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Contemporary Trends and Challenges in Finance

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Contemporary Trends and Challenges in Finance

Proceedings from the 2nd Wroclaw International Conference in Finance

Springer

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ISSN 2198-7246 ISSN 2198-7254 (electronic)
Springer Proceedings in Business and Economics
ISBN 978-3-319-54884-5 ISBN 978-3-319-54885-2 (eBook)
DOI 10.1007/978-3-319-54885-2

Library of Congress Control Number: 2017939566

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

This volume presents papers from the 2nd Wrocław International Conference in Finance held at Wrocław University of Economics on September 27–28, 2016. 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 28 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 have been organized along the major fields and themes in finance, i.e. the econometrics of financial markets, stock market investments, macrofinance, banks and other financial institutions, public finance, corporate finance and household finance.

The part on the econometrics of financial markets contains seven papers. The paper by Ewa Dziwok investigates some liquidity measures using data from the Polish market. The paper by Agata Kliber analyses the impact of sovereign CDS on other instruments in financial markets. The paper by Paweł Kliber examines the factors influencing overnight interest rates on the Polish interbank market. Blanka Łęt studies in her paper whether the listings of natural gas prices in different derivative markets are linked. Paweł Miłobędzki examines whether the US dollar, the pound sterling, the Swiss franc and the Japanese yen are hedges or safe havens for Polish stocks and bonds. Marta Chylińska and Paweł Miłobędzki provide an application of a VEC DCC-MGARCH model for copper futures. The paper by Piotr Płuciennik and Magdalena Szyszko presents an analysis of the dependences between inflation expectations extracted from inflation-linked swaps and the exchange rate, oil prices and the interbank rate.

The part on stock market investments contains four papers. The paper by Agata Gluzicka applies the risk parity idea to the portfolios of stocks on the Warsaw Stock Exchange. Sabina Nowak in her paper uses modified versions of models by Fama and French to include order imbalance factors. The paper by Joanna Olbryś studies the interaction between market depth and market tightness on the Warsaw Stock Exchange. In their paper Paulina Roszkowska and Łukasz Langer investigate mispricing in equity markets by studying abnormal excess returns determined by classical and modern asset pricing models.

The part on macrofinance contains five papers. The paper by Małgorzata Iwanicz-Drozdowska and Paweł Smaga presents an analysis of factors influencing the development of financial systems in 40 countries. The paper by Marta Karaś and Witold Szczepaniak discusses an alternative method for calculating the CoVaR of the banking system. In their paper Darko Lazarov, Tanja Lakovic and Emilija Miteva-Kacarski investigate the influence of the quality of financial information on the development of stock markets in 38 countries. The paper by Magdalena Ligus and Piotr Peternek examines the preferences of home buyers in relation to urban environmental attributes. Małgorzata Olszak and Iwona Kowalska study the effect of macroprudential policies and microprudential regulations on the sensitivity of leverage and liquidity-funding risks to the business cycle.

The part on banks and other financial institutions contains five papers. The paper by Beata Lubinska presents a model of the optimization used for management of banking books. Marta Małecka investigates VaR model testing for no-failure cases. The paper by Helmut Pernsteiner and Jerzy Węcławski contains an analysis of relationship banking in Poland. Alicja Wolny-Dominiak analyses the prediction of total loss reserves in non-life insurance company by using a generalized linear model. In their paper Ewa Wycinka and Tomasz Jurkiewicz investigate the use of a mixture cure model for a sample of consumer credit accounts of a Polish financial institution.

The part on public finances contains three papers. Elena Querci and Patrizia Gazzola present an analysis of a model of health care providing low costs and high value. The paper by Petra Jánošíková and Radka MacGregor Pelikánová analyses the real estate transfer tax in different EU countries. The paper by Tomasz Skica, Jacek Rodzinka and Rusłan Harasym contains an analysis of the impact of the financial policy of local government units on the development of entrepreneurship.

The part on corporate finance contains two papers. Julia Koralun-Bereźnicka examines how the capital structure of companies in 13 EU countries depends on the firm size and debt maturity. The paper by Elżbieta Rychłowska-Musiał describes investment decision rules using real options theory.

The part on household finance contains two papers. Katarzyna Kochaniak analyses the risk profiles of household financial asset portfolios and their determinants in 15 euro area countries. The paper by Beata Lewicka contains the analysis of factors which have a significant impact on having a consumer credit or a mortgage loan among people over the age of 50.

We wish to thank the authors for making their studies available for our volume; their collegial, professional 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 markets, institutions and business organizations, we recognize that there are myriad issues that still need to be researched. We hope that the studies included in our volume will encourage further research and analyses in the interesting field of modern finance.

Wrocław, Poland — Krzysztof Jajuga
Fairfield, CO — Lucjan T. Orlowski
Tallinn, Estonia — Karsten Staehr
December 23, 2016

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Part I
Econometrics of Financial Markets

Chosen Measures for Pricing of Liquidity

Ewa Dziwok

Abstract The financial crisis of 2007–2009 showed that especially liquidity risk was underestimated or was not taken seriously into account. The existing liquidity measures proved to be inadequate or incorrectly used. This is why the alternative measures should be considered. The aim of the article is to examine the specific measures of liquidity using a sample of daily data. The particular attention will be paid to the yield curve fitting error, precisely to root mean squared error. The analysis covers the time series of errors calculated from daily WIBOR data and yield curve construction using two types of parametric models—Nelson-Siegel and Svensson one. By employing chosen liquidity measures into Polish financial market one can confirm their effectiveness in case of market disturbances.

1 Introduction

The financial crisis of the years 2007–2009 showed many shortcomings among which one of the most important was an underestimation or even omission of liquidity on specific level of its existence. Even more, recent crisis showed that its character was strictly multi-dimensional, that is why the approach to this case should be multi-dimensional as well.

A motivation for this study was caused by well-known problems with liquidity risk on international, macro, global level that comes from lack of mechanisms which coordinates national approaches, greater complexity in the international context as well as scarcity of data on international level.

From the micro-perspective the liquidity risk is the key problem to keep the enterprise healthy. The existing regulations, especially in banking system, have influenced their profitability and have changed their model of investments. An existing literature shows several examples of alternative measures of market liquidity. Duffie and Singleton (1997) showed that changes in swap spreads are related to changes in counterparty and liquidity risk, Flood et al. (2015) showed the behavior

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_1

of liquidity measures for equity, corporate bond, and futures markets, van der Merwe (2015) describes measures of market liquidity.

The goal of this research is to investigate a range of liquidity measures with special attention to alternative ones. The main focus is put on the yield curve fitting error, precisely on root mean squared error. By calculation and analysis of the time series that consist of errors calculated from daily WIBOR data it could be found that there is strong inter-relation between turmoil in the market and level of the error. The result was confirmed by two different models used for a yield curve construction: Nelson-Siegel and Svensson one.

2 Liquidity and Liquidity Risk

The problem with liquidity takes place when there is a difficulty to fulfill all payment obligations at time when they mature, to their full amount and in the appropriate currency.

This short description shows that liquidity is a specific attribute of the institution—if the institution has enough liquidity, it could be definitely seen as one of its strengths (in a SWOT analysis of the institution). The characteristic aspect of liquidity is that is must be available all the time—regardless of the situation on the market and even in crisis situations where the probability of their occurrence is very small.

Economic theory offers at least two different concepts of liquidity (ECB 2007). One of them is called monetary liquidity and it relates to the quantity of liquid assets in the economy, which is related to the level of interest rates. A second concept is market liquidity, which is generally seen as a measure of the ability of market participants to undertake transactions without an influence on the prices. These two concepts are quite different and although there is a relationships between them, they are usually separately evaluated.

Some sources distinguish three types of liquidity (Nikolaou 2009): funding liquidity connected with cash management framework, market liquidity associated with asset-pricing models and central bank liquidity related to monetary policy context. All these types are strongly linked to each other by bilateral influence and inter-reactions. Sometimes additional, broader—in its meaning—type of liquidity is mentioned (Chorofas 1998)—macroeconomic liquidity which could be considered as surplus to the needs of the real economy and can influence market behaviour.

Following the Basel Committee of Banking Supervision (Committee of European Banking Supervisors 2009), funding liquidity is “the ability to fund increases in assets and meet obligations as they come due, without incurring unacceptable losses”. It could be understood as a flow concept where liabilities can be simply financed through different sources and at an acceptable and reasonable price. In other words, the institution is liquid while its inflows exceed the outflows. The risk that is connected with the funding liquidity appears in the situation when the institution could not fulfill its obligations without a delay.

Sometimes the sources of the risk is endogenous in nature and comes directly from the institution (moral hazard, fraud etc.), sometimes is exogenous and depends on the market situation.

Market liquidity, called sometimes as trading liquidity, is the ability to trade quickly at a low cost without large changes in their prices (O'Hara 1995) and—in its nature—is highly connected with funding liquidity. The main characteristics of liquid (healthy) market are: narrow bid-ask spreads, low transaction costs and lack of influence of large volumes of transactions (or large number of transactions) on prices. Market liquidity could be divided into several subclasses concerning asset type as well as subsets of whole financial markets (focus on the country, currency etc.). The market liquidity risk arises while there are problems to achieve a fair price of the asset immediately.

Central bank liquidity means the ability of the central bank to provide the required liquidity to the financial system. As a liquidity provider the central bank uses its tools to steer the liquidity on the desired level. Among popular tools are direct ones: open market operations (OMO), reserve requirements, and those which have an indirect influence on money in the economy—the short term interest rate (s) (target rate), credit requirements, taxes etc. The central bank liquidity risk appears on the counterparty level as a consequence of inappropriate monetary policy or unexpected turmoil.

