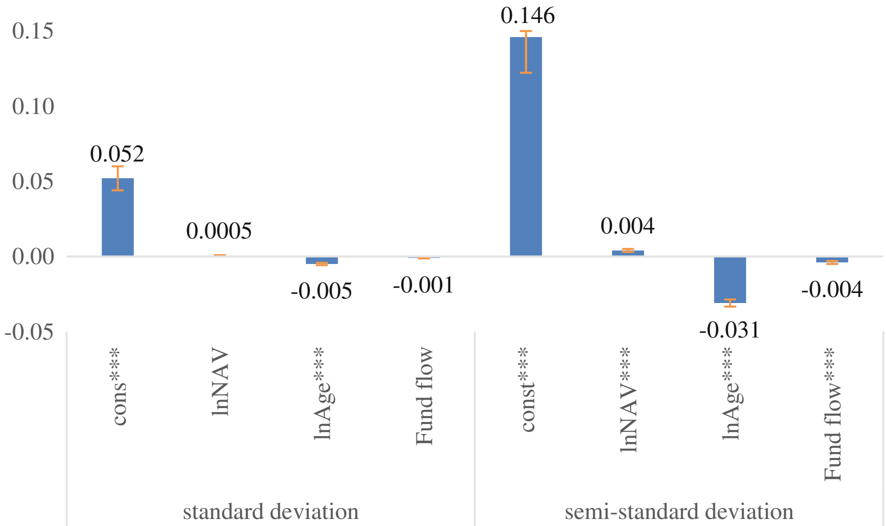

Fig. 2 The β-coefficients and standard errors for the small funds

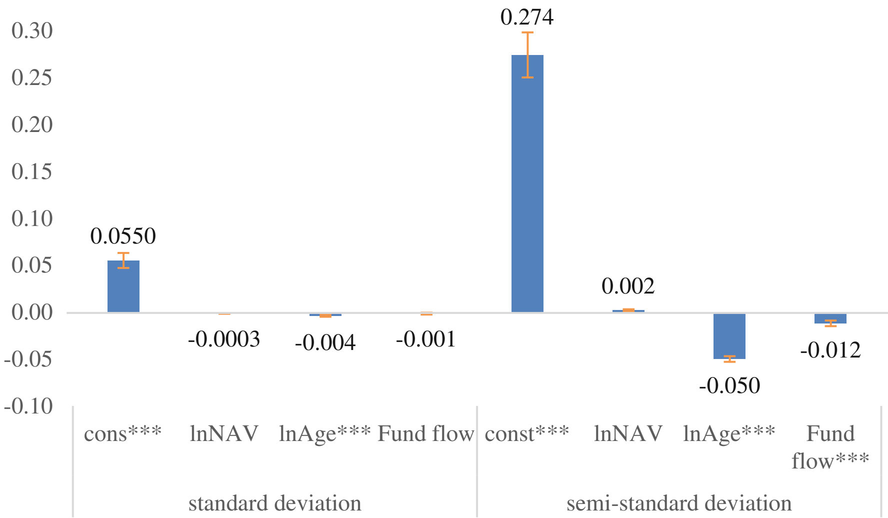

Fig. 3 The β-coefficients and standard errors for the large funds

Also, disappearance of the impact of fund size on the level of the negative deviation of return rates along with its increase has been observed. In the group of small funds, the size increases the risk level, which, in turn, is lowered along with an increase of its age and fund flows. In the case of large funds, only the age and the fund flow have impact on the risk. It means that those managing longer-existing funds focus on the best allocation of new assets, rather than on an increase of the fund size.

High constant value indicates the influence of other factors not taken into account in the study. Undoubtedly, further research should consider market factors, especially those included in the Fama-French or Carhart model. Attention should also be paid to other risk measures, such as value at risk.

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Part V
Other Areas of Finance

Understanding the Overfunding in Crowdfinancing: The Elements of Attractiveness

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Abstract Crowdfunding projects are subject to the evaluation of the online community, which participates in the financing process on an entirely voluntary basis. This unique feature of crowdfunding increases the importance of project's owner communication and presenting skills to increase project attractiveness to its target group of recipients. In the all-or-nothing crowdfunding model, most of the projects that have successfully gained financing exceed the financial goal by only a small amount, which makes them only slightly overfunded. However, a limited number of projects have enticed a relatively high number of people into financing them, and, as a result, these projects are strongly overfunded. Based on a unique dataset of 814 overfunded projects, we investigate the drivers of the overfunding success stories. Along with standard statistical measures, we conduct logit regressions. Our results give evidence that the lower the requested amount and the higher the number of supporters, the higher the probability becomes that the project will be strongly overfunded. Moreover, our findings confirm that an active attitude of the project's owner, as seen through news reports and previous project experience, and crowd participation, as seen through the number of comments, have the positive influence on the probability of a higher overfunding rate.

1 Introduction

Crowdfunding is one of the most innovative and novel sources of funding for commercial, social, cultural and non-profit endeavours. With the increase in its popularity, several different types of crowdfunding have been developed. Among them, the broadly employed *reward-based all-or-nothing* form enables the initiator

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to collect donations in return for rewards. The initiator is allowed to keep the entire collected amount only if it is equal to or exceeds the declared goal. In the latter case, data reveals that for a large stake of successfully funded projects the collected amount only slightly exceeds the financial goal. However, there is a limited number of campaigns that exhibit higher rates of overfunding, which makes them highly interesting to investigate.

Although some published studies refer to overfunding in crowdfinancing (Mollick 2014; Koch 2016; Cordova et al. 2015), the problem of underlying determinants has not been sufficiently studied. Moreover, since the majority of previous papers on crowdfunding are based on Kickstarter or other platforms in the United States and Western European countries, there is still a gap in empirical research devoted to the specifics of Eastern European crowdfunding. Therefore, our research explores the drivers that result in projects' obtaining a significant excess of the target amount (*i.e.*, overfunding) in crowdfunding projects in a Polish context.

The paper is structured as follows: In Sect. 2, we conduct a brief literature review of empirical studies on overfunding's determinants. In Sect. 3, we describe the study's empirical research design, while we discuss the obtained findings in Sect. 4. In the last section, we provide conclusions and implications for further research.

2 Literature Review

The majority of papers on crowdfunding campaigns concentrate on the determinants of reaching the funding goal. It has been confirmed that the target amount requested by the initiator and the duration of the project significantly affect the chance of reaching the declared goal (Mollick 2014; Cordova et al. 2015). Furthermore, the supportive effects of a project's communication tools, such as photos and videos, has been proven (Beier and Wagner 2015; Colombo et al. 2015; Mollick 2014). Similarly, as pointed out by Wang et al. (2018) and Mrzyglod et al. (2018), the interaction between a project's authors and its supporters in addition to its presence in the media increase the probability of success. Moreover, Zhou et al. (2016) analyze the importance of the project's description and the initiator's experience in crowdfunding campaigns. Researchers note that the readability, tone and complexity of the language used in the campaign significantly influence the success of the project. Additionally, according to their research, initiator's experience with crowdfunding initiatives and experience in backing other projects also have a positive effect on crowdfunding campaign.

Despite the growing literature on crowdfunding, there have been few studies on overfunding. Cordova et al. (2015) use the database of technology projects. They conduct linear regressions to explain the level of overfunding. The authors identify the following variables that positively impact the overfunding rate: the number of funders supporting the project; the mean amount contributed to the project by supporters, the mean daily amount contributed to the project and the duration of the campaign. Moreover, Cordova et al. (2015) confirm the expected negative relationship between the target amount and the overfunding rate.

Koch (2016), in a later study on overfunding in crowdfunding campaigns, conducts linear regressions. He provides further evidence that the funding goal is negatively correlated with the overfunding rate. Koch also points out that the number of rewards pledges, an informative description of the project, number of pictures, videos and the length of the founder's platform membership have positive influences on a project's overfunding. Furthermore, corresponding to a study conducted by Cordova et al. (2015), Koch finds that a longer duration of the project increases the level of overfunding. Concerning the duration variable, the positive relationship with the level of the overfunding may be surprising considering the results of studies devoted to the crowdfunding success drivers, which indicate the negative influence of the length of the campaign on the probability to achieve the target amount (Mollick 2014; Crosetto and Regner 2014).

3 Research Design

In this paper, we concentrate solely on successful crowdfunding projects. We calculate two measures of the level of overfunding separately for each project, as seen in Eqs. 1 and 2.

$$overfund1_i = (don_i - target_i)/target_i \tag{1}$$

$$overfund2_i = \begin{cases} 0 \ if \ \ overfund1_i < 0.1 \\ 1 \ if \ \ overfund1_i \geq 0.1 \end{cases} \tag{2}$$

In the first equation, don_i is the collected amount (money donated), and $target_i$ is the requested amount for a project i. After obtaining the first measure of overfunding, $overfund1_i$, we conduct Kolmogorov-Smirnov (K-S) and U Mann-Whitney (UM-W) tests to check for the statistical differences between the first and fourth quartiles of the overfunding distribution across the selected determinants.

The need to adopt a second measure of overfunding comes from the statistical properties of $overfund1_i$, which does not follow a normal distribution and is highly skewed. Following the literature, which confirms that successful projects are overfunded only by small margins above the requested target (Mollick 2014), we set a threshold of 10% for the project to be deemed an attractive one. We argue that the 10% limit is large enough to distinguish projects that are more valuable to social communities that engage in the crowdfunding process. After obtaining the $overfund2_i$ measure, we conduct a logit regression, which is the standard approach in the case of binary data. Logit regression allows for the capture of changes in the probability p of overfunding as a function of the selected antecedents. In accordance with previous research (Cameron and Trivedi 2010), we examine results based on the pseudo-R^2 measure, predictive accuracy and the standard post-estimation

Table 1 Description of variables

Variable	Definition
Target	The amount the owner seeks to raise (thousands of PLN)
Duration	The length of project' funding campaign (in months)
Supporters	The number of backers supporting the project (in dozens)
Comments	The number of comments from the crowd related to the project
Comm > 5	Binary variable, the value of 1 if the project has more than 5 comments
Media	The number of media notices related to the project
Media > 5	Binary variable, the value of 1 if the project has more than 5 media notices
News	Project's news published on the project's website by the project's owner
News > 5	Binary variable, the value of 1 if project has more than 5 news
Capital	Binary variable, 1 if the project's author is from the capital city (Warsaw)
Previous	The number of previous projects conducted on the PolakPotrafi.pl platform by the project's author
Nonformal	Binary variable, the value of 1 if the project's author is an individual person: female, male or group of individuals

Source: Own compilation

analysis concerning the correctness of regression specification (link test) and the goodness of fit (Hosmer-Lemeshow test).

Drawing on the literature, we have selected nine potential overfunding determinants among which we distinguish three control variables (target, supporters, duration) and six additional factors that describe the project and the project's owner. In the latter case, we concentrate on media presence, news from initiators and the impact of project information on network activity, expressed by the number of comments. We also check the project author's previous experience with crowdfunding and the relevance of the category of the author. We classify authors into separate categories: non-formal: individuals or non-formal groups of individuals and formal: formal teams, foundations, association, firms, *etc*. In the case of the logit regression, we transform the variables *media*, *news* and *comments* into binary variables, whereas for the differences tests we proceed with original values. All variables are described in Table 1.