Last type of liquidity is a macroeconomic one and is connected with a whole financial system. The risk is called the systemic liquidity risk and is usually associated with a global financial crisis and effect of contagion. Before that type of risk is measured, there is a need to answer the questions: how to measure a liquidity risk globally, whether is possible a feasibility of international regulations and which regulations are universal and which ones should be set individually for different countries.

3 Liquidity Measures

The problem how to measure liquidity has emerged together with financial market operations. The bank managers were obliged to keep money for the expenses and tried to calculate appropriate amount to cover the needs of depositors as well as the other counterparties. On the other hand supervisors started to control the system as a whole quite early to omit or at least reduce the risk of contagion.

Considering the funding liquidity the risk is measured at the institution level and in case of bank the most popular is gap analysis, building term structure of expected cash flows and term structure of expected cumulated cash flows as well as fund transfer pricing policy (Castagna and Fede 2013).

Market liquidity could be measured by (Fleming 2003):

- bid-ask spread: calculated as the difference between the bid and ask price to show how much a trader can lose by selling an asset and buying it back right away. The spread usually increases at time of uncertainty.
- market depth: how trading volume is changing during time, trading frequency, Market depth measures the amount that can be traded at a given moment in time as indicated by the trading book
- price impact market resiliency: how many units traders can sell or buy at the current bid or ask price without moving the price

Central bank liquidity risk is usually measured by evaluating the liquidity delivered to the economy by the central bank, in form of e.g. open market operations.

At the supervisory level liquidity is measured by the enterprise (e.g. bank) and monitored by the supervisor (central bank). Basel regulations proposed two standards for liquidity risk: liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR); the indicators that allow to measure and monitor the short-term and long-term liquidity.

Apart from the well-known and often used measures there are also some other studies showing alternative liquidity measures. The research of Fleming (2000) described the yield curve fitting errors as a measure of market illiquidity. It could be implemented through noticeable influence of turbulent market on yields that are modeled with a yield curve. Yield curve fitting errors show a possibility for an alternative income especially for speculators and arbitrageurs.

4 Chosen Liquidity Measures and Application into Polish Market

The research shows the deviation between market yields and those implied by the estimated term structure of interest rates. For a given day the difference between the quoted yield of an asset and the yield implied by term structure model has been calculated. The aim is to show how these deviations are affected by liquidity considerations, especially in turmoil time when shortage of quotations, wider spread and reduced demand can influence the prices.

For the research purposes two models from parametric group of models are taken into account: first one based on four parameters (Nelson and Siegel 1987), and the second one developed by Svensson and based on six parameters (Svensson 1994). The choice of parametric models was provoked by their role in monetary policy of central banks (BIS 2005). These two vectors of parameters have been calculated day by day since 2005 by minimizing mean square errors between market and theoretical yields:

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

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

k—number of assets

The data come from Polish money market, and include WIBOR (money market fixing quotations), for maturities from one day to one year (T/N-tomorrow next, 1W-one week, 2W-two weeks, 1M-one month, 3M-three months, 6M-six months, 9M-nine months, 1Y-one year), taken daily between 2005 and 2012 when the biggest volatility could be observed.

The comparison of two types of parametric models covers calculation of the mean and standard deviation over a number of days. A low mean value confirms the flexibility of each model and demonstrates its ability to fit precisely into the data. The standard deviation level enables the assessment of the reliability of the entire sample.

In the considering case the RMSE was calculated for Nelson-Siegel and Svensson parametric model. To achieve the results two macros were written in VBA code which helped to receive two panel results in form of daily vectors of parameters (a four-parameter vector for the Nelson-Siegel model and six-parameter vector for the Svensson one). Additionally, two vectors of RMSE were calculated (a goodness of fit statistics is presented in Table 1).

It is easy to notice that the mean of average price errors is very small, although the Svensson model shows a slightly better result than the Nelson-Siegel one (that appears to be less flexible). The results of RMSE statistics show that Svensson model produces lower mean value of RMSE as well as lower standard deviation.

The plots of errors for chosen methods let analyze their sensitivity to disturbances in the market (Fig. 1). From the beginning of financial crisis the volatility of financial instruments' rates had become very high which caused problems with fitting the data. As a chart shows, the most resistant to the market disturbances (starting in autumn 2008) turned out to be the Nelson-Siegel model.

The chosen measure confirms that there is a strong inter-relation between turmoil in the market and level of the error. Together with the beginning of market turmoil (IX.2007–III.2008) the difference between market and theoretical yields started to increase. The highest level of the error was noticed during last days of November and in the beginning of December 2007 regardless of the chosen model.

Table 1 Goodness of fit statistics

Model	Nelson Siegel	Svensson
Observations	1957	1957
Mean	0.00047	0.00032
Standard Deviation	0.00096	0.00061

Source: Own calculations

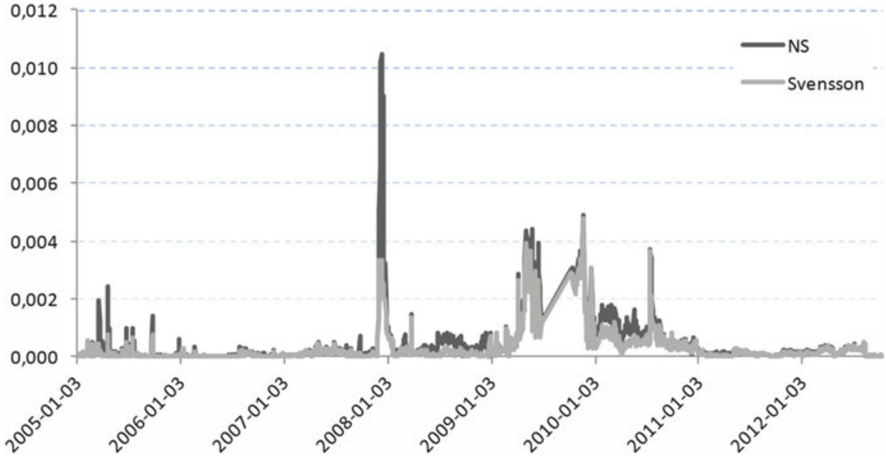

Fig. 1 RMSE errors for the different types of model fitting technique. Source: Data from www.reuters.pl, own calculations

High variability could be also observed in a whole year 2009—despite the fact that the error was not very high, we have seen an increased volatility due to lack of liquidity.

5 Summary

Two different models were applied here (based on Nelson-Siegel and Svensson research) to show the root mean squared error as a market liquidity measure. The presented summary statistics (represented through a low value for the mean and the standard deviation) let assume that both methods are suitable to analyze liquidity. The chosen measure—the root mean squared error proved to be sensitive to market turmoil when its level significantly increased (as it was expected).

The most important conclusion from this study is that the goodness of fit criteria vary over time and that it can be an interesting alternative to other measures. Comparing to Basel III liquidity criteria, both measures (LCR, NSFR) are based on the asset-liability situation in banking sector that are published with time-lag (for preparation, calculation and delivering of data). In case of proposed measure, a current situation in the interbank market could be presented almost at once. In that sense the proposed measures could be treated as an alternative indicator of market liquidity. Additionally, Polish market as an emerging one, is sufficiently sensitive to new information, to implement here alternative measures of market liquidity.

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Not as Black as Is Painted? Influence of sCDS Market on Domestic Financial Markets Before and After the Ban on Naked sCDS Trade

Agata Kliber

Abstract In the article we analyze the impact of sovereign CDS on other financial market within a country and verify whether the impact changed after imposing the ban on trade of the non-covered sCDS in Europe (November 2012). We analyze European sCDS of both emerging as well as developed economies, who retained their own currencies, i.e. Poland, Hungary (emerging markets) and Sweden and United Kingdom (developed ones), over the period 2008–2013. We investigate the degree of influence between the sCDS and foreign exchange market, sCDS and sovereign bond, as well as sCDS and stock exchange ones. The results vary depending on the analyzed country, indicating clearly that the Central European markets are much prone to sunspots and volatility transmission than the Western ones. However, in general the results support the hypothesis that the impact of the CDS on the other financial markets diminished after November 2012.

1 Introduction

One of the most common indicators of a country's solvency risk is sovereign CDS spread. The construction of the instruments is as follows. The buyer of the CDS protects himself against the insolvency of his debtor entering the sCDS contract. He pays the seller a pre-specified amount, so called: premium or spread, expressed in basis points. In the case of the credit event (e.g. delay in payment, decline to pay, etc.), the seller of the CDS pays the buyer the amount pre-specified in the contract.

The underlying instrument of sovereign CDS is the government bond. Primarily, the buyer of the sCDS was not obliged to possess the bond. Thus, the instruments could have been used to simply speculate on government default. During the Greek crisis such speculators were blamed for raising the cost of the issuers of government debts (including Greek debt itself)—see also Augustin (2014). Therefore, the legislators in European Parliament and the Council of the European Union issued

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_2

a new Regulation, which came into force on 1 November 2012. According to this Regulation (EU No 236/2012) it is forbidden to enter short position in uncovered sovereign debt through the CDS contract in European Union (ISDA 2014).

This decision has been widely criticized by the market analysts and investors, because of its negative impact on the market liquidity (ISDA 2014). In the case of Western Europe, the volume traded fell even by 50%, while in the case of the Central one—by 40%. At the same time, market participants started to utilize another indices, e.g. iTraxx Europe Senior Financials.

The aim of our research was to verify whether imposing the new regulation could have any significant impact on the interrelations between the sCDS market with other financial markets within the same country. We analyzed four different markets: Sweden and the United Kingdom (safe and developed), Hungary (risky and developing), as well as Poland (still developing but less risky). The main criterion of the choice was whether the countries retained their own currencies up to the end of 2013, since one of the analyzed financial markets was the foreign exchange one. The other sectors of interest were: the sovereign bonds and the stock exchange one. We end our sample in 2013 since in this year another regulation came into force—the Dodd-Frank one (see: ISDA 2015). We believe that taking into account longer period we would be unable to distinguish between the effect of the two different regulations.

Our article contributes to the existing literature in the following way. First, we analyze possible causality from sCDS market to the other financial markets within a country, interpreting the results as the degree of immunity against volatility transmission or herd behavior. Secondly, we analyze the role of the new regulations from November 2012 on the strength of those relationships, which up to our knowledge has not been done yet.

The remainder of the paper is as follows. First, we present the data and shortly describe the four segments of financial markets in the analyzed countries. Next, we discuss the volatility models estimation and the results of the causality-in-variance tests. We check the robustness of the results analyzing patterns of impulse response functions. We end out article with the discussion of the results.

2 The Data

We collected the data of the sCDS, bonds, exchange rates and indices for four countries that retained their own currencies up to the end of 2013, i.e. Hungary, Poland (central Europe), as well as Sweden and United Kingdom (the developed markets of Western Europe).

2.1 Bond Market

Domestic bonds market is documented as being the most isolated from the abroad incidents (Kocsis 2014). Let us compare the dynamics of the sCDS spreads together with the dynamics of the sovereign bonds yields. It appears that in the case of Sweden (Fig. 1) the bond's yield and sCDS spread changed in opposite direction. The growth of the sCDS spread was accompanied with the decline of the bond yield. This could indicate that the internal evaluation of the government solvency (yield) was different to the external one (CDS spread).

Similar pattern is observed in the case of the British sCDS and bonds (Fig. 2). The changes of the bond yield were much less dynamic than the sCDS spread, and starting from autumn 2011 the instruments started to change in opposite direction.

In the case of Poland, again, the dynamics of the bonds was more "flattened" than the dynamics of sCDS spread. However, the overall tendency was similar—see Fig. 3.

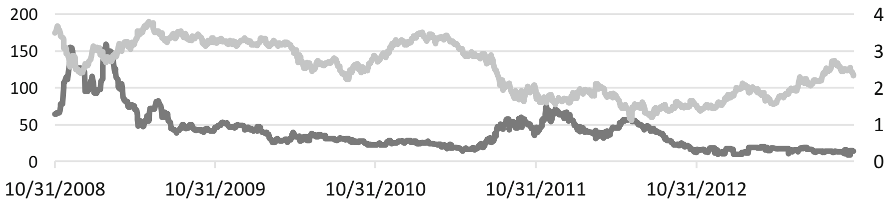

Fig. 1 Dynamics of sCDS (*left axis*, *black line*) and bonds (*right axis*, *grey line*)—Sweden

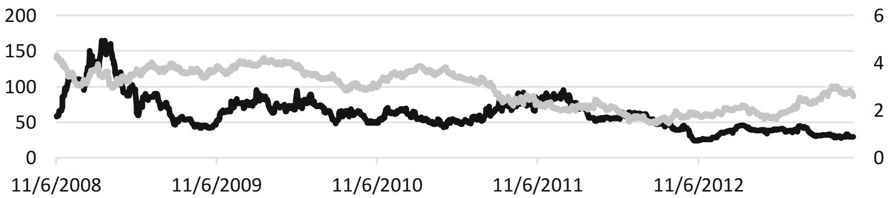

Fig. 2 Dynamics of sCDS (*left axis*, *black line*) and bonds (*right axis*, *grey line*)—UK

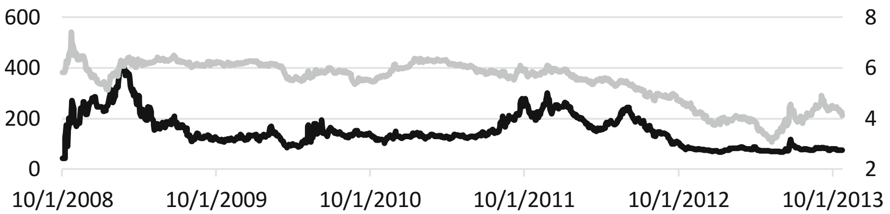

Fig. 3 Dynamics of sCDS (*left axis*, *black line*) and bonds (*right axis*, *grey line*)—Poland

In the case of Hungary (Fig. 4) the overall tendencies were similar, although the changes of the sCDS spreads were more sharp and dynamic. The Hungarian crisis of 2010 was reflected in the growth of the sCDS spread, while the yield of the domestic bonds did not react.

2.2 Exchange Rate

All of the analyzed countries retained their own currencies up to the end of 2013. However, each of the country conducted their own exchange rate policy. In the case of the United Kingdom, Sweden and Poland the exchange rate regime was free floating, and in the case of Hungary: floating.

In the case of Sweden (Fig. 5) we observe the constant upward trend, which seems to be opposite in comparison to sCDS changes. Drop of SEKEUR is accompanied with the growth of CDS—the periods of depreciation correspond to the periods of the country risk growth.

In the case of the Great Britain (Fig. 6) similar patterns were observed. However, in some periods the instruments showed common tendency (e.g. from October 2009 to March 2010 or from July 2011 to January 2012).

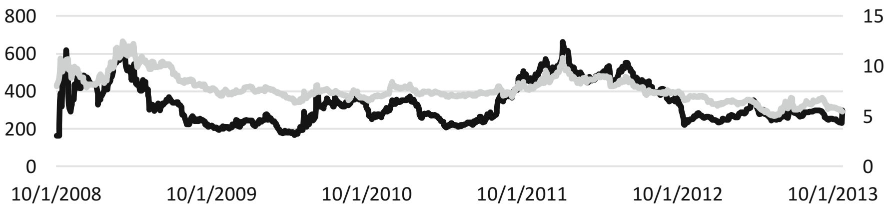

Fig. 4 Dynamics of sCDS (*left axis*, *black line*) and bonds (*right axis*, *grey line*)—Hungary

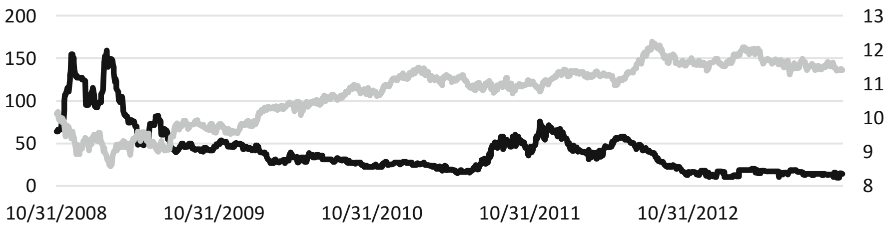

Fig. 5 Dynamics of the Swedish CDS (*left axis*, *black line*) and SEKEUR (*right axis*, *grey line*) exchange rate

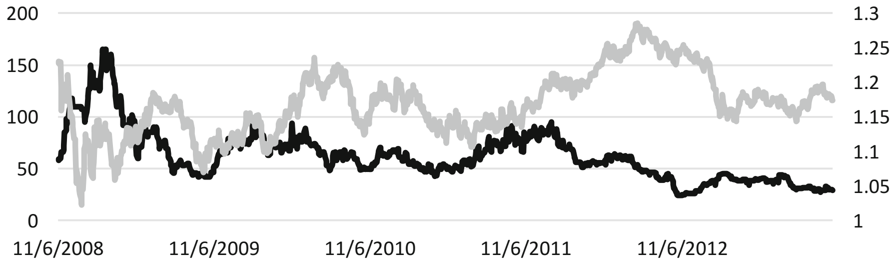

Fig. 6 Dynamics of the British CDS (*left axis*, *black line*) and GBPEUR (*right axis*, *grey line*) exchange rate

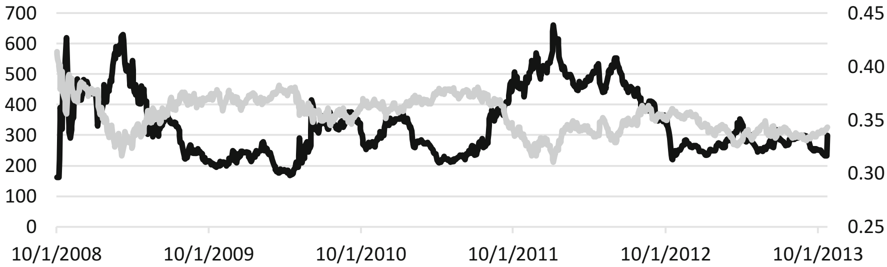

Fig. 7 Dynamics of the Hungarian sCDS (*left axis*, *black line*) and HUFEUR (*right axis*, *grey line*) exchange rate

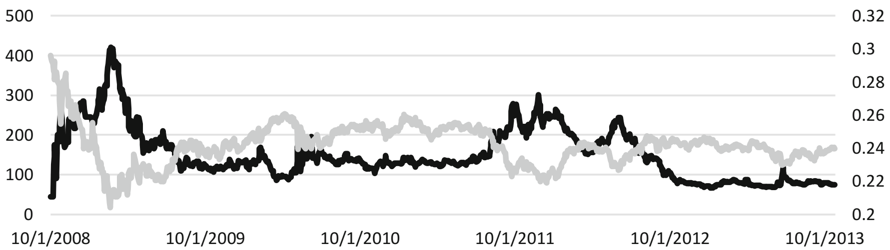

Fig. 8 Dynamics of the Polish CDS (*left axis*, *black line*) and PLNEUR (*right axis*, *grey line*) exchange rate

In the case of Polish CDS the relationship was clearly opposite—the same concerns Hungary. At the end of 2008 and beginning of 2009, due to the crisis transmission and speculative attacks on the East-European currencies, we observe depreciation in all the cases (Figs. 7 and 8).