In the study, we use data on the 957 successful projects extracted from the archives of the PolakPotrafi.pl platform within the time span March 2011 to September 2016. We eliminate projects with incomplete or incorrect information and proceed with 814 projects that successfully obtained the requested target amount.

4 Findings

Table 2 presents descriptive statistics for selected continuous variables. The mean overfunding level is 32%, whereas the median value is much lower (11%). The mean duration of the campaign for the projects in our sample was 37 days with a median of

Table 2 Variables univariate characteristics

Variable	Mean	Median	Min.	Max.	Std. Dev.	Skewness	Kurtosis
Overfunding	0.3297	0.1120	0.0001	8.7995	0.75	6.36	52.75
Target (thous. PLN)	8.4395	5.500	0.150	100	10.65	4.26	26.10
Supporters (in dozens)	11.317	7.1	0.3	368.8	18.30	10.94	187.79
Duration (in months)	1.24	1.33	0.167	3.1	12.76	0.28	0.75
Media	1.81	0	0	35	3.82	3.89	19.92
News	5.37	4	0	66	6.66	2.83	14.54
Comments	6.83	1	0	1705	60.72	27.01	755.04
Previous	0.14	0	0	9	0.53	7.80	102.88

Source: Own computation in program Statistica

Table 3 Overfunding across the quartiles and differences tests

	Quartiles (medians)				1–4 quartiles differences tests p-values	
Variable	Q1	Q2	Q3	Q4	K-S	UM-W
Target	0.1604	0.0992	0.0880	0.1273	$p > 0.10$	0.1805
Supporters	0.0716	0.0875	0.1113	0.1913	$p < 0.001$	0.0000
Duration	0.0693	0.1291	0.0739	0.2501	$p < 0.001$	0.0000
Media	0.1229	0.0844	0.074	0.1463	$p > 0.10$	0.3918
News	0.0825	0.0898	0.1017	0.2754	$p < 0.001$	0.0000
Comments	0.0818	0.0908	0.1300	0.1759	$p < 0.001$	0.0000

Source: Own computation in program Statistica
K-S Kolmogorov-Smirnov test, *UM-W* U Mann-Whitney test

40 days. The projects had an mean funding goal of PLN 8439.52, and half of them had goals of more than PLN 5550. The projects in our sample differ significantly with respect to media presence, news and comments from the crowd. Indeed, in the sample, there are projects that have attracted much attention in social media and gathered more than 1000 comments or more than 30 media notices. The results in Table 2 also reveal high skewness and kurtosis levels in the variables' distribution.

In Table 3, we summarize the comparison results of overfunding and the selected variables. In columns 2–5 of Table 3, we report the median values of the overfunding coefficients across the quartiles of the variables, while in columns 6–7, we report the *p*-values of the differences test between the 1st and the 4th quartiles (Kolmogorov-Smirnov, U Mann-Whitney). The obtained results indicate that the overfunding level is significantly higher for the projects with larger number of supporters—the overfunding level rises starting from the 1st until the 4th quartile. Moreover, overfunding is higher for projects with a longer campaign length and a larger number of comments and news from the project's initiator. There is no significant pattern between the overfunding level and the funding goal and media presence.

The results of both tests are consistent and give preliminary evidence of the importance of the selected variables.

Due to dichotomous data structure, the quartiles' median values for the variables *capital city* and *nonformal* are not included in Table 3. However, we apply Kolmogorov-Smirnov test and U Mann-Whitney test and find no differences between the overfunding rates of projects submitted by initiators coming from Warsaw and by different categories of authors.

In Table 4, we report the results of the logit regressions. In all specifications except the last one, we employ the same control variables. In Table 4, we report variable coefficients, standard errors (in brackets), and the post-estimation checks for each specification.

In the first specification (Model A), all the coefficients have the expected sign. However, the results are not statistically significant for the project's *duration* and

Table 4 Logit regression results—variables coefficients

Variable/model	A	B	C	D	E
Target	−0.1509***	−0.1511***	−0.1488***	−0.1488***	−0.1520***
	(0.0200)	(0.0201)	(0.0200)	(0.0200)	(0.0200)
Supporters	0.1576***	0.1548***	0.1527***	0.1529***	0.1530***
	(0.0199)	(0.0197)	(0.0198)	(0.0198)	(0.0198)
Duration	−0.2961	−0.2941	−0.2715	−0.2635	
	(0.1913)	(0.1914)	(0.1934)	(0.1937)	
Media > 5	−0.2283				
	(0.2697)				
News > 5	0.2882*	0.2882*	0.3079*	0.3111*	0.2862*
	(0.1668)	(0.1667)	(0.1675)	(0.1676)	(0.1664)
Comm > 5	0.8100***	0.8112***	0.8131***	0.8006***	0.7733***
	(0.2150)	(0.2151)	(0.2155)	(0.2161)	(0.2133)
Capital city		0.1716			
		(0.1840)			
Previous			0.6885***	0.6857***	0.6970***
			(0.2210)	(0.2210)	(0.2203)
Non-formal				0.1623	
				(0.1991)	
LR stat.	164.35***	164.51***	176.27***	176.00***	173.34***
Link-test predict coef. predict^2 coef.	0.9827***	0.9813***	0.9786***	0.9784***	0.9764***
	0.0833*	0.0821	0.0569	0.0576	0.0731
H-L stat.	12.78	13.95	9.87	7.45	8.75
McFadden pseudo R^2	0.1461	0.1462	0.1567	0.1565	0.1541
Correctly classified	67.08%	67.44%	67.44%	67.32%	67.32%

Note: *LR stat.* log-likelihood χ^2 statistics, link-test predict coefficients and squared predicted coefficients, *H-L stat.* Hosmer-Lemeshow χ^2 statistics
Coefficients; standard errors (in brackets); **p*-value < 0.1, ***p*-value < 0.05, ****p*-value < 0.01

number of media notices (*media* > 5). In the second and fourth specifications (Models B and D), we investigate the relevance of the project's localisation (*capital city*) and the type of the project's owner. Surprisingly, both binary variables are not statistically significant for the overfunding success level. The third specification (Model C) reveals the importance of the previous experience of the project's owner with crowdfunding platforms. The coefficient sign has two possible explanations. First, the crowd does not punish for an author's having had previous projects or, alternatively, the owner acquires knowledge about the proper structuring of the project and communication with the crowd. In the last specification, we include only statistically significant variables, and we argue that the best model supports the relevance of the project's target amount; the number of supporters; the level of project's vitality, which corresponds to *news* and *comments*; and the importance of the owner's experience (*previous*). The obtained results are stable across all specifications, and the post-estimation tests confirm the appropriateness of the specifications.

5 Conclusion

The growing interest in crowdfunding in Poland and other Central and Eastern European countries justifies the relevance of the research question undertaken. While previous studies devoted to the crowdfunding projects did not cover the problem of overfunding determinants sufficiently, our study fills this gap and extends some theoretical conclusions that were presented in the previous literature. With a unique underlying dataset of 814 overfunded projects extracted from the Polish crowdfunding platform PolakPotrafi.pl, we examine the antecedents of overfunding within this paper. We obtain several interesting findings. First, we find that two out of three control variables—the number of supporters and the target amount declared by the project's initiator are significantly related to overfunding. That conclusion aligns with the existing literature both on overfunding and on crowdfunding success. Indeed, more popular projects attract attention from a larger group of supporters, which increases the overfunding level. Conversely, projects with higher funding goals have to either attract a larger group of supporters or target supporters who are willing to donate larger amounts. Surprisingly, our study reveals that the duration of a campaign is not statistically significant. We argue that the duration may have a significant impact on the level of the overfunding, however, it is not a determinant of overfunding as defined in our paper. Furthermore, our study reveals that a project's vitality is positively related to overfunding. Active communication between the project's initiator and supporters is important at every stage of the campaign. In the case of overfunded projects, presenting information about further developing the declared scope may be an incentive for further donations. Our results also prove that the project's initiator's experience as measured by the number of previous campaigns is positively related to overfunding. It has been noted in previous studies that initiator-related aspects influence funding and overfunding success. Our analysis shows that previous experience with crowdfunding increases the chance of that a project will be strongly overfunded. On one hand, it may be the case that a project's initiators improve the campaign due to their experience, or, on the other hand, the author may already be known among the donators, who may be willing to support a similar project.

Although we have made every effort to be complete and accurate in this research, some limitations still exist. First of all, due to data limitations, we measure the project's initiator's experience with crowdfunding in one platform; however, experience on different crowdfunding platforms may significantly further improve the quality of the campaign. Moreover, we assume that further studies should include additional variables in the analysis, primarily with respect to communication tools, such as photos and videos, that describe the quality and readability of the project's description.

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Valuation of Household Losses in Child's Death Cases for Insurance Purposes

Anna Jędrzychowska and Ilona Kwiecień

Abstract This article addresses the problem of the quantification of household loss resulting from the death of a child. The authors try to create a model combining methods of life valuation for the purpose of correctly managing the risk of a child's death in personal finances. These decisions also include decisions concerning insurance; it is necessary to determine the correct sum insured in life insurance and to make claims under liability insurance, if entitled. There are no systematic approaches to such claims processes in Poland, neither are there systematic rules for setting the proper sums in life insurance. Nevertheless, against the background of differences in valuation in practice, this issue is currently being discussed. Still, both kinds of decision focus rather on non-economic loss (pain and suffering) in practice; in contrast the authors indicate wider spectrum referring to the economic loss that the household actually experiences and economic basis of "non-economic" loss valuation.

The value of the loss results not only from direct costs, such as the funeral. According to the authors, in broad terms, the value can be determined based on the incurred and planned expenditure, as well as any legitimate benefits or support expected by the household. Thus, the model is based on a combination of economic approaches from the theory of value, including the cost of production, the willingness to pay, expected benefits, and needs analysis.

In the opinion of the authors, this can function as the basis for determining the level of insurable and also claiming interest, as well as preventing situations that could be perceived as morally dubious in cases in which the amounts are overstated, or undue loss where amounts are understated. In this way, this model could become an important element in the household financial management process.

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1 Introduction

The death of a child is an event that causes loss to the household, in both economic and non-economic terms. It functions as the basis for two particular decision areas in the field of personal finance management:

- claims in tort liability, including liability insurance, in cases where there is an entity responsible for the event that could be covered by liability insurance (widespread in third-party motor liability insurance which is compulsory, but also in medical malpractice cases)
- life insurance, in situations where parents have concluded an insurance contract on the child's life, making themselves beneficiaries.

In practice, these decisions are often not based on a financial analysis of the loss, but rather on an emotional assessment, on ad hoc basis (by "rule of thumb"), or—in life insurance cases—through the prism of the potential ability (or willingness) to pay a specified premium.

Nevertheless, in the authors' opinion, it is possible to build a model allowing an estimation to be made of the loss of the household, using economic methods. Our approach takes into account research on the valuation of goods, including the value of human life (in this instance, the value of the child): among others Hofflander (1966) and Schultz (1961), Becker (1975), in addition to overviews and more sociological studies such as Zelizer (1994). In these studies, both economic (cost of production, utility theory, etc.) and non-economic (hedonic damages, willingness to pay or accept, etc.) aspects of value are considered; however, this is more often from the point of view of society than of the individual household.