2.3 Stock Exchange

In the case of Sweden we take into account OMXS30 index: OMX Stockholm 30 Index (see: NASDAQ OMX 2014). In the case of United Kingdom we analyze the FTSE250 index (see: FTSE Group 2015). In the case of Poland we study the dynamics of WIG20 index (Warsaw Stock Exchange Index, see: WSE 2013), while in the case of Hungary—BUX: the official index of blue-chips shares listed on the Budapest Stock Exchange (see: http://bse.hu/).

Figures 9, 10, 11 and 12 present the dynamics of the sCDS series together with the stock indices. In all the cases the dynamics was similar but changes went in opposite directions. The values presented in the charts are the close values of the indices and close values of the sCDS contracts (in basis points). The relationships between the measures are obvious—the increase of the index value is considered a

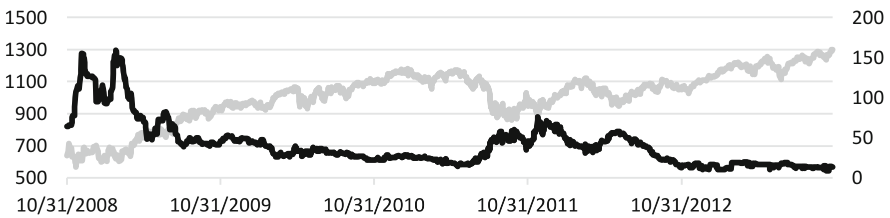

Fig. 9 Dynamics of OMXS30 (*left axis*, *grey line*) and Swedish CDS (*right axis*, *black line*)

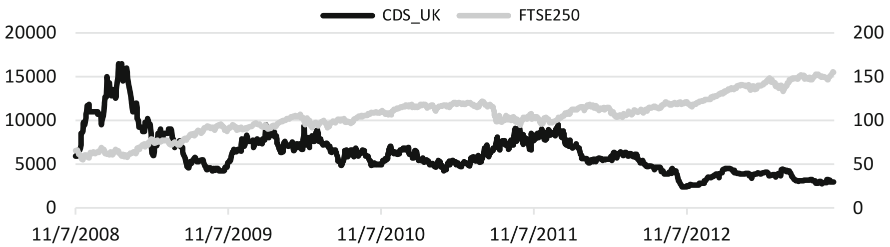

Fig. 10 Dynamics of FTSE250 (*left axis*, *grey line*) and British sCDS (*right axis*, *black line*)

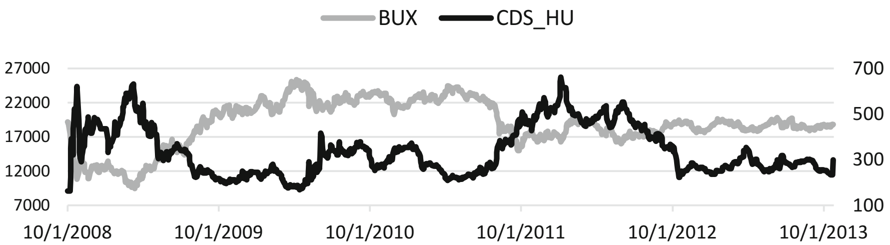

Fig. 11 Dynamics of BUX (*left axis*, *grey line*) and Hungarian sCDS (*right axis*, *black line*)

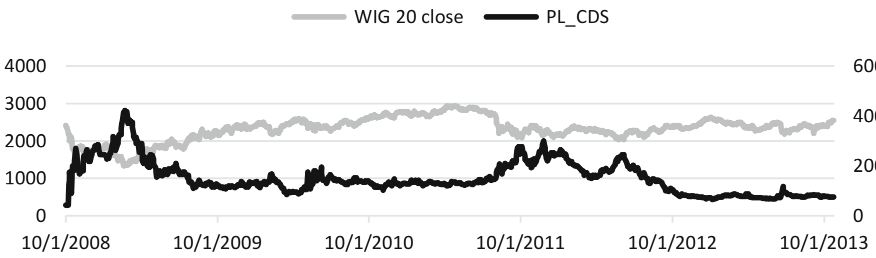

Fig. 12 Dynamics of WIG20 (*left axis*, *grey line*) and Polish sCDS (*right axis*, *black line*)

positive phenomenon and thus the risk of the country should diminish. The decline of the index value is considered as negative information and thus should be accompanied with the growth of the risk of the country.

3 Causality in Mean and Variance

In the first step of the research we computed the unrestricted VAR system for the markets in each country separately. The number of lags (1) was chosen based on the value of Schwarz information criterion. Next, we computed the statistics of Granger causality from sCDS to the system of the other variables, for each country separately. We took into account both Granger and instantaneous causality. The results are presented in Table 1. We observe that before the ban, feedback occurred in the case of Sweden, UK and Poland, while in the case of Hungary—feedback and Granger causality. However, after the ban was imposed, the relationships ceased in the case of Sweden and the United Kingdom. In the case of Poland and Hungary, feedback has been present even in the second period.

Since in financial markets the relationships in volatility are even stronger than in mean (although volatility itself is in fact not observed) we decided to check also the causality in conditional variance. We estimated the univariate volatility models of GARCH-type (Bollerslev 1986) for each series in each country and performed the Hong (2001) test on the squared standardized residuals obtained in this way. We chose the best model based upon its ability to explain all linear and non-linear dependencies of the data, as well as upon the significance and stability of the parameters.

For the sake of consistency we do not present the results of the GARCH estimation (they are available upon request). For the same reason, we do not present the formula of the Hong test in the article, as well. We refer the Readers to the original work of Hong (2001), to the work of Cheung and Ng (1996), as well as to: Osińska (2008, 2011) and Łęt (2012).

We performed the Hong test using Daniell and Tuckey-Hanning kernels, taking into account both feedback (including the lag 0) and Granger causality (excluding the lag 0). We took into account short-term and long term relationships, running the

Table 1 Results of the causality test in mean and variance before and after November 2012—summary of the results

Market	Sweden	United Kingdom	Hungary	Poland
Before November 2012				
CAUSALITY in MEAN				
CDS to all markets	FEEDBACK	FEEDBACK	FEEDBACK and Granger causality	FEEDBACK
CAUSALITY in VARIANCE				
Stock exchange	FEEDBACK and Granger causality for large M	FEEDBACK	FEEDBACK and Granger causality	FEEDBACK and Granger causality
Bonds	FEEDBACK	FEEDBACK	FEEDBACK and Granger	FEEDBACK and Granger
Foreign exchange	FEEDBACK and Granger causality for larger M	NO	FEEDBACK and Granger	FEEDBACK and Granger
After November 2012				
CAUSALITY in MEAN				
CDS to all markets	NO	NO	FEEDBACK	FEEDBACK
CAUSALITY in VARIANCE				
Stock exchange	NO	NO	NO	NO
Bonds	NO	NO	NO	NO
Foreign exchange	NO	NO	Granger for M = 20 and M = 50	NO

Note: feedback denotes that the causality was depicted when lag 0 was included, Granger causality—when lag 0 was excluded in the test statistics

test for the following lags: M = 1, 5, 10, 20, 50. We report the results in short form in Table 1. We present the results for the whole period, then the period up to November 2012 and the period starting from November 2012.

In the case of Sweden, we observe that the null hypothesis of no causality was rejected almost in each case in the full period, and also in the period prior to the new regulation. The exception was the Granger causality between CDS and bonds. However, after November 2012 we do not reject the null hypothesis in any case but the lag 50 (i.e. over 2 months history). The results undoubtedly suggest that there has been a change in the interrelations between the sCDS market and the remaining financial markets and that the change coincide with the implementation of the new regulations.

When we take into account the United Kingdom, it appears that before the new regulations there existed instantaneous causality between CDS and bonds as well as CDS and FTSE250. No causality between CDS and GBPEUR was observed.

However, after implementing the new regulations, all the interrelationships ceased. Again, the results strongly support the thesis that the new regulations contributed to weakening of the relationships between the analyzed markets.

The results differ in the case of Poland and Hungary. In Hungarian markets, in the period prior to November 2012 the null hypothesis was rejected in each case. Thus, we conclude that the changes of CDS volatility influenced significantly volatility of the other instruments. However, as the new regulation had been implemented, this influence ceased. We did not reject the null hypothesis in any case, apart from interrelations with HUFEUR for lags 20 and 50, Daniell kernel.

The results obtained for Poland are similar to the results obtained for Hungary. Causality from CDS market used to be strong prior to November 2012, and afterwards the relationships disappeared (Table 1).

4 Robustness Check: Volatility Impulse Response

In order to check the robustness of the results, we computed the accumulated impulse response functions for the system of variables before and after the 2012-ban. We took into account the results of the VAR model, which was computed in the first step of the research. We present the results in Figs. 13, 14, 15, and 16. We present the values of impulse response, and we assess their significance based on the upper and lower value of the 95%-confidence interval, which is not present in the figures for the sake of clarity. We observe that the responses of bond (dark gray dashed line), exchange rates (light gray dotted line) and stock indices (black solid line) diminished drastically in the second sub-period.