In this paper, the authors build a model combining and modifying such methods as cost of production, willingness to pay and utility theory. Cost of production is conceived according to the classical theory of economics (Murphy 2006), which states that the value of the good is equal to the cost of its production. Willingness to pay is used in statistical life valuation (Blomquist 1981) through the prism of expenditure: investments that a person is willing to pay to avoid an undesirable event. This method is modified by the authors to take into account the expenditures that a household is willing to pay in order to have a child, which also indicates value simply as the costs that parents are willing to take on. This is related to expected benefits and utility theory from the psychological school of economics (the so-called "Austrian school", which includes E. B. de Condillac and C. Menger) (Stankiewicz 2000, Smith 1997). This theory presents an individualized value, and the usefulness is determined by the ability of a good to satisfy the specific needs of an entity (the investor). Indeed, the assumption that a child is a specific kind of good—a long-term asset that causes the flow of well-being and has a certain value—was the basis of Becker's fertility model (1960).

Assuming that a rational household seeks full compensation (in accordance with both the principle of making the victim whole in tort liability, and the principle of insurance), the concept is based on the aforementioned economic methods, according to the period or component of the loss:

(a) expenditures incurred by the child until death (cost of production),
(b) the loss of expected benefits in the future (the utility),
(c) planned expenditure (willingness to pay).

In this paper, the authors analyse these three areas on the basis of factors chosen as relevant and typical for a household with a child or children:

1. expenses incurred by the child,
2. household members' own work for the child,
3. the child's work for the household,
4. care provided by the child to its parents in their old age.

By combining these two classifications, we get a model for the valuation of household loss, as below:

(a) Expenditures incurred by the child until its death (cost of production): these include expenses paid as well as household members' own work for the child over the period preceding the child's death.
(b) The loss of expected benefits in the future: this includes the lost child's work for the household, which due to death can no longer be performed (3), and the care which could reasonably have been expected of the child by the parents during their old age (4).
(c) Planned expenditures: this is a complement to (1) and (2), calculated for the period after the death of the child, as the value of expenses on and work for the child that the household still has to carry out. In a full assessment in accordance with the willingness to pay method, it would also be necessary to take into account expenditures already incurred, as discussed later in the article.

2 Valuation of Loss Components

This section will discuss four components for valuing a child's household, as identified in the introduction. They will be divided into two categories:

1. expenditures (financial and non-financial) on the child, which corresponds both to expenses on the child and household members' own work for the child, and
2. benefits that the household could reasonably expect from the child, but which, due to the child's death, will not be received.

The calculations are based on an increasing annuity. All values are in the PLN currency; the authors wish to indicate that, according to Table 1 of the Polish National Bank in January 2018, the exchange rate to the euro was 4.17.

Table 1 The monthly costs of a single child in a household, by biological type and average net income per person

	Type of biological household		
	With one child	With two children	With three or more children
Average net income per person	754.11 PLN	462.05 PLN	89.45 PLN
Monthly cost of a single child	640.71 PLN	414.07 PLN	119.83 PLN
Average monthly growth rate of the child's cost	0.50%	0.72%	1.66%

Source: Own calculation based on "Household Budgets Survey in 2006" (and subsequent reports)

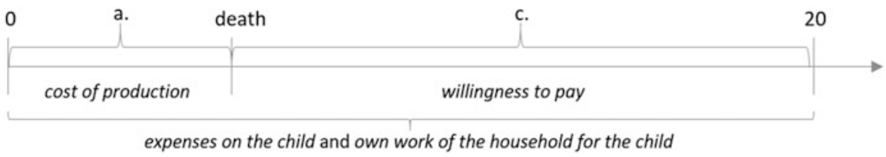

Fig. 1 Relation between components of loss and the economic sources of data for calculation. Source: Own work

2.1 *Expenditures (Financial and Non-financial) on the Child*

For calculating expenditure on the child, we employ a combination of two methods—cost of production (a) and willingness to pay (c)—on the basis that the child's death interrupts the expenditures process. The relation between these two periods is presented in Fig. 1.

2.1.1 Financial Expenses Incurred by the Child

In order to estimate this value, it is necessary to calculate what part of its total expenses the household spends on the child. The following estimation method can be used: the cost of a child in a household with two adults is determined according to the formula (1) as the difference between total household expenses (two adults) with a certain number of children (i) and a two-person household with no children, divided by the number of children (Jędrzychowska et al. 2018):

$$AVCC_i = \frac{C_{Ci} - C_C}{i}. \qquad (1)$$

where:

i—number of children in the household,

C_C—total expenses of a two-person household without children,

C_{Ci}—total expenses of a two-person household with i children, and.

$AVCC_i$—average variable cost of a child in a household with two adults and i children.

This method assumes that the variable cost of each child in the household is the same. It is based on the assumption of the same (average) variable cost of each child, relative to the cost of maintaining two adults without children. It should be emphasized that, in this method, the average cost of a child depends on the biological type of the household i.e., on the number of children in a household with two adults.

Using the report "Household Budgets Survey in 2006" (and the subsequent reports for the years 2006–2017) published by the Central Statistical Office, the following values for the monthly average costs of a child in particular types of biological household were obtained. The average monthly growth rate of these amounts was also determined (Table 1). The table also shows the average monthly net income per person. It was considered that the received cost values should be scaled proportionally to the income of a given household by the ratio between its income and the estimated average income. This is based on the assumption that expenditures on a child depend on the wealth of the household.

Following this, the present value of these expenses was determined in order to show the amount that the child's parents planned to spend on raising and maintaining it at the time of its birth (i.e., death of a child at the age of 0 years). This amount was also estimated for particular types of biological households. As shown in Table 2, for households with one child, the value is around 209 thousand PLN, for households with two children, it is around 183 thousand PLN, and for large families, it is worth 237 thousand PLN. This final value—for families with three or more children—is the highest, which results from these families' experiencing the highest growth rate of expenditure on children (last line of Table 1): about 1.6% per month.

In addition, the economic value of a child's life was determined for particular moments in its life, as a combination of two components: real loss (the value of expenses incurred up until the child's death) and emotional loss (expenses that its parents were still willing to cover). This value could function as the basis for determining the amount of compensation. The last column of Table 2 contains the amount of expenses incurred by the parents up until the child's death, i.e., the part of the previous column that corresponds to the real loss.

2.1.2 Own Work of the Household for the Child (Non-financial Expenditures)

The expenditure necessary for raising a child includes not only direct financial expenses (mentioned above) but also the household members' own work for the benefit of the child: so-called contribution out-income.

A number of assumptions were made in this valuation, which makes use of the CSO's "Time Use Survey 2013": a study containing information on the average time spent performing activities that can be considered as related to childcare (see Table 3). The report assumes that, after the age of 17, the household no longer

Table 2 The present value of expenses incurred by a child, depending on the type of biological household and the moment of the child's death (in PLN)

Household	With one child		With two children		With three or more children	
Age of the child at the time of death	Full value of the child at the moment of death	Value of expenditures incurred up until death	Full value of the child at the moment of death	Value of expenditures incurred up until death	Full value of the child at the moment of death	Value of expenditures incurred up until death
0	209,919.15	0.00	183,744.04	0.00	236,942.70	0.00
5	244,418.89	48,296.14	213,941.96	33,465.10	275,883.69	13,182.64
10	284,588.58	121,421.09	249,102.83	90,533.11	321,224.54	50,774.05
15	331,360.06	229,363.13	290,042.31	184,876.00	374,017.07	154,313.60
20	385,818.33	385,818.33	337,710.11	337,710.11	435,485.92	435,485.92

Source: Own calculation based on "Household budgets survives in 2006" (and subsequent reports)

Table 3 Time (in minutes per day) to perform activities related to raising a child

	Two adults with a child					
	Of 6 years old	Of 17 years old	Of 6 years old	Of 17 years old	Of 6 years old	Of 17 years old
	Unisex		Women		Man	
Food processing	66	75	105	118	26	30
Work related to maintaining order	37	44	49	51	25	36
Work related to the preparation and maintenance of clothing	9	11	16	20	1	1
Shopping and use of services	22	26	27	32	17	20
Childcare	147	28	201	38	92	18
Commuting (access) relating to looking after children	11	6	15	8	7	4

Source: Own work based on "Time Use Survey 2013"

works for the child. Some of the activities (such as food processing, maintenance work, and work relating to the preparation and maintenance of clothes, as well as shopping and use of services) are performed for all members of the household. In the calculation, these values are divided by the number of members of the household. However, time dedicated to childcare and commuting (access) relating to childcare is shared only by the children who are part of the household.

Then, we found rates for the working hour that employees of the relevant professions receive. Assuming that on this basis, unpaid work can be priced. As before, CSO reports were used, this time from the study "Structure of wages and salaries by occupation in October 2006" and subsequent reports up until 2016 (reports are issued every 2 years). It was assumed that work relating to maintaining order and to the preparation and maintenance of clothes, as well as shopping and using services, can be treated in the same way as cleaning tasks, which is why they were given a valuation in the category of "household aids and cleaners" (average hourly rate: 10.10 PLN, monthly increase: 0.0045). Work associated with food processing was valued according to "cooks" (average hourly rate: 14.68 PLN, monthly increase: 0.0096), childcare according to "child carers and teacher assistants" (average hourly rate: 12.40 PLN, monthly increase: 0.0038), and to estimate the costs of commuting, the category "drivers of passenger vehicles" was used (average hourly rate: 13.71 PLN, monthly increase: 0.00316).

Based on these assumptions, the value corresponding to "willingness to pay" at the time of childbirth (aged 0 years) was set. Similarly to the case of child expenses, this value shifts according to the age at which the child dies, in order to take into account the fact that part of the work for the child has already been done (therefore the results of a job have been lost), and some work will go undone that would have

Table 4 Value of a household's own work (made in the past and potential in future) for a child (for selected age of child at time of death) (in PLN)

Age of the child at the time of death		0	5	10	15	20
Women	With one child	337,745.81	393,248.02	457,870.98	533,113.51	620,720.75
	With two children	215,740.13	251,192.98	292,471.85	340,534.13	396,494.55
	With three or more children	162,573.64	189,289.58	220,395.78	256,613.70	298,783.37
Men	With one child	129,775.19	151,101.32	175,932.00	204,843.13	238,505.27
	With two children	79,865.69	92,990.12	108,271.31	126,063.67	146,779.88
	With three or more children	59,235.03	68,969.20	80,302.99	93,499.29	108,864.15

Source: Own calculation based on "Structure of wages and salaries by occupation in October 2006"

Table 5 Value of the household's own work for the child made for child death (for selected age of child at time of death) (in PLN)

Age of the child at the time of death		0	5	10	15	20
Women	With one child	0.00	128,701.76	255,453.24	429,788.72	620,720.75
	With two children	0.00	72,590.84	152,172.09	268,329.05	396,494.55
	With three or more children	0.00	51,689.88	111,226.25	200,259.91	298,783.37
Men	With one child	0.00	54,515.30	104,737.91	169,410.33	238,505.27
	With two children	0.00	29,914.86	60,382.08	102,017.94	146,779.88
	With three or more children	0.00	21,006.13	43,459.97	74,937.07	108,864.15

Source: Own calculation based on "Structure of wages and salaries by occupation in October 2006"

been done willingly (i.e., work that parents would have wanted to do for the child). The respective values for selected ages of the child at the time of its death are given in Table 4.

However, when calculating only the work actually performed for the child, the following values were obtained (Table 5). These amounts should be considered as a permanent job for raising a child because of his.