In the case of Sweden we observe a significant response of bonds and FX rate to the sCDS shock before the ban. After the ban only the response of the stock market became significant, but much lower (Fig. 13), while the other markets did not respond significantly to the sCDS shocks. In the case of the United Kingdom the

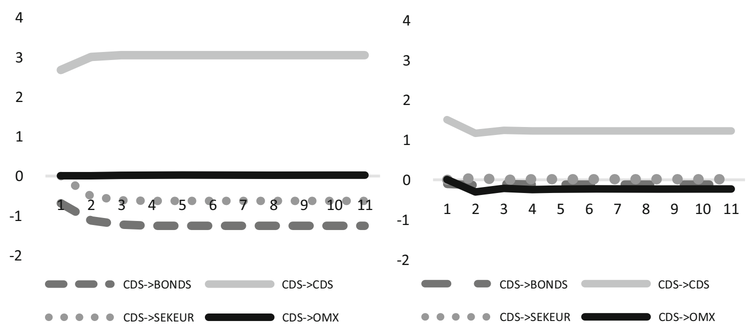

Fig. 13 Cumulative impulse response function—Sweden before the ban (*left panel*) and after the ban (*right panel*)

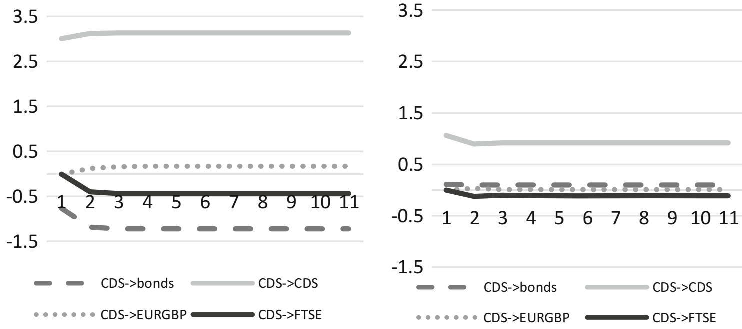

Fig. 14 Cumulative impulse response function—United Kingdom before the ban (*left panel*) and after the ban (*right panel*)

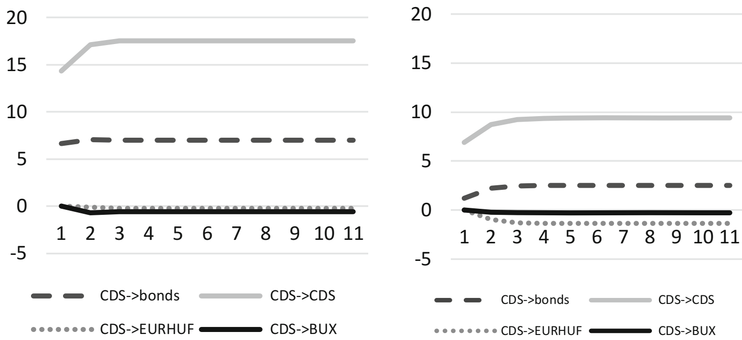

Fig. 15 Cumulative impulse response function—Hungary before the ban (*left panel*) and after the ban (*right panel*)

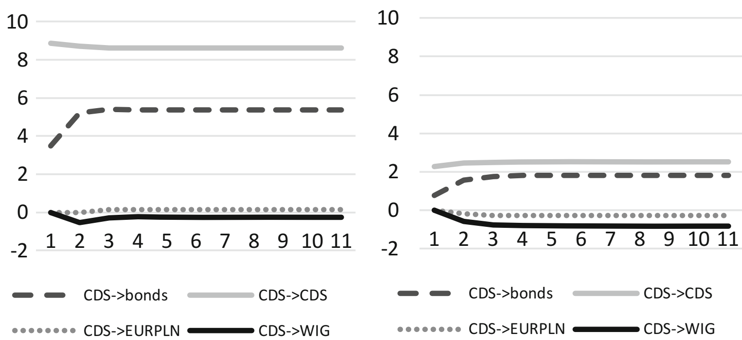

Fig. 16 Cumulative impulse response function—Poland before the ban (*left panel*) and after the ban (*right panel*)

responses of the stock, bonds and foreign exchange markets were significant before the ban and became insignificant afterwards (Fig. 14).

In the case of Poland and Hungary the situation was different. The response of FX rate and stock market proved to be insignificant before the ban. After the ban was imposed, in the case of Hungary (Fig. 15) the reaction of exchange rate became significant, while in the case of Poland (Fig. 16)—the reaction of stock exchange. In both cases the response of bonds remained significant, as well. However, the strength of response diminished drastically, as in the case of Sweden and the United Kingdom (including the reaction of sCDS to its own impulses). It is worth noting that the value of response was much higher in the case of the emerging economies, and even after the ban their values exceeded the before-ban values of responses in the developed ones.

We can interpret the results in a similar way to Orlowski (2016)—the high response of a given market to sCDS one is a sign of strong integration between them. We observe that in general the most integrated were the sCDS and bonds one. As the response became much weaker after the ban, we can suppose that the markets became much less integrated.

5 Conclusions

In the article we compare the behavior of various financial markets in developing and developed European economies. The group of the developing economies comprised of Hungary and Poland, while the developed ones were represented by the United Kingdom and Sweden. The choice of the countries depended on whether the country retained its own currency up to the end of 2013. We analyzed interdependencies between the following pairs of markets: CDS and bonds, CDS and foreign exchange, CDS and stock market. We investigated the strength of the interdependencies during the financial crisis and verified whether the ban on uncovered CDS trade could contribute to weakening of those relationships. We estimated GARCH-type models of volatility and run a series of causality-in-variance tests.

The obvious drawback of the study is the lack of additional variables, that could have influenced the interactions among the markets (i.e. the proxy of global volatility). Moreover, there is no evidence that the reason of the change of relationships was this particular ban on uncovered sCDS trade. The relationships started to cease during the year 2012 (see also Kliber 2016) and in fact it is impossible to determine whether the reason was the ban, any other international event or a group of events, or was it just a coincidence. However, if we assume that the ban was the reason of the relationships end, the conclusions are as follows.

First, the results differ significantly depending on whether the analyzed country was an immune and safe Western-European market or a more risky and developing one. When we analyze the interrelationships in variance in the case of *Sweden* it appears that before the crisis only the bond market was free from the sCDS influence—if we take into account the lead-lag relationships (in the case of the immediate response the hull hypothesis of non-causality was rejected). Starting from November 2012 no causality in variance was observed (the null hypothesis was rejected only for very distant lags).

In the case of the *United Kingdom*, before November no causality from sCDS to the stock exchange market was observed, and also no lead relationships between sCDS market and the bond one. Since the new regulations came into force, all the causality relationships have disappeared.

When we analyze the causality in the case of *Poland* and *Hungary*, the results for the CEE countries are consistent—changes in volatility of the CDS market used to cause changes of volatility in the stock, bonds and foreign exchange markets prior to November 2012. Afterwards, no such causality was found.

The results are to some extend supported by the analysis of impulse response functions. Responses of all markets in each country diminished drastically in the second sub-period (even if the confidence interval narrowed to such extend that the response became significant). The degree of change was similar in both analysed group, but the response of emerging markets after the ban was still stronger than the response of developed ones before the ban.

To summarize—the November regulation seems to have changed the causality patterns between the sCDS and the other financial markets. However, the change was different in different countries. In these safe markets (Sweden, UK) the influence of sCDS on the other financial markets within the country was negligible. This indicates that the economies are relatively immune to herd behavior and panic. On the other hand, the CEE group seems to be less stable. The less developed markets are indeed more prone to volatility transmission, herd behavior and panic and the impact of the regulations from November 2012 on these markets was undoubtedly positive.

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Determinants of the Spread Between POLONIA Rate and the Reference Rate: Dynamic Model Averaging Approach

Paweł Kliber

Abstract In the paper we consider the factors that determine the overnight interest rates in the Polish interbank market (measured by the POLONIA rate index). In 2008 the Polish central bank (NBP) adapted the policy similar to the European Central Bank (ECB) and since then it has been trying to place the POLONIA rate around the NBP reference rate, mainly by influencing the liquidity conditions through open market operations. We try to answer the question how effective this control was. We identify a set of factors that determine overnight rates, namely: liquidity, expectations, confidence in the banking sector and central bank operations. We analyze to what degree each of these factor has been influencing the POLONIA rate in the period from 2006 to 2016. To this end we have used a non-standard econometric method, namely dynamic model averaging, which allows to identify the set of variables that provide the best description of the explanatory variable. The results reveal that before the outbreak of financial crisis in 2008 the spread between POLONIA rate and reference rate could be explained mainly by liquidity conditions. After the crisis had begun, the importance of liquidity factor decreased and the expectations played a more important role in determining the spread. The liquidity situation has regained its importance in determining the spread since the beginning of 2012, after the central bank had undertook appropriate measures to normalize the situation on the interbank market.

1 Introduction

In the article we consider the factors that determine the short term interest rate in the interbank market in Poland. In particular, we are interested in the determinant of behavior of POLONIA rate—the index of overnight interbank loans. It is considered as the one of the most important interest rates as it is believed, according to the expectation hypothesis, that the POLONIA rate determines interest rates for longer maturities. Therefore the Polish central bank (NBP) has set as its operational target

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_3

to allow the POLONIA rate to run close to the NBP reference rate by maintaining appropriate liquidity circumstances.

The problems with performing this policy appeared with the outbreak of the financial crisis in 2008. The crisis had a significant impact on the functioning of the money market. Interest rates and volatility in this market increased substantially. The crisis triggered a sudden slump in the interbank money market. The turnover in the unsecured interbank deposits market fell significantly and the loans in this market were given at shorter maturities.