2.2 Lost Benefits Expected from the Child in the Future

In order to determine the full extent of household damage, it is necessary for the authors' assessment to take into account the lost benefits that the household could have expected from "investing" in having a child. These are primarily:

- lost child labour input into the household, and
- lost care (support) in old age.

Table 6 The value of a child's work calculated for its age at time of death (in PLN)

Child's age at the time of death	0	1	2	3	4
Value of the child's work calculated at the moment of death	28,973.08	29,868.26	30,791.10	31,742.46	32,723.21
Child's age at the time of death	5	6	7	8	9
Value of the child's work calculated at the moment of death	33,734.26	34,776.55	35,851.05	36,958.74	38,100.66
Child's age at the time of death	10	11	12	13	14
Value of the child's work calculated at the moment of death	39,277.86	35,426.54	31,663.81	27,987.63	24,396.00
Child's age at the time of death	15	16	17		
Value of the child's work calculated at the moment of death	20,886.99	16,512.95	12,239.52		

Source: Own work based on "Time Use Survey 2013"

The scope of these benefits depends on many individual circumstances, as well as cultural and environmental factors that are beyond the scope of consideration. Instead, the authors will try to model a certain "typical" situation.

2.2.1 Child Labour Input into the Household

To estimate the value of work that a child contributes to its household, the CSO "Time Use Survey 2013" report was used. This study takes into account the time spent by children on housework in two age groups: 10–14 and 15–17. The calculations therefore include only those years; the age ranges below 10 years and above 17 years received the value 0. It is important to understand that the valuation relates to the loss, i.e., if the child dies at the age of 0, the household loses all its future contributions from 10 to 17 years of age, which are discounted at the moment of death. For this reason, a child's death at 18, 19 and 20 does not result in a loss to the household of the child's housework, because it is assumed that, by the end of 17 years, it was included in household work. The value of a child's lost work calculated according to the child's age at time of death is presented in Table 6.

Of course, this factor will also depend on the type of biological household. It should be taken into account that, in a household with one child (i.e., a three-person household), the household receives two thirds of that value, because one third of the child's housework is for its own benefit. Accordingly, for a household with two children, this number is three quarter, and for three children—four fifths, etc.

2.2.2 Lost Care (Support) in Old Age

The valuation of this component was made using the Life Tables for Poland 2016, from which information on the average life expectancy of an *x*-year old was taken. Then, these values were compared (separately for women and men) with the average

Table 7 Average life expectancy in months divided into months in full health and without full health

Age	Men		Women	
	Average life expectancy (months)			
	In full health	Without full health	In full health	Without full health
20	470	184	520	229
25	410	187	460	230
30	350	190	400	230
35	290	194	340	232
40	230	198	280	233
45	170	204	220	236
50	110	213	160	240

Source: Own work based on data from Eurostat

Table 8 The present value of care costs after losing health (in PLN)

Parent's age at the time of the child's death	The present value of care costs after losing health	
	Men	Women
20	437,297.83	796,573.18
25	446,115.20	789,468.97
30	460,233.70	775,462.58
35	484,539.60	775,965.88
40	503,549.62	770,998.14
45	538,388.18	776,770.51
50	587,574.71	786,343.52

Source: Own calculation based on "Structure of wages and salaries by occupation in October 2006"

life expectancy at full health. This value was set for Poland at 59.1 years for men and 63.4 years for women (according to Eurostat). On this basis, the life expectancy and health status were determined (in months), and thus the need for care for selected exemplary x-year-olds (Table 7).

Subsequently, the assumption was made that following a deterioration in health, a person needs 1 h of care from their closest family members for the first 5 years, 3 h of care and help during the next 5 years of health deterioration, 5 h in the next 5 years, and after 15 years of progressive deterioration in health, 10 h of support is required. The hourly rate was based on the average hourly rate estimated in the CSO's "Structure of wages and salaries by occupations in October 2006" report, and subsequent reports up until 2016. The rate for the category "healthcare and social assistance" was adopted in the calculations. The initial gross hourly wage amounts to 20.67 PLN, and the growth rate (per month) was 0.002869. Based on these assumptions, the present value of care costs was calculated after losing health (Table 8).

In assessing this component of loss, it must be indicated that social security systems or private market instruments, such as care insurance or medical savings accounts, could also be considered as a source of finance for old age care. Due to the limited scope of this article, an analysis of this issue and alternatives has been omitted by the authors and will instead be a subject of reflection in further work.

3 Numerical Examples

In this part, will be presented values of damages relating to the loss of a child will be determined, and the dynamics in time of individual damage components will be shown.

3.1 Example 1

A married couple, of which the wife is 20 and the husband 25, loses a child. Two options will be considered: Option 1, the deceased child was 0 years old (death at delivery), and Option 2, the child was 5 years old. In addition, the considerations will be divided into three cases relating to the number of children in the household (i.e., the biological type of the household). The calculated value of damages relating to the death of a child are presented in Table 9.

The total value of household loss in the case of an only child is about two million PLN if the child is dead at birth and about 2.3 million PLN if the child dies aged five.

It should be noted that Value (4.)—representing the cost of care in old age—is the largest; importantly, it also does not depend on the age of the child, or on the age of the parents. In the case of an only child who dies at birth, it is an amount of 64.07% of the total takeoff. In the analogous situation for an only child who dies at the age of five, the significance of this amount decreases (there have already been expenditures made on the child) and amounts to 54.96% of the total loss. In families with a larger number of children, this category represents about 50% (with two children) and 40% (with three children) of the total amount. Of course, in the case of a child who dies at birth, the cost of production is 0 PLN. This is due to the fact that the calculation omits costs incurred during pregnancy, as well as the costs associated with psychological consultations and the treatment of trauma after losing a child.

3.2 Example 2

Another couple, of whom the woman is 45 and the man 50, loses a child. Three options will be considered: that the deceased child was 10, 15 or 20 years old. In addition, the considerations will be divided into three cases relating to the number of children in the household. The calculated values of damages related to the death of a child are presented in Table 10.

Table 9 Value of household loss due to the death of a child, calculated for Example 1 (in PLN)

Number of children	Child's age at the time of death	The value of household loss due to the death of a child			
		a. Cost of production			
	Component	1.	2.	sum	
1	0	0.00	0.00	0.00	
	5	244,418.89	128,701.76	373,120.65	
2	0	0.00	0.00	0.00	
	5	33,465.10	102,505.70	135,970.80	
3	0	0.00	0.00	0.00	
	5	13,182.64	72,696.01	85,878.65	
		b. Loss of future benefits			
	Component	3.	4.	sum	
1	0	19,315.39	1,242,688.38	1,262,003.77	
	5	22,489.51	1,242,688.38	1,265,177.89	
2	0	21,729.81	621,344.19	643,074.00	
	5	25,300.70	621,344.19	646,644.89	
3	0	23,178.46	414,229.46	437,407.92	
	5	26,987.41	414,229.46	441,216.87	
		c. Willingness to pay			
	Component	1.	2.	sum	
1	0	209,919.15	467,521.00	677,440.15	
	5	196,122.75	426,503.46	622,626.21	
2	0	183,744.04	295,605.81	479,349.85	
	5	180,476.86	241,677.40	422,154.26	
3	0	236,942.70	221,808.67	458,751.37	
	5	231,236.25	185,562.76	416,799.01	
		a. + b. + c.			
		a.	*b.*	*c.*	sum
1	0	0%	65%	35%	1,939,443.92
	5	17%	56%	28%	2,260,924.75
2	0	0%	57%	43%	1,122,423.85
	5	11%	54%	35%	1,204,769.95
3	0	0%	49%	51%	896,159.29
	5	9%	47%	44%	943,894.53

Source: Own calculation

The total value of household loss in the case of an only child is about 2.5 million PLN.

As in Example 1, the largest part of the total damage is the costs relating to care provided to parents in their old age. These values, depending on the number of children in the household, represent about 55%, 45% or 40% of total damages, respectively. Although the percentage is lower, it should be noted that this the amounts for this category are higher than the values from Example 1: this is due to the age of the parents and their closer proximity to the moment of needing care.

Table 10 Value of household loss due to the death of a child, calculated for Example 2 (in PLN)

Number of children	Child's age at time of death	Value of household loss due to the death of a child			
		a. Cost of production			
	Component	1.	2.	sum	
1	10	121,421.09	360,191.15	481,612.24	
	15	229,363.13	599,199.05	828,562.18	
	20	385,818.33	859,226.01	1,245,044.34	
2	10	90,533.11	212,554.17	303,087.28	
	15	184,876.00	370,346.99	555,222.99	
	20	337,710.11	543,274.42	880,984.53	
3	10	50,774.05	154,686.22	205,460.27	
	15	154,313.60	275,196.97	429,510.57	
	20	435,485.92	407,647.52	843,133.44	
		b. Loss of future benefits			
	Component	3.	4.	sum	
1	10	26,185.24	1,364,345.22	1,390,530.46	
	15	13,924.66	1,364,345.22	1,378,269.88	
	20	0.00	1,364,345.22	1,364,345.22	
2	10	29,458.40	682,172.61	711,631.01	
	15	15,665.24	682,172.61	697,837.85	
	20	0.00	682,172.61	682,172.61	
3	10	31,422.29	454,781.74	486,204.03	
	15	16,709.59	454,781.74	471,491.33	
	20	0.00	454,781.74	454,781.74	
		c. Willingness to pay			
	Component	1.	2.	sum	
1	10	163,167.49	273,611.82	436,779.31	
	15	101,996.93	138,757.59	240,754.52	
	20	0.00	60,278.10	60,278.10	
2	10	158,569.72	188,188.99	346,758.71	
	15	105,166.31	96,250.81	201,417.12	
	20	0.00	0.00	0.00	
3	10	270,450.49	146,012.55	416,463.04	
	15	219,703.47	74,916.02	294,619.49	
	20	0.00	0.00	0.00	
		a. + b. + c.			
		a.	*b.*	*c.*	*sum*
1	10	21%	60%	19%	2,308,922.01
	15	34%	56%	10%	2,447,586.58
	20	47%	51%	2%	2,669,667.66

(continued)

Table 10 (continued)

Number of children	Child's age at time of death	Value of household loss due to the death of a child			
2	10	22%	52%	25%	1,361,477.00
	15	38%	48%	14%	1,454,477.96
	20	56%	44%	0%	1,563,157.14
3	10	19%	44%	38%	1,108,127.34
	15	36%	39%	25%	1,195,621.39
	20	65%	35%	0%	1,297,915.18

Source: Own calculation

4 Conclusion

The above considerations constitute a proposal for modelling the extent of loss in a household, which is obviously imperfect as a result of its basis on certain assumptions, and of the difficulties of taking into account so-called "emotional loss".

The valuation of a child for a household was first based on the concept of "cost of production" (a), i.e., expenditures necessary for maintaining and raising a child. It is obvious that their level depends on many factors, including household wealth, as well as social attitudes regarding the scope of expenses, including education and the period of supporting the child. Interrupting this "production" process means that we are dealing with real loss, economic in nature. In the *willingness to pay* approach (defined in Sect. 1), it is also necessary to take into account planned expenses, not incurred yet, which determine the value of the good (i.e., the child) according to the method. This is done by determining what amount the parents are willing to spend on such a good, which usually involves limiting their own consumption or increasing their gainful activity, and therefore making additional efforts. The assessment should also take into account financial outlays; in this way, we take into account the emotional value to a certain extent (a + c).

The calculations presented may, as set out in the introduction, serve important financial decisions. In the area of claiming under tort liability or liability insurance, they allow the full damage to be determined in accordance with the common rule in tort liability of *making the victim whole*. Referring to the Polish tort liability system, the amounts calculated as (a + c) indicate the proper value of compensation for pain and suffering, whereas only taking into account the amount for expenditures incurred (a) would be completely unfair because, by analogy to property damage, it does not even compensate the actual financial loss. It is worth noting that a review of judicial decisions allows it to be stated that such underestimation does take place in practice.

Lost benefits calculations allow an indication to be made of the right compensation for the deterioration of the parents' living situation, which in liability cases is very often—in the Polish system—judged "roughly" as a symbolic amount.

The scope of this paper does not allow for a verification of the results using judgements, review among others in Kwiecień (2015) among others).

For life insurance purposes, in order to determine the insurance sum (policy limit), a + c should be taken, up to the period which is assumed for financial and non-financial care. In fact, depending on the age of the child at the time of death, the initial period of insurance would involve a surplus sum insured for expenditures, so the greater part of the compensation would be to cover emotional loss in cases where the child dies sooner. The closer to the end of the insurance period (assuming that the insurance period = the period of planned childcare, e.g., 18–24 years old), the closer the guarantee sum is to the actual loss (Letablier et al. 2009). As the sum insured in life insurance is contractual, nothing stands in the way of the insecurity of the household also including the value of lost profits in its total, bearing in mind the expenditure incurred. In the authors' opinion, reasonably expected benefits will not continue to lead to enrichment; however, there is no legal restriction in life insurance (Leimberg et al. 1999; Smith et al. 1999).

Summing up the most important conclusions drawn from the calculations, it is also worth stressing the following:

– The largest share in total loss value is the lost benefits in the form of expected care in an old age, and we should be aware that longer life expectancies will make this value grow still larger.
– In this type of calculation, one should not forget about the value of money in time and the real increase in the values considered; this is important when thinking about a life insurance contract for the longer term.
– A policy limit fixed at two million PLN for a child's life insurance or for claims under liability insurance does not constitute an unfounded whim detached from reality.
– Costs relating to pregnancy not included in the calculation will increase the cost of production/willingness to pay, while the costs of trauma treatment—also not taken into account—will create further needs.

Finally, the authors wish to emphasize that a lot of assumptions have been made in this paper. Moreover, due to the scope of the article, not all aspects have been taken into account, and the EU currency has not been used.

The article contains a model for the valuation of the entire loss of the household, but we have to remember that— for example, in tort law, according to the prohibition of enrichment—for the economic part of the loss (rather than the pain and suffering), other sources of finance should also be considered. In life insurance, to reduce premiums and optimize protection, a model of joint protection can be considered, taking into account the probability of the death of individual family members. These perceptions will be discussed in the authors' future work.

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Public or Private? Which Source of Financing Helps to Achieve Higher Health System Efficiency?

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Abstract In this study, we analyze the relationship between health care system's financing and health system's efficiency. We pose the following research hypotheses: (H1) system with higher ratio of public financing should achieve higher efficiency; (H2) public financing increases system efficiency for hospitals and lowers for outpatient care. We find that private financing in stationary care can lead to negative externalities, while private financing in the case of ambulatory care helps to achieve better elasticity and adjustments to the system and patients' needs. In order to prove these assumptions we analyze data for 21 European OECD countries (in the years 2000–2015) which describe population's health status representing life expectancy (LE) and the structure of financing (public versus private spending).

1 Introduction

Expenditure on health continues to grow. In the context of ageing societies, those funds should be spent in the most efficient way so as to bring the best possible health effects. Generally, health benefits may be financed from both public and private sources so health care system efficiency is influenced by adopted funding schemes:

– public—taking form of general government taxes or obligatory social insurance;

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– private—in the form of out-of-pocket payment or private insurance (usually voluntary);

Those two sources of funding (public and private) create specific, sometimes contrary, economic incentives from the point of view of health service providers. Based on that, we can assume that the structure of expenditure may affect the efficiency of the entire health system financing.

The aim of this research is to analyze the financing structure of the health system in terms of the share of public vs. private funds which allow to achieve the highest possible health outcomes. Taking into account the specific nature of the health system functioning, we divide it into 2 subsystems—outpatient health care, including primary health care and outpatient specialist care, and inpatient health care (stationary care).

We pose the following research hypotheses:

(H1) The system with higher ratio of public financing should achieve higher efficiency;

(H2) Public financing increases efficiency of the system for hospitals and lowers for outpatient care.

For the years 2000–2015, we analyze the relationship between health outcomes achieved by the health systems, described by the health status of a population (life expectancy—LE) and the structure of health financing schemes. Data comes from OECD Database and covers 21 European OECD countries. Calculations are supported with GRETL and EViews 10.

It is important that in this study we analyze the volume of public and private expenditure regardless of the mechanisms of financing. Therefore, the public funds can be collected both in the form of taxes (general or earmarked taxes), but also in the form of social health insurance. Despite the public nature of these funding mechanisms they create different incentives for healthcare providers. This nuance, according to the employed methodology, could be captured in this study. For example, social health insurance, comparing to tax financing might increase per capita health spending (Wagstaff 2010) although we can observe strong positive co-movement between those two dominant public financing schemes (Chen and Lin 2016).

2 Literature Review

There is a general consensus that health system should provide equal access to benefits, based on the needs, not on wealth. This is a difficult task—several studies confirm that the poor have greater health needs, while the access to benefits is limited (Johar et al. 2018). Ucieklak-Jeż (2016a, b) shows, that people in Poland, declaring income in the first and second quintile group, rate their health as worse, contrary to other inhabitants. At the same time, the highest health inequality is observed in the social groups with the lowest total equivalent disposable income. Thus, a method of financing the health care system, taking into account the deep consequences for a given society—should promote equal access to benefits. This is in fact the decision of ideological and political nature (Liaropoulos and Goranitis 2015).

At large, all funds involved in the health care system can be divided in two main subgroups: public and private sources. Notwithstanding the variety of the employed solutions, in all European countries we can find some forms of mixed health systems, where private and public sectors interact (Mackintosh et al. 2016; Jeong 2005; Boone 2018; Soltes and Gavurova 2015). These two sources act as connected vessels—the reduction of public financing is to increase out-of-pocket payments or private insurance (Linden and Ray 2017). The proportion of them might potentially afect the overall efficiency of the health system. There is much evidence that private medical services cost more than the same services delivered/financed from public sources. This can be a source of potential inefficiency, while it does not bring important differences in generated results (Morgan et al. 2016; Zelený and Bencko 2015; Wagstaff and Moreno-Serra 2009; Stefko et al. 2018), nor does it bring equity or macroeconomic efficiency allowing the ability to control costs (Chernichovsky et al. 2003; Siedlecki et al. 2018).

In this study, we focus on the analysis of the relationship between the volume and structure of health spending and life expectancy. Foregoing results suggest that this relationship is very low. Babazono and Hillman (1994) found that total health care spending p.c. are not related to health outcomes. This assumption is confirmed by Nixon and Ulmann (2006), who conclude that increases in health care spending are only marginally associated with increase in life expectancy. On the other hand, some studies suggest that healthcare financing structure may have a significant effect on equity of financing, healthcare utilization, and finally, on health status (Leiter and Theurl 2012; Chen and Lin 2016).

While the relationship between the volume of expenditure and health effects is still not confirmed, the proportion of public health expenditure might be significant (Or 2000). Lichtenberg (2002) suggests that public health expenditure has a higher marginal effect on longevity than private health expenditure, but generally results in this field are mixed—Linden and Ray (2017) found that both private and public health expenditures have similar positive effects on life expectancy (Ucieklak-Jeż et al. 2015; Gavurova and Vagasova 2018; Beluca et al. 2017).

On the basis of findings presented in the literature, we hypothesize that the proportion of public/private resources is significant from the point of view of the health state of a population, although we suppose that this effect might be different in the case of outpatient and inpatient care, above all due to a distinct level of information asymmetry. We assume, that it is related to different patterns of behavior—patients are guided mainly by emotions and values, while health care providers think in the context of procedures and protocols (Barile et al. 2014). Also Johar et al. (2018) suggest that outpatient and inpatient care acts differently from the point of view of relationship between wealth and access to health care. Although those findings cannot be directly employed in European countries, as most of the presented studies come from the USA, we can suppose, that inpatient and outpatient subsectors can react diversely for different health financing schemes.

3 Methodology and Results

The research sample covers data for 21 European OECD countries (Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Italy, Latvia, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden) from the years 2000–2015. We estimated two econometric models by employing OLS method, where the dependent variable was life expectancy for a newborn (LE0). The use of life expectancy LE as the variable describing the results achieved by the given health system refers to the best possible state of health of the population. Outcomes should not have a technical dimension, represented by the number of performed medical procedures (ACHMA Workgroup 2003).

Explanatory variables employed in this study include:

– Public financing ratio (PUB_CHE)—public expenditure expressed as a percentage of current health care expenditure (CHE);
– Public financing ratio for inpatient care (PUB_INP)—expressed as a percentage of public spending in overall expenditure for inpatient care;
– Public financing ratio for outpatient care (PUB_OUT)—expressed as a percentage of public spending in overall expenditure for outpatient care;
– GDP (PPPUSD)—country's General Domestic Product expressed in USD (PPP)—as a control variable describing the wealth of a given country;
– CHE (%GDP)—current health expenditure expressed as a percentage of GDP—this is also a control variable which describes the overall level of funds spent on health care;
– Alcohol consumption—expressed in liters of pure alcohol consumed during the year. This control variable characterizes the overall lifestyle of a given country. We assume that if the lifestyle is less favorable, a country needs to consume more funds to achieve the same health effects. Other possible control variables (sugar consumption, daily smokers, physical activity) cannot be implemented due to lack of data for all countries/years;
– Country and year dummies.

The analyzed variables have an abnormal distribution (employed tests: Shapiro-Wilk, Doornik-Hansen, Lilliefors, Jarque-Bera). However, this is not a limitation in the context of the application of the OLS method.

In order to verify the H1 hypothesis, we estimate Model 1:

$$LE = a_0 + a_1 * GDP + a_2 * CHE\_GDP + a_3 * PUB\_CHE + a_4 * ALC \quad (1)$$

During the second part of this study we divided the overall health care spending into two subcategories:

– inpatient care (hospitals);
– outpatient care (ambulatory centres)—this category covers both PC doctors and ambulatory specialists.

According to that, the estimated model takes the form (Model 2):

$$LE = a_0 + a_1 * GDP + a_2 * CHE\_GDP + a_3 * PUB\_INP + a_4 * PUB\_OUT + a_5 * ALC \quad (2)$$

To confirm the usefulness of the estimated model we test the variance. We also verify the hypothesis that the distribution of the residuals of the model is normal. To evaluate the normality of the distribution of residuals, we use the Jarque'-Bera test (Madalla 2006; Kufel 2013). The value of the test statistic is 1,205,607 for Model 1 and 1312 for Model 2 (the cut-off point for the significance level $\alpha = 0.05$ is 5.991).

Our results suggest that the level of health care financing does not influence the health state of a population. We can observe that there is no statistically significant relationship between achieved health outcomes, expressed by LE and:

– the overall level of health care spending (CHE_GDP);
– the ratio of public spending (PUB_CHE);
– the overall level of country's wealth expressed by GDP;
– life style described by the level of alcohol consumption (Table 1).