As it was shown in Kliber and Płuciennik (2011) in this period NBP lost some of its control over POLONIA rate. Since 2010 the central bank has started to use fine-tuning operations with the maturity shorter than the main open market operations. The main bulk of these operations was designed to absorb liquidity. In 2010 and 2011 the operations were performed on ad-hoc basis and during reserve maintenance periods. Since 2012 NBP has started to carry out fine-tuning operations regularly on the last working day of maintenance periods. All these operations were carried out to stabilize the POLONIA rate at the level close to the reference rate (Fig. 1).

The problem of the influence of central bank policy on the overnight interbank interest rate was considered in many publications. In most of the research ARMA-GARCH models were used. Wetherilt (2003) analyzed the influence of the monetary policy of the Bank of England on short term interest rates. The articles (Nautz and Offermanns 2007; Soares and Rodriges 2011; Liznert and Schmidt 2008; Abbassi and Nautz 2010) as well as De Socio (2013) contain research on EONIA spread. Hassler and Nautz (2008) studied the spread of EONIA analyzing the integration and long memory in time series. The articles (Schianchi and Verga 2006) as well as (Hauck and Neyer 2014) provided the theoretical background for the analysis of factors determining the spread. Würtz (2003) pointed out the role of liquidity expectations in forming interbank rates.

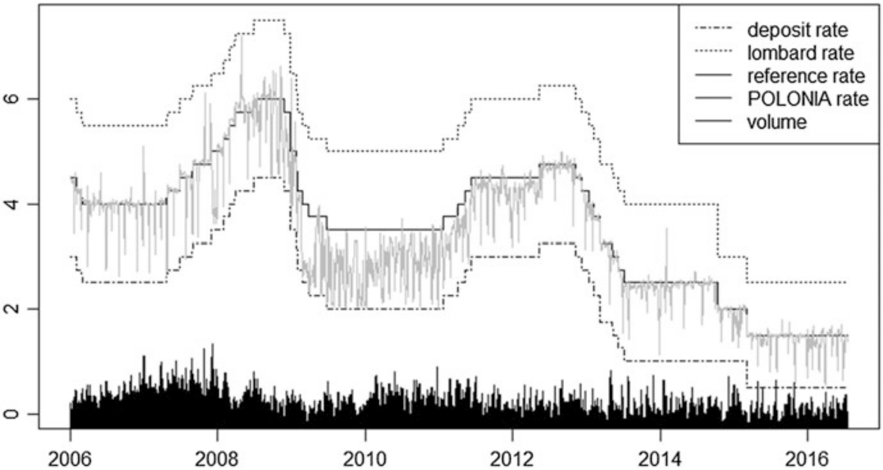

Fig. 1 POLONIA rate, the main central bank rates and the volume of transactions in the Polish overnight interbank market

Similar analysis for the spread of POLONIA was performed in Kliber and Płuciennik (2011) and Kliber et al. (2016). In the last paper econometrical analysis was supported by the results of the survey directed to the headquarters of commercial banks.

In this paper we take a different approach to the problem of identifying the factors that play most important role in determining overnight rates. The existing literature usually makes use of the method that consists of dividing *ad hoc* the period under research into several subperiods and estimating econometrics models for each of them independently. We instead use the dynamic model averaging approach (DMA). This procedure allows to use various models to describe the phenomena under research and dynamically choose the model that provides the best description of the dependent variable. It has this advantage over the standard econometric procedure that there is no need to arbitrary indicate the moments of regime-switching. Instead, it allows the data to choose the right model.

The procedure was developed in Raftery et al. (2012) and since that time has been successfully adapted to describe and predict economic variables, like for example inflation (Koop and Korobilis 2012) or prices of raw materials (Koop and Tole 2013). The method of mixing different models is considered as the best method for forecasting.[1] However, it is used here rather as a tool for identifying factors that give the best predictions and that can serve as a 'causes' (in Granger sense) of the phenomena under research.

2 Dynamic Model Averaging

We assume that the dependent variable is described by a set of time-varying regression models, in which coefficients can change with time. Each one of K models can be represented by the following linear state-space formulation:

$$y_t = x_t^k \theta_t^k + \epsilon_t^k, \tag{1}$$

$$\theta_t^k = \theta_{t-1}^k + \eta_t^k, \tag{2}$$

where $\epsilon_t^k \sim N\left(0, h_t^k\right)$ and $\eta_t^k \sim N\left(0, Q_t^k\right)$ are independent random disturbances (the first has dimension 1 and the second is a vector random variable). Here y_t is dependent variable, k is the index of the model that applies at the time t and x_t^k is a vector of explanatory variables in the model k. It is thus assumed that at each moment a different set of variables can have impact on the dependent variable.

Let L_t be the model that applies at the moment t. It is assumed that the sequence of models forms a Markov chain with the transition matrix $\Pi = (\pi_{ij})_{i,j=1\ldots K}$, where

[1] See for example remarks of Nate Silver (2012), who successfully used it to predict the results of the US presidential elections in 2012 in all 50 states.

$\pi_{ij} = P(L_t = j | L_{t-1} = i)$. Let us denote by p_t^k the probability that at the moment t the model k applies. The probabilities can be calculated in a two-step procedure resembling Kalman filter with a prediction step and an updating step, accompanied by the standard Kalman procedure for estimating the parameters of the model (1)–(2). The procedure allows to calculate estimators for the probabilities of different models at the moment t

$$p^k_{t|t} = P(L_t = k | y_1, \ldots, y_t), \tag{3}$$

as well as the estimators of the coefficient vectors in different models $\theta^k_{t|t}$ when all observations up to time t are known.[2]

3 Variables and Models

The dependent variable y is the spread between POLONIA rate and the reference rate of the Polish central bank. We try to check which possible factors had influence on this variable. The set of potential explanatory variables is given in Table 1.

The time series of POLONIA spread displays autocorrelation of the first order, so we have to use lagged values of this variable, $y(-1)$, to control it. The variables *btc_m* and *btc_f* represent the ratio of total bid volume to total cover volume in main and fine-tuning open market operations, respectively. These variables reflect to what degree the demand of commercial banks is met by NBP. High values of these variables mean that the demand for liquidity was satisfied during the operations only to a low degree, and banks had to seek for liquidity in the interbank market, which tends to increase the spread. The variable *df_lf* represents the difference between the sum of deposits at the end of the day made by commercial banks in NBP and the amount of lombard credit. This variable serves as a proxy, indicating current liquidity situation. In a situation of loose liquidity the demand in the overnight market is low, which tends to decrease the spread. The last three variables describe liquidity situation.

The next two variables are connected with the expectations concerning future changes of interest rate. The variable *ois1w_ref* represents the spread between one week OIS (overnight indexed swap) rate and the reference rate. If OIS rate is well

[2] The technical details are omitted here due to limitations on the length of article. They can be found in Raftery et al. (2012), where the method was developed. In the later computations, instead of using the full specification of the matrices Q_t^k the estimators of covariance matrix from the prediction phase is used (multiplied by some specified forgetting index). One should note that the parameters h_t^k, the standard deviations of the error term in eqn. (1), are not constant, which allows to account for heteroscedascity. As in Koop and Korobilis (2012) we estimate it using moving average of lagged observations.

Table 1 Possible explanatory variables

Var. name	Description
$y(-1)$	Lagged dependent variable
btc_m	Bid to cover ratio in main open market operations
btc_f	Bid to cover ratio in fine-tuning open market operations
df_lf	Difference between end of the day deposit and lombard credit
ois1w_ref	Spread between OIS1W and reference rate
var_ois1w	Variance of OIS1W
wois3m	Spread between WIBOR3M and OIS3M

below the reference rate, it means that banks expect the POLONIA rate to rise, which should have positive influence on the spread. The variable *var_ois1w* is a measure of uncertainty of these expectations. We defined it as a square of the first differences of OIS1W (one week OIS) rate, which serves as a proxy for conditional volatility of this rate. This variable should have a negative impact on the spread.

The variable *wois3m* represents the spread between three months WIBOR and the OIS rate with the same maturity. The spread between interbank rates of unsecured loans and the rates of much more safer swap instruments are commonly considered as a measure of risk in the banking sector ("fear index"). This variable is used to account for the lack of confidence in the market, which began with the outburst of financial crisis.

Apart from these explanatory variables we also use a few dummy variables to control some characteristics of the dynamic of the dependent variable. They are presented in Table 2.

We consider four models, which describe four different factors influencing the POLONIA spread (Table 3). These aspect are: liquidity, expectations, risk (or "fear") and central bank policy.[3]

The first model (M1) applies in the periods in which liquidity situation is the main factor determining the overnight rates. This regime occurs in the normal market circumstances. The second model (M2) describes the regime in which the overnight rate is determined mainly by the expectations concerning future changes of interest rates. Such conditions occur for example when banks expect the interest rates of the central bank to change. In some regards it is an inconvenient situation, as it disturbs the way the banks manage their reserves during maintenance period.[4] The third model (M3) applies in the periods of high uncertainty in the banking sector. The banks are reluctant to lend money in the interbank market over the

[3]Alternatively, one can make estimations using all 256 possible models which can be build using all variables (assuming that variables $y(-1)$, *d_reqRes* and *d_reqRes1* should be present in each model) and then checking the influence of each variable. Such analysis was done and the results were very similar to the results of the analysis based on the four models. The analysis presented here has this advantage that the results are much easier to interpret.

[4]For example one of the goals of operational framework of European Central Bank is to eliminate the effects of expectations on EONIA rate. See for example (Linzert and Schmidt 2008).

Table 2 Dummy variables

Var. name	Description
d_reqRes	Last day of a maintenance period
d_reqRes1	Second to last day of a maintenance period
d_main	Day of main open market operation
d_fine	The series of fine-tuning operation has started (0 – before the event, 1 – after it)

Table 3 The models

Model	Variables
M1 (liquidity)	$y(-1)$, *btc_m, btc_f, df_lf, d_reqRes, d_reqRes1*
M2 (expectations)	$y(-1)$, *ois1w_ref, var_ois1w, d_reqRes, d_reqRes1*
M3 (risk)	$y(-1)$, *wois3m, d_reqRes, d_reqRes1*
M4 (policy)	$y(-1)$, *d_main, d_fine, d_reqRes, d_reqRes1*

longer periods and manage their liquidity mainly through overnight deposits. The last model (M4) is formulated to check the influence of the central bank operations on the spread.

4 Empirical Results

The data in the analysis cover the period from the beginning of 2006 (2 January 2006) till the half of 2016 (the last observation is from 15 July 2016). During this period the market survived the outburst of the financial crisis, the fall of the confidence in the interbank sector and the attempts of the central bank to calm down the market and regain control over overnight rates.

The regression analysis (not presented here) of all explanatory variables and all proposed models reveals that most of the variables are statistically significant and all models describe the dependent variable with very high accuracy. The dynamic analysis should help us to distinguish which model applies in different periods.

Figure 2 presents the results of the DMA analysis. The plots depicts the probabilities that particular model applies in the specific period. Before November 2008 the POLONIA spread could be explained mainly by the liquidity factors, apart from the short episode at the turn of 2007 and 2008, when the role of perceived credit risk in interbank market (M3) grew. Beginning from November 2008 the spread was driven by expectations concerning future rates (M2). This regime had lasted till the second half of 2011, when the importance of the expectations fell and the spread could be again explained mainly by the liquidity factors. The restored "liquidity regime" has been lasting since then. Only at the beginning of 2016 the situation began to change and there was a significant increase in the importance of the expectations.

The results reveal also the that the operations of the central bank alone (M4) do not allow to explain the dynamics of POLONIA rate. The central bank policy

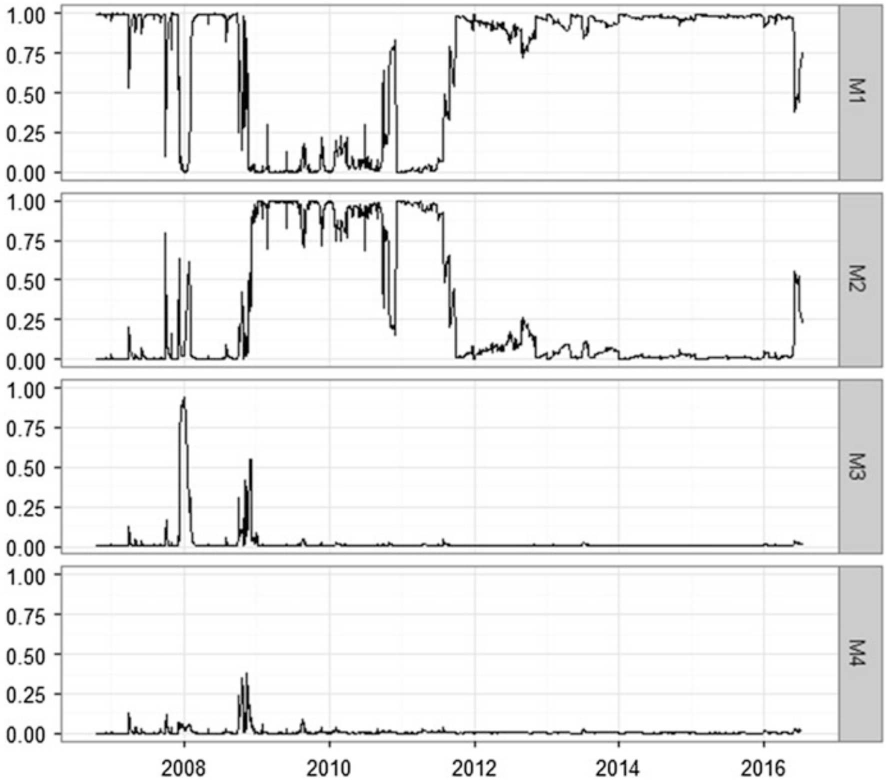

Fig. 2 Probabilities of different models

should be analyzed in the context of market conditions—either the current liquidity situations or the expectations of the commercial banks.

5 Conclusions

In the article we have considered the factors determining the behavior of the overnight rate in the Polish interbank market. To this aim we have used a dynamic model averaging approach and tried to distinguish the periods in which the dynamics of POLONIA rate is governed by different factors. We have proposed three models and each of them contains a set of variables that represents different aspects of the forces that influence overnight rate.

The results of the analysis are in many aspects similar to those presented in Kliber and Płuciennik (2011) and Kliber et al. (2016). Under the normal circumstances the main factor determining the spread is liquidity. This is in accordance with the operational objectives of the Polish central bank, according to which the bank should control overnight rate by setting liquidity situation in the banking sector. After the beginning of the financial crisis the liquidity situation ceased to be the main factor explaining the overnight rate. Instead, the rate was determined by the expectations concerning future changes in the central bank interest rates. The uncertainty increased and the guesses concerning the future policy of the central bank were the main factor determining the overnight rates. The role of the liquidity fell dramatically, which is understandable in the situation of systematic liquidity surplus in the banking sector, augmented by the introduction of the "Confidence Pact". The fear factor, concerning the risk of default in the banking sector, was not a very strong factor. Its importance rose at the beginning of 2008 and during the initial period of the crisis. At the end of 2011, probably thanks to fine tuning operations of NBP, there was a return to normal circumstances, in which the liquidity is the main factor determining the spread.

The results can be compared with the analysis of EONIA spread, as the countries in the euro zone are the biggest trade and financial partners of Poland and because the operational framework of the Polish central bank is modeled on the framework of ECB. According to the analysis of Soares and Rodriges (2011) prior to the financial markets turmoil the EONIA spread was stable and its dynamics was determined by liquidity conditions and end-of-maintenance period effects. After the outburst of the crisis the liquidity factor became much less significant. The authors also remark that after the ECB had started to provide additional liquidity to the banking sector commercial banks preferred to obtain more liquidity in regular operations and deposit the excess in the deposit facility instead of trading in the interbank market. These findings are very similar to the observations made in this paper that after the crisis, as the central bank started to provide additional liquidity, the importance of the liquidity condition as the factor determining the interbank overnight interest rates has decreased. Instead, there was an increase in the importance of the credit and deposit facilities provided by the central bank. In our analysis this rise of the importance of central bank reveals in the switch towards the models in which the POLONIA spread was determined by the expectations concerning changes of the central bank interest rates.

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World Natural Gas Markets: Characteristics, Basic Properties and Linkages of Natural Gas Prices

Blanka Łęt

Abstract In recent years the world natural gas market is changing mainly due to the wider access to LNG (Liquefied Natural Gas). This technology allows to trade between the market participants all over the world. The natural gas prices on the American and European market are predominantly benchmarked to Henry Hub and National Balancing Point (NBP) natural gas. The goal of this paper is to compare basic properties of selected time series and to investigate whether the listings of natural gas in the derivatives markets are linked. We show that the probability distribution of returns is not normal and that there is a strong ARCH effect. We use multivariate GARCH model to describe the linkages between several series. We are taking into account two return series of natural gas futures contracts (Henry Hub and National Balancing Point) and two returns series of crude oil futures contracts (West Texas Intermediate and Brent) to measure the strength of linkages across two commodity markets, the most important fossil fuels.

1 Introduction

Natural gas is one of the most traded commodity in the world but historically the world trading markets were regionalized. The world natural gas market is changing mainly due to the wider access to LNG (Liquefied Natural Gas). A conversion of a natural gas to a liquid form allows to simplify storage and transport of this commodity and to trade between the partners from different part of the globe. But the price difference between the United States, Europe and Asia is still large due to the region-specific factors affecting supply and demand and because of the liquefaction, shipping and regasification costs.

Natural gas market attracts investors looking for opportunities to earn money. There are many ways to invest in natural gas market. Two of the widely used instruments are Henry Hub and National Balancing Point futures contracts.

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_4

Henry Hub (HH) Natural Gas Futures is one of the largest physical commodity futures contract in the world by volume and allow investors to manage risk resulting from the very volatile natural gas prices. The delivery point is the Henry Hub in Louisiana. It is traded via open outcry and electronically using CME-Globex. The contract size is 10,000 mmBtu and is priced in USD. The price of Henry Hub natural gas is commonly regarded as a benchmark for United States.

National Balancing Point (NBP) Natural Gas Futures is another physical commodity futures contract. The delivery point is the NBP Virtual Trading Point. The contract size is 1000 therms per day per delivery period and is priced in GBP. National Balancing point is one of the main trading hubs in Europe.

Historically the price of the natural gas and the crude oil prices have moved together. We want to describe the nature of the linkages between natural gas and oil futures contracts. In order to do so, we use the most important light sweet crude oil futures: West Texas Intermediate (CL) and Brent (B), which are USD denominated.