Those findings do not allow us to adopt the H1 hypothesis—the highest ratio of public spending does not bring a better health status of a population.

Based on the estimated model (Model 2, Table 2) we can observe:

– positive and statistically significant coefficient for the variable PUB_INP, which indicates that a higher share of public expenditure spent on hospital care translates

Table 1 Model 1 (dependent variable = LE)

Variable	Coefficient	Standard error	t-ratio	p-value
Const	85.2852	0.8612	99.03	<0.0001***
PUB_CHE	−0.0074	0.0081	−0.9040	0.3667
Alcohol	−0.0396	0.0280	−1.4110	0.1592
CHE_GDP	−0.0762	0.0479	−1.590	0.1128
GDP_USDPPP	0.000005	0.000007	0.7414	0.4590

Country and time dummies are statistically significant for 90% and 94% cases

Table 2 Model 2 (dependent variable = LE)

Variable	Coefficient	Standard error	t-ratio	p-value
Const	84.3936	1.0235	82.4600	<0.0001***
PUB_INP	2.1544	0.9263	2.3260	0.0207**
PUB_OUT	−2.5937	0.6728	−3.8550	0.0001***
Alcohol	−0.1036	0.0325	−3.1890	0.0016***
CHE_GDP	−0.05556	0.0506	−1.0980	0.2732
GDP_USDPPP	0.0000006	0.000007	0.8509	0.3955

Source: Own study

Country and time dummies are statistically significant for 75% and 94% cases

Table 3 Fitting measures for Model 2

Mean dependent variables	78.96383	S.D. dependent variables	2.937375
Sum of squared residuals	47.62465	S.E. of regression	0.408068
R-squared	0.983172	Adjusted R-squared	0.980700
F(42, 286)	397.8385	P-value (F)	3.2e-229
Log-likelihood	−148.9004	Akaike criterion	383.8009
Schwarz criterion	547.0314	Hannan-Quinn	448.9182

into longer life expectancy (LE), assuming the other variables are at the same level (GDP, CHE, ALC);

- negative and statistically significant coefficient for the variable PUB_OUT indicates that a lower share of public expenditure spent on ambulatory care translates into longer life expectancy (LE), assuming the other variables are at the same level (GDP, CHE, ALC);
- negative and statistically significant coefficient for the variable ALCOHOL suggests that higher alcohol consumption lower the expected length of life—countries characterised by higher alcohol consumption must spend more funds to achieve the same LE.

The share of public funding of hospitals higher by 10 p.p translate into the average life expectancy (LE) longer by 0.2 year. Public financing for outpatient care increased by 10 p.p. decreases the efficiency of the system and, assuming the same spending, decreases LE by 0.26 year. That also means that the increase in the ratio of private funding (by 10 p.p.) prolong LE by 0.26 year. The estimated model is characterised by very high fitting measures (R-squared = 0.983172) (Table 3). *According to that, we are entitled to adopt the H2 hypothesis.*

4 Conclusions and Discussion

We cannot confirm the existence of the relationship between the overall level of health care spending and the expected length of life in our research. In other words, countries which spend more on health care do not improve the state of health of their population. Similarly, a higher share of public expenditure does not allow to achieve better efficiency expressed by the expected length of life. Those findings are consistent with results presented in the literature—higher level of health spending, though it reduces certain health indicators (like infant mortality or premature death), is not significantly linked to longer life (Babazono and Hillman 1994; Or 2000; Nixon and Ulmann 2006). Although Lichtenberg (2002) suggests that public health expenditure has a higher marginal effect on longevity than private health expenditure, we cannot confirm that observation.

A number of the presented studies examine the impact of the volume of the expenditure, or their structure, separately for men and women. The novelty of our research lies in the fact that we analyze the impact of the structure of expenditure, separately for sub-sectors of the health care system.

According to that, we are able to observe that the structure of expenditure has different effects (in fact opposable) on the efficiency of the two analysed subsectors—ambulatory (outpatient) care and stationary (inpatient) care. Our main findings are:

– health systems with higher ratio of public financing in a subsector of ambulatory care achieve lower performance;
– health systems characterized by higher ratio of public funds spent on stationary care achieve improved performance when compared to the systems where the ratio of public financing is lower.

Based on them, we can propose some policy implications—the health system focused on effectiveness should ensure:

– higher elasticity of financing for ambulatory care;
– stable financing for hospitals;

Out-patient care can react much faster to market changes—ambulatory care is, from its nature, much more flexible. Hospital care requires much expenditure on infrastructure. It is characterized by high fixed costs and, for the continuation of the activity, require stable funding. It is also important that the costs of hospital treatment are very high comparing to outpatient care and require redistribution mechanisms.

We plan to use other measures of health system's outcomes in further research. Although the lack of relationship between the level of expenditure and the state of health of a population may seem quite surprising, the relationship between the state of health of a population and access to the healthcare benefits is relatively week (Ucieklak-Jeż et al. 2017). However, for higher age groups, the strength of this relationship increases (Bem and Ucieklak-Jeż 2016; Bem et al. 2016), which suggests that in further research other life expectancies for this age groups should be employed. It is also important to take into account the problem of equal access to benefits for all income groups, which can be reduced when the share of private ratio increases (Krůtilová 2010).

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Innovation System in a Global Context: A Panel Approach

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Abstract Searching for innovative solutions and investing in technology development determine competitiveness and progress of individual organizations and the entire economy. The research and development (R&D) expenditures are catalyst for innovation and therefore determine economic development which can be measured by the value of gross domestic product. The research is driven by a question how Poland is scored in comparison to other countries in this context, while more generally it aims to contribute to theoretical understanding of innovation role in economy development. Referring to the theory of endogenous growth, the research is driven by following questions: What is the relationship between GDP (gross domestic product) and GERD (gross domestic expenditures on research and development), and between VAI (value-added industry) and GERD? Does an increase in investment of GERD determine the growth of GDP and/or VAI? We studied the relations for selected countries with econometric modelling to set Poland in the global context. The panel data came from the World Bank databases. The results of analysis show generally a positive relationship between GDP and GERD, and between VAI and GERD.

1 Introduction

Expenditures on the research and development (R&D), searching for innovative solutions and investing in technology development are prerequisites for ensuring competitiveness and progress of individual organizations, thus serving the development of the entire economy. The development of knowledge and innovation based economy has been a necessity for Poland and other countries of the Central-East Europe (European Innovation 2006; European Commission 2014). The economic development achieved due to innovation is connected with national innovation

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policy. The policy embraces all activities which stimulate the innovative development of business entities through creating appropriate system conditions. It refers to the activities of public authorities at central, regional or local level supporting development, diffusion, and use of innovations. These activities are important factors determining expenditures on research and development.

Referring to the theory of endogenous growth, the research is driven by a question of relation between R&D expenditures and economic development, particularly in Poland. Assuming, that economic development in measured by gross domestic product (GDP), there are following questions to answer: What is the relationship between GDP (gross domestic product) and GERD (gross domestic expenditures on research and development), and between VAI (value-added industry) and GERD? Does an increase in investment of GERD determine the growth of GDP and/or VAI? The area has been explored statistically and econometrically by many researchers, including the European Union (European Innovation 2006) and Organization for the Economic Co-operation and Development (Sutherland et al. 2011; Égert et al. 2009), but there has been no common or agreed approach to innovation system definition and its empirical verification. According to Pisu et al. (2012) the basic approach which can be applied to assess research and development expenditures on economic development is macro-econometric modelling, which estimates the impact of the capital expenditures (GERD) on the growth (GDP) and assumes its growth-maximising level. This study builds on the econometric modelling. The panel data came from the World Bank databases. In a more general context, it aims to contribute to a theoretical understanding of the role of innovation in a contemporary economy.

The following part of the paper presents a literature review. The third section consists of econometric modelling which sets Poland in a global context. The study closes with conclusions.

2 Literature Review

Innovation system includes "all important economic, social, political, organisational, institutional, and other factors that influence the development, diffusion, and use of innovations" (Edquist 2004, p. 182). According to Carlsson et al. (2002), it determines process of creating, disseminating and implementing innovation. The systems perspective allows to understand better that transfer of knowledge depends on market but also non-market factors, and determines economic growth. The relationship between innovation and economic growth led to a number of empirical studies (Uzawa 1965; Romer 1990; Grossman and Helpman 1991; Aghion and Howitt 1992). They are based on the endogenous models of growth and aim to explain the growth determinants such as innovation. This stream of research has intensified in recent years.

For instance, Pessoa (2007) claimed that conducting research on the links between economic growth and R&D expenditures requires awareness as these relationships are not clear. He explained that expenditure on new technology may be incurred in country A, before the technology can be obtained in country B, and finally the products manufactured based on this technology will be the income of country C. This is in line with the theory of technology diffusion (Grossman and Helpman 1991; Barro and Sala-i-Martin 1995). The results of the empirical research ultimately indicated lack of a strong relationship between the economic categories as observed by comparing the economy of Ireland and Sweden. On the other hand, the literature on determinants of economic growth contains a number of quantitative studies which report empirical results of some stylised fact (Teixeira et al. 2014). Firstly, innovative activity measured by R&D expenditure and patenting is closely associated with the output and GDP per capita at the country level (Fagerberg 1987; Fagerberg and Srholec 2008). The second stylised fact is that there is a significant positive correlation between productivity and the industries' expenditures for R&D (Griliches 1987; Nadiri 1993; Gault 2003). Aghion et al. (2010) confirmed the importance of innovation and education in the economic development creation.

Also, Besley et al. (2013) claimed that investment in new ideas (technological and managerial) is a crucial engine of growth. It supports new companies, new products, and processes development but also allows existing firms to incorporate new technologies and reorganise their production processes towards global best practice. The authors state that fostering a supportive environment for investment and innovation is central to having a dynamic and productive economy. Simultaneously, Fagerberg et al. (2004) confirmed cumulative but also controversial social and economic impact of technology and innovation. Fagerberg et al. also supported Archibugi and Coco (2005), stating that it may be difficult to put numbers on the concept of development determinants as socio-economic development means both quantitative and qualitative changes in the society and economy.

Sutherland et al. (2011) and Égert et al. (2009) conclude that infrastructure expenditures (including R&D expenditures) has positive effects which is larger than to be anticipated from a greater overall capital stock. However, additional investments in mature networks often generate lower marginal benefits, which suggests stronger effect on growth at lower provision levels. These expenditures seem to have non-linear effects and the positive effect of infrastructure on growth does not implies that additional expenditures on infrastructure are desirable as additional investment require additional costs. According to Barro (1990) additional public infrastructure investment may decrease growth because the same resources cannot be used in more productive investments (crowding-out effects). Also, maintenance costs and expenditures for new investment are connected with trade-off. Additional investment expenditures might decrease resources for maintenance and operation spending and impact growth negatively (Hulten 1996).

A strong relation between expenditures on R&D, both in the public and private sector, and development, in European Union Member States, was demonstrated by Szopik-Depczyńska et al. (2018). Non-linear and positive relationship between GDP per capita and R&D expenditures has been proved by Lederman and Maloney (2003) and more recently by Hunady et al. (2017). They based their findings on the panel data analysis. Lederman and Maloney (2003) preformed the analysis at the level of countries, while Hunady et al. (2017) considered the region for Visegrad countries.

Based on this literature review, we formulate the hypothesis about a positive relationship between GDP and GERD, and between VAI and GERD and take an approach based on panel data.

3 Global Perspective as GDP-GERD and VAI-GERD Relations

To set Poland's local market in the global perspective, the relations between GDP and GERD and VAI and GERD are analysed. GERD are current and capital gross expenditures on R&D carried out by resident companies, government laboratories, universities, research institutes, etc., in a country. VAI reflects the contribution (value-added) of labour and capital to production by industry. We answer the question of whether the increase of investment of GERD determines the growth of GDP and/or VAI. We have followed methodology applying GDP metrics, as in research cited in the literature review.

The panel data of variables for selected countries used in this study come from the World Bank (http://wdi.worldbank.org/table/5.13). We used gross domestic expenditures on research and development (GERD, in billions of USD), gross domestic product per capita (GDP per capita, USD) and value-added industry per capita (VAI per capita, USD). All variables are in real prices and are stationary around the trend (panel ADF test results are available on request). We estimated models for 36 countries for the period from 2000 to 2014. The analysis includes all countries for which the relevant data were available. Furthermore, there has been added one more dummy variable BREAK. It takes 0 for the pre-crisis period (2000–2009) and 1 for the post-crisis period (2010–2014).

We ran random effect models to verify the relation between GDP and GERD and between VAI and GERD. To verify whether the increase of investment of GERD determines the growth of GDP and/or VAI, two models were estimated separately for each country. First, we estimated the panel model for GDP per capita (ln is the logarithm of the used variables) (1).

$$\ln GDPp_{it} = \alpha + \beta_1 \ln GERD_{it} + \beta_2 BREAK_t + u_{it} \quad (1)$$

Next, we estimated the panel model for VAI per capita (2).

$$\ln VAIp_{it} = \alpha + \beta_1 \ln GERD_{it} + \beta_2 BREAK_t + u_{it} \quad (2)$$

At the end, we estimated simple regression models (1) i (2) for each country (Table 1). We used general least squares (GLS) or ordinary least squares (OLS) as

Table 1 The list of estimated models

Variable	Model GDP per capita	Model VAI per capita
Constant	−5.153* (0.284)	−7.645* (0.194)
GERD	0.200* (0.025)	0.395* (0.019)
BREAK	−0.069* (0.013)	−0.066* (0.010)
Observations	15	15
Countries	36	36
Hausman test	17.631*	30.186*

*Significant at the 0.05 level, (.) In brackets standard errors (s.e.) of estimated coefficient

the estimation method[1]. VAI and GERD models for 36 countries between 2000 and 2014 were estimated. The beta coefficient is estimated for each country separately and its values are different, which means that the value of the coefficient "depends" on the country. Some of the beta coefficients are similar and on the basis of this similarity, countries with a similar beta value were divided into groups of countries with a similar degree of dependence between the analysed variables.

The R2 value and Durbin Watson statistics (DW) were analysed to consider spurious correlation which occurs when R2 is close to 1 and DW is close to 0. For our models, the value of DW statistic was close to level 2 which indicates that the phenomenon of spurious regression should not appear in the models.

Table 1 presents the random-effects models (1) and (2) with estimated results for both dependent variables; that is, GDP per capita and VAI per capita. The results of the analysis confirm the significant positive relation.

A Hausman test statistic for both models shows that the random effects estimator is consistent, implying that there is no correlation between the included variables and the error term, and therefore the random-effects estimator is a better choice than the fixed-effects estimators.

In the case of model (1), the estimated coefficient is 0.2 (s.e. 0.025) and it is significant at the 5% level. It means that an increase in GERD causes an increase in the GDP per capita. For the model (2), the estimated coefficient is 0.395 (s.e. 0.019) and it is also significant. So an increase in GERD causes an increase in the VAI per capita. The estimated coefficient for the dummy variable is negative and significant for both models. It means that the real level of the GDP per capita and VAI per capita were lower during post-crises period than in the pre-crisis period. Figure 1 presents countries' classification by the estimation results for the countries for those countries with significant relationship between GERD and growth of GDP per capita during the period 2000–2014 (Appendix, Table 2). The countries on the left from

[1]Generalized least squares (GLS) was used for estimating the unknown parameters in both models when there was observed a certain degree of correlation between the residuals in a regression model, as in these cases, ordinary least squares (OLS) can be statistically inefficient, or even give misleading inferences.

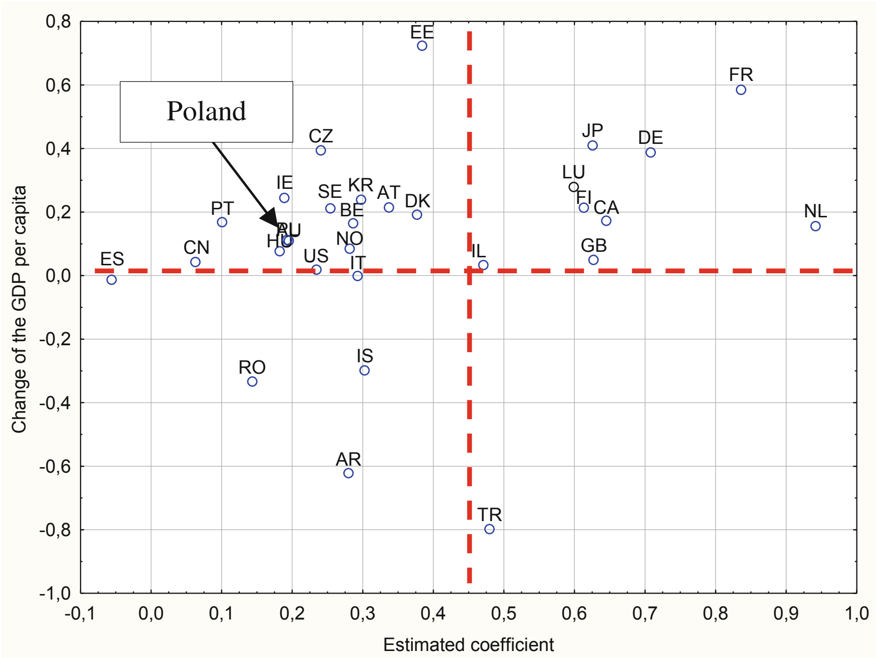

Fig. 1 Countries classification by growth of GDP per capita (2000–2014) and by estimated coefficient β_1 for simple version of model (1)

approximately 0.45 on the horizontal axis, which is the difference between min and max β_1, are considered to have a weak dependence, those from 0.45 are classified as strong. We can therefore distinguish four groups of countries: the growth of GDP per capita and a strong relationship between GERD and GDP (upper right corner), the growth of GDP per capita and moderate relationship (upper left corner), the decline in GDP per capita and a rather weak relationship (bottom left) and the decline in GDP per capita and a rather strong relationship (bottom left).

Figure 2 presents countries' classification by the estimation results for those countries with a significant relationship between GERD and growth of VAI per capita during the period 2000–2014 (Appendix, Table 3). In this case, we can divide the countries into three groups based on the strength of the relationship. Countries below 0.3 on the horizontal axis are considered to have a weak dependence, those from 0.3 to 0.6 are classed as moderate, and those above 0.6 are viewed as strong. The only outlier on the figure is China (CN).

Globally, the estimation results show positive relationship between GDP and GERD, and between VAI and GERD. An increase of GERD causes an increase in the GDP per capita, and also an increase in the VAI per capita. We can also conclude that both variables were lower during post-crises period than in the pre-crisis period. There are some countries where the relationship is not significant. In the GDP per capita model, these countries are: Greece, Mexico, Slovenia, Singapore, the Slovak

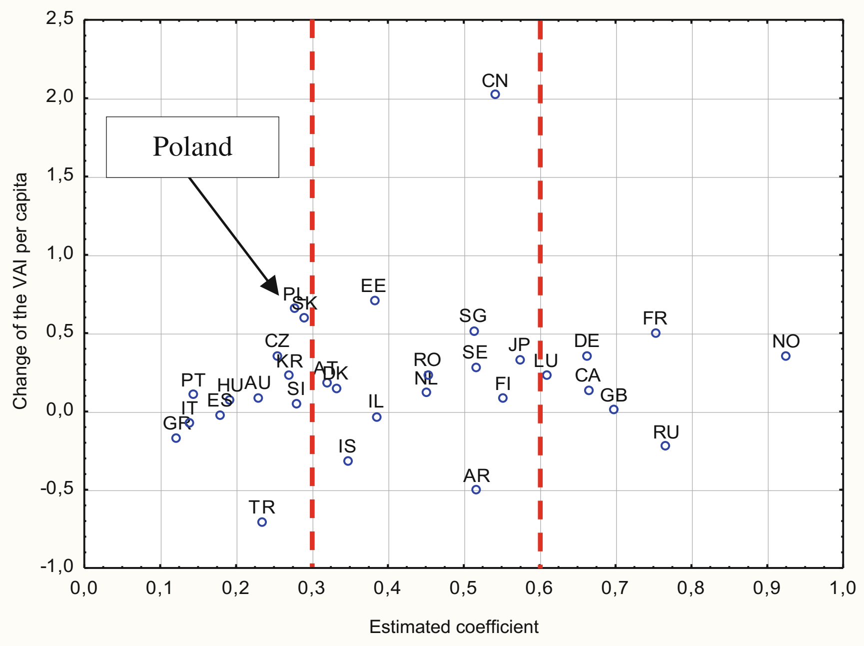

Fig. 2 Countries classification by growth of VAI per capita (2000–2014) and by estimated coefficient β_1 for simple version of model (2)

Republic, and Russia. For the VAI per capita model, these countries are: Belgium, Greece, Ireland, Mexico, and the United States. According to the value of the estimated coefficient, remaining countries can be divided into three groups by their sensitivity to changes in GDP or VAI: weak, moderate and strong. Poland was in the largest group of countries with moderate sensitivity and simultaneous growth of GDP per capita. For the second classification, although Poland was in the group of countries with weak dependence, we observe the highest level of VAI growth relating this group.

4 Conclusion

Globally, the estimation results confirm that there is a positive relationship between GDP and GERD, and between VAI and GERD. An increase of GERD causes an increase in the GDP per capita, and also an increase in the VAI per capita. It can also be concluded that both variables (GDP per capita and VAI per capita) were lower during post-crises period than in the pre-crisis period. Locally, the GDP-GERD and VAI-GEDR relationships for Poland are weak. However, level of VAI growth is the highest. There are Slovakia, the Czech Republic, Slovenia, but also Spain, Australia and South Korea in the same group although with lower VAI change.

In the case of Poland, it can therefore be concluded that the level of R&D expenditures bring the expected effect in the form of economic growth measured by changes of the GDP. At the same time, being aware of the fact that the share of expenditure on R&D in Poland is far below the average of EU countries, a postulate demanding a significant increase of these expenditures can be formulated. Expenditures on R&D should be implemented not only in the public sector but also in the private sector. This would enable Poland to approach the path of constant innovation growth, increase productivity per capita and improve the competitiveness of economy.

The main research limitation results from the length of the series for which the comparable data was available. Available observations determine the number of degrees of freedom necessary to estimate the model correctly. There are also factors which affect the GBP-GERD and VAI-GERD relationships which could not be included in the econometric model. The presented research does not consider types of GERD relating different types of R&D entities in particular, or types of VAI relating different effects. There are characteristics of industry, the type of economy (more/less developed) and national culture (Jang et al. 2016) which also play a role. Attaching subsequent variables decreases the number of degrees of freedom of the model and to avoid this problem the model has such a simple form. The model will be the subject of further analyses along with the extension of number of available data and the inclusion of subsequent explanatory variables, potential development drivers, both exogenous and control ones. The estimation method will be also adjusted to future research results and therefore robust estimation methods might replace classical estimation methods. However, at this stage of research, the application of relatively not complicated econometric model gives certain advantages. The simplification, which meets methodological and scientific standards, allows better understanding of complex relations and determinant referring GDP, GERD and VAI. Secondly, the modelling does not consider social impact as the added-value might be expressed as spill-over effects (external effects) related to science and society (Wojewnik-Filipkowska and Kowalski 2015). That is also a subject of another future research which might be helpful for explanation of Poland's score in the analysis conducted within this research. Regardless of future research, the fact is that the development of innovation system in Poland has been observed for about a decade which might be too short to observe the impact of the related expenditures on the growth.

Apart from the above findings and with respect to identified research limitations, the research generally contributes to the theoretical understanding of role of innovation (here represented by GERD) and may inspire public policy, proving that supporting and financing R&D infrastructure is an important component of system influencing local and national economic growth.

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Appendix

Table 2 Estimation results for the simple regression (1)

Country	α	β1	β2	R2	F	DW	DH	BP
Argentina^{GLS} (AR)	−6.886*	0.280*	−0.009	0.978	3.993*	1.669	7.359	5.015
Australia^{OLS} (AU)	−5.333*	0.195*	−0.014	0.889	48.261*	2.481	0.538	2.004
Austria^{OLS} (AT)	−6.375*	0.337*	−0.017	0.963	157.894*	1.909	0.224	0.281
Belgium^{GLS} (BE)	−5.993*	0.286*	−0.016	0.738	16.910*	2.169	0.913	1.182
Canada^{OLS} (CA)	−9.838*	0.645*	0.043**	0.818	26.972*	1.069	5.713	1.297
China^{OLS} (CN)	−7.337*	0.063*	−0.084*	0.500	5.997*	1.579	0.073	2.421
Czech^{GLS} (CZ)	−5.769*	0.241*	−0.032	0.945	6.136*	1.499	2.945	0.460
Denmark^{OLS} (DK)	−6.614*	0.377*	−0.017	0.866	38.610*	1.348	3.100	7.300
Estonia^{OLS} (ES)	−6.305*	0.384*	−0.134*	0.857	35.891*	1.044	0.493	2.228
Finland^{OLS} (FI)	−8.765*	0.613*	0.001	0.916	65.336*	0.751	0.051	2.345
France^{OLS} (FR)	−12.369*	0.836*	−0.063*	0.965	166.376*	1.899	3.283	3.641
Germany^{OLS} (DE)	−11.298*	0.708*	−0.035	0.972	206.351*	1.610	1.999	5.672
Greece^{GLS} (GR)	−4.471*	0.092	−0.149*	0.844	8.224*	2.148	0.754	2.691
Hungary^{OLS} (HU)	−5.651*	0.182*	−0.075*	0.507	6.166*	1.869	2.843	1.289
Iceland^{GLS} (IL)	−5.282*	0.303**	−0.071	0.928	6.219*	1.803	6.029	7.088
Ireland^{GLS} (IR)	−4.822*	0.189*	−0.006	0.599	8.966*	1.480	0.038	6.053
Israel^{GLS} (IS)	−5.711*	0.462*	0.003	0.443	4.767*	2.579	2.485	2.945
Italy^{OLS} (IT)	6.461*	0.293*	0.054*	0.567	7.862*	1.404	6.029	0.625
Japan^{OLS} (JP)	10.845*	0.626*	0.038*	0.991	692.99*	1.704	5.924	4.468
Korea^{OLS} (KR)	−6.920*	0.298*	−0.067*	0.911	61.286*	1.856	0.080	0.404
Luxembourg^{OLS} (LU)	−6.475*	0.599*	0.080*	0.899	53.567*	1.086	3.004	0.747
Mexico^{OLS} (MX)	−5.360*	0.088	−0.017	0.077	0.498	1.073	3.567	1.380

(continued)

Table 2 (continued)

Country	α	β1	β2	R2	F	DW	DH	BP
Netherlands^{GLS} (NL)	−12.028*	0.942*	−0.099*	0.743	17.329*	1.250	4.590	3.892
Norway^{OLS} (NO)	−3.650*	0.282*	−0.058*	0.710	14.699*	1.494	1.497	6.133
Poland^{OLS} (PL)	−5.029*	0.193*	−0.098**	0.403	4.055*	1.039	0.991	2.361
Portugal^{OLS} (PT)	−2.952*	0.101*	0.041*	0.866	38.702*	0.718	0.462	2.104
Romania^{GLS} (RO)	−4.008*	0.144*	0.009	0.941	5.582*	1.349	0.775	4.917
Russia^{OLS} (RU)	0.063	−0.539	−0.502*	0.608	9.299*	0.626	2.118	3.029
Singapore^{OLS} (SG)	−1.279*	0.051	−0.171*	0.694	13.632*	1.439	0.466	1.911
SlovakRepublic^{GLS} (SK)	−1.801*	0.030	0.007	0.285	0.756	1.800	0.345	2.192
Slovenia^{GLS} (SI)	−1.021*	0.067	−0.002	0.406	1.598	1.423	3.617	3.354
Spain^{OLS} (ES)	−3.014*	−0.056*	0.003	0.388	3.801**	1.395	0.668	4.724
Sweden^{GLS} (SE)	−4.172*	0.254**	0.031	0.917	2.844	1.469	1.906	2.749
Turkey^{GLS} (TR)	−10.016*	0.480*	0.030	0.985	26.259*	2.113	1.264	8.328
United Kingdom^{OLS} (GB)	−10.191*	0.627*	−0.001	0.759	18.923*	1.605	1.221	3.824
United States^{GLS} (US)	−8.253*	0.235*	−0.020	0.717	15.181*	1.945	6.874	12.143

GLS or *OLS* Generalized or Ordinary Least Squares estimation, *R2* determination coefficient, *F* joint test statistics, *DW* Durbin-Watson statistics, *DH* -, *BP* Breush-Pagan statistics

*Significant at the 0.05 level, **Significant at the 0.1 level

Table 3 Estimation results for the simple regression (2)

Country	α	β1	β2	R2	F	DW	DH	BP
Argentina^{GLS} (AR)	−5.127*	0.517*	0.017	0.945	14.578*	1.522	2.864	2.442
Australia^{OLS} (AU)	−6.049*	0.229*	−0.029**	0.869	39.639*	2.114	4.879	2.110
Austria^{OLS} (AT)	−6.635	0.319*	−0.027	0.928	77.523*	1.742	0.046	1.522
Belgium^{GLS} (BE)	−4.481*	0.061	0.022	0.844	2.220	1.993	1.640	0.988
Canada^{OLS}(CA)	−10.447*	0.664*	0.020	0.682	12.841*	1.267	3.141	0.101
China^{GLS} (CN)	−11.669*	0.541*	0.009	0.996	285.726*	1.496	2.264	2.163
Czech^{GLS} (CZ)	−6.246*	0.254*	−0.036	0.898	4.936*	1.518	1.068	3.233
Denmark^{OLS} (DK)	−6.773*	0.331*	−0.025	0.734	16.588*	1.520	2.873	11.358
Estonia^{OLS} (ES)	−6.693*	0.382*	−0.149**	0.799	23.817**	1.059	1.170	2.366
Finland^{OLS} (FI)	−8.722*	0.552*	−0.066*	0.827	28.780*	1.683	10.752	13.671
France^{OLS} (FR)	−12.005*	0.752*	−0.074*	0.943	98.715*	2.160	6.466	2.432
Germany^{OLS}(DE)	−11.243*	0.663*	−0.036	0.942	98.083*	1.599	5.786	10.141
Greece^{OLS} (GR)	−5.196*	0.122	−0.294*	0.877	42.699*	1.764	1.789	3.034
Hungary^{OLS}(HU)	−6.176*	0.192*	−0.090*	0.477	5.475*	1.919	2.929	3.941
Iceland^{GLS} (IL)	−5.992*	0.347**	−0.066	0.921	10.480*	2.232	1.709	4.116
Ireland^{GLS} (IR)	−4.177*	0.052	0.066	0.639	2.789	1.659	4.729	6.857
Israel^{GLS} (IS)	−7.667*	0.385*	−0.022	0.821	17.744*	2.101	2.335	5.158
Italy^{OLS} (IT)	5.419*	0.140	0.070*	0.427	4.463*	1.451	3.501	0.144
Japan^{OLS} (JP)	10.637*	0.574*	0.015	0.979	279.860*	1.924	0.561	0.597
Korea^{OLS} (KR)	−7.024*	0.271*	−0.045**	0.910	60.462*	1.925	0.043	0.670
Luxembourg^{OLS} (LU)	−6.908*	0.608*	0.074*	0.872	41.006*	1.167	0.795	0.682
Mexico^{OLS} (MX)	−5.937*	0.120	−0.020	0.087	0.575	1.081	3.367	1.212
Netherlands^{GLS} (NL)	−7.948*	0.451**	−0.014	0.853	2.202	1.159	0.513	2.124
Norway^{OLS} (NO)	−11.022*	0.925*	−0.110**	0.858	36.247*	1.571	1.154	3.885
Poland^{GLS} (PL)	−6.691*	0.278*	−0.014	0.984	4.919*	1.720	1.627	0.120

(continued)

Table 3 (continued)

Country	α	β1	β2	R2	F	DW	DH	BP
Portugal^{OLS} (PT)	−5.552*	0.145*	−0.022**	0.917	66.406*	1.350	0.534	0.414
Romania^{GLS} (RO)	−8.337*	0.452*	0.105*	0.865	21.726*	1.590	3.487	1.380
Russia^{OLS} (RU)	−12.479*	0.767*	−0.028	0.454	4.994	1.458	2.319	2.117
Singapore^{OLS} (SG)	−7.520*	0.513*	−0.001	0.901	54.525*	1.331	0.265	3.711
Slovak Republic^{GLS} (SK)	−6.242*	0.291**	−0.056	0.930	2.262	1.318	0.182	4.164
Slovenia^{OLS} (SI)	−6.164*	0.280*	−0.166*	0.429	4.512*	1.689	0.322	4.305
Spain^{OLS} (ES)	−5.786*	0.179*	−0.129*	0.890	48.365*	1.802	0.621	0.878
Sweden^{GLS} (SE)	−8.647*	0.516*	0.067**	0.894	5.018*	1.857	3.979	2.707
Turkey^{GLS} (TR)	−7.828*	0.234**	−0.061	0.894	2.090	1.642	1.123	10.262
United Kingdom^{OLS} (UK)	−11.144*	0.698*	−0.098*	0.885	46.031*	1.266	4.478	4.378
United States^{OLS} (UK)	−5.739*	0.161	−0.028	0.127	0.871	0.856	0.994	5.805

GLS or *OLS* Generalized or Ordinary Least Squares estimation, *R2* determination coefficient, *F* joint test statistics, *DW* Durbin-Watson statistics, *DH* -, *BP* Breush-Pagan statistics

*Significant at the 0.05 level, **Significant at the 0.1 level

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