Some of the previous studies of the natural gas markets have shown the lack of cointegration between United States and Europe prices. Siliverstovs et al. (2005) investigated the degree of integration of natural gas markets in Europe, North America and Japan. The relationship between international gas market prices and their relation to the oil price were explored through principal components analysis and Johansen likelihood-based cointegration procedure. Obtained results suggest that the European and the North American markets were not integrated in the time period between the early 1990s and 2004. Neumann (2009) investigate price dynamics covering the period from 1999 until 2008 using daily spot prices for natural gas in North America and Europe. Results of the analysis using Kalman Filter technique suggest an increasing convergence of natural gas spot prices. Brown and Yücel (2009) used bivariate causality tests between the weekly Henry Hub and NBP prices of natural gas and showed bidirectional causality, indicating coordinated movement in natural gas prices across the Atlantic. They concluded that there is a possibility that the coordination of natural gas prices across the Atlantic could be facilitated through co-movements with crude oil prices. Li et al. (2014) examined the relationships between the North American, European and Asian natural gas markets for evidence of convergence and integration for the January 1997 through May 2011 period. The analyses were conducted under a multivariate framework. They found evidence of convergence among the Asian and UK prices. The North American gas price displays distinctive behaviour. They conclude that there is not a fully integrated international natural gas market and that the integration between Europe and Asia appears to be due mechanisms linking natural gas prices to oil prices rather than the result of market supply and demand interactions. Geman and Liu (2015) investigated whether the US and UK gas markets are moving toward integration. Studying the cointegration of the Henry Hub and National Balancing Point indexes for the period January 2005 to April 2014 they concluded that there is no convergence between two markets.

Marzo and Zagaglia (2008) modeled the joint movements of daily returns on one-month futures for crude oil, heating oil and natural gas through the multivariate GARCH with dynamic conditional correlations using data between November

1, 1990 and November 22, 2005. They found that at the daily frequency the conditional correlation between the futures prices of natural gas and crude oil has been rising over the last 5 years of the examined period.

Efimova and Serletis (2014) investigated the empirical properties of oil, natural gas, and electricity wholesale price volatilities using a range of univariate and multivariate GARCH models and daily data for the period from 2001 to 2013. They found that price spillovers are rather unidirectional, suggesting the existence of a hierarchy of influence from oil to gas and electricity markets. They showed the oil–gas correlations decreased during times of recession or slow economic growth, specifically, 2003–2005 and 2009–2010 and the decrease in the correlation between oil and gas since 2011.

Following the question by Neumann (2009) of whether "LNG doing its job" in integrating international gas market, in our study we undertake to check what is the current situation on the two natural gas markets and to investigate whether the daily listings of natural gas in the derivatives markets are linked with each other. We also examine whether the strength of linkages with oil market is again high. For this purpose we use multivariate GARCH framework to describe the linkages between daily returns series.

The structure of the article is as follows. First we describe the methodology: a multivariate CCC-GARCH model and the two constant conditional correlation tests. Then we examine basic properties of selected series and present the estimation results. Finally, Sect. 4 concludes our findings.

2 Constant Conditional Correlation Model

Let $\boldsymbol{r}_t = (r_{1,t}, r_{2,t}, \ldots, r_{n,t})'$ denote a multivariate time series of returns with the following decomposition:

$$\boldsymbol{r}_t = \boldsymbol{\mu}_t + \boldsymbol{y}_t, \tag{1}$$

where $\boldsymbol{\mu}_t = E(\boldsymbol{r}_t|\mathcal{F}_{t-1})$ is conditional mean, $\mathcal{F}_{t-1}$ is the information set available at the time $t-1$. Conditional expected value $\boldsymbol{\mu}_t = (\mu_{1,t}, \mu_{2,t}, \ldots, \mu_{n,t})'$ can be modeled simply by using univariate ARMA(p,q) model for each conditional mean $\mu_{i,t}$:

$$\mu_{i,t} = a_{i,0} + \sum_{j=1}^{p} a_{i,j} r_{i,t-j} - \sum_{j=1}^{q} b_{i,j} y_{i,t-j}. \tag{2}$$

A general multivariate GARCH model for $\boldsymbol{y}_t$ is given by equation:

$$\boldsymbol{y}_t = \boldsymbol{H}_t^{\frac{1}{2}E_t}, \tag{3}$$

where E_t is n-dimensional i.i.d. process with zero mean and identity covariance matrix $E_t \sim iid(0, \boldsymbol{I_n})$, $\boldsymbol{H}_t^{\frac{1}{2}}$ is a $n \times n$ matrix satisfying $\boldsymbol{H}_t^{\frac{1}{2}} \cdot \boldsymbol{H}_t^{\frac{1}{2}=\boldsymbol{H}_t}$, $E(\boldsymbol{y}_t|\mathcal{F}_{t-1}) = 0$ and $E(\boldsymbol{y}_t\boldsymbol{y}_t'|\mathcal{F}_{t-1}) = \boldsymbol{H}_t$.

Specific multivariate GARCH model is specified by parametrization of positive definite covariance matrix $\boldsymbol{H}_t$. The Constant Conditional Correlation CCC-GARCH model have been proposed by Bollerslev (1990). It is the class of multivariate time series model with time varying conditional variances and covariances, but constant conditional correlations. The following equation defines CCC model:

$$\boldsymbol{H_t} = \boldsymbol{D_t R D_t} = \left(\rho_{ij}\sqrt{h_{ii,t}h_{jj,t}}\right), \tag{4}$$

where $\boldsymbol{D}_t = diag\left(\sqrt{h_{11,t}}, \ldots, \sqrt{h_{nn,t}}\right)$, $\boldsymbol{R} = (\rho_{ij})$ is an $n \times n$ time invariant, positive definite matrix containing the constant conditional correlations. The model has a specification for each conditional variance in $\boldsymbol{D}_t$ belonging to the GARCH family. The simple GARCH(1,1) model has the following form:

$$h_{ii,t} = \omega_i + \alpha_i {y^2}_{i,t-1} + \beta_i h_{i,t-1}. \tag{5}$$

Another choice is the GJR model, where the past positive shocks can have different impact on today's volatility than past negative shocks:

$$h_{ii,t} = \omega_{i,t} + \alpha_i {y^2}_{i,t-1} + \gamma_i I(y_{t-1} < 0) y_{t-1}^2 + \beta_i h_{i,t-1}, \tag{6}$$

where $I(y_{t-1} < 0)$ is a dummy variable that takes the value 1 when y_{t-1} is negative and 0 otherwise.

The validity of the assumption that conditional correlations are constant remains an empirical question. Some tests that verify this assumption have been proposed in the literature. Tse (2000) and Engle and Sheppard (2001) test is a common choice with the constant conditional correlations null hypothesis.

3 Basic Properties of Returns and the Estimation Results

For the natural gas and crude oil futures contracts we take the daily prices between the period January 2, 2015 and June 1, 2016. We obtain four data sets having total 355 observations. In this study we examine the percentage logarithmic returns calculated by $r_t = 100 \cdot \ln\left(\frac{p_t}{p_{t-1}}\right)$, where p_t is the price of a contract at the time t.

Figure 1 presents the prices of two natural gas and two crude oil futures contracts in selected period. Because the National Balancing Point (NBP) futures contracts is denominated in GBP, we convert the prices using historical USD/GBP exchange rates and thanks to this modification all prices are denominated in USD. Figure 2 presents the returns series of selected futures contracts. The NBP and HH returns

Fig. 1 The price of two natural gas and two crude oil futures contracts

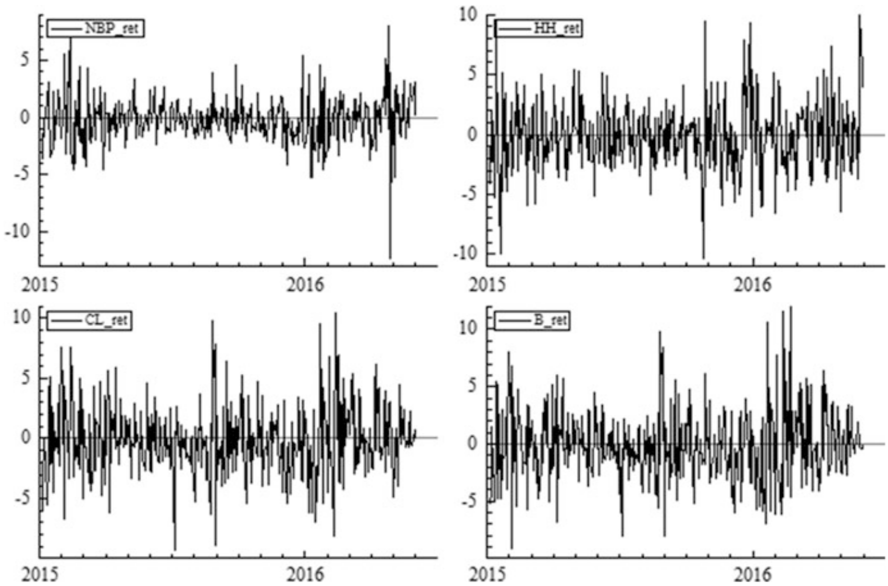

Fig. 2 The returns of two natural gas and two crude oil futures contracts

series have different dynamics. As we can see the HH returns series is more volatile than NBP.

We conduct the Box-Pierce tests to check whether there are some significant autocorrelations in returns series and to detect the ARCH (autoregressive conditional heteroscedasticity) effect. Table 1 contains the results of the Box-Pierce tests. As we can see the large *p*-values suggests that there is no significant autocorrelations in our series. Using the results of similar tests for squared returns we conclude that there is a strong ARCH effect in all the series.

Figure 3 presents the kernel estimators of the density of four daily returns series. The distribution of NBP is non-Gaussian, sharp peaked and heave tailed. The visual inspection of kernel estimator of the density of HH series suggests that the

Table 1 The results of Box-Pierce test

	NBP	HH	CL	B
	P-values from Box-Pierce tests H0: No autocorrelation in returns			
lag = 5	0.3027	0.6096	0.1870	0.3243
lag = 10	0.1988	0.4097	0.3144	0.3151
	P-values from Box-Pierce tests on squared returns H0: No autocorrelation in squared returns			
lag = 5	0.0000	0.0000	0.0000	0.0000
lag = 10	0.0000	0.0003	0.0001	0.0000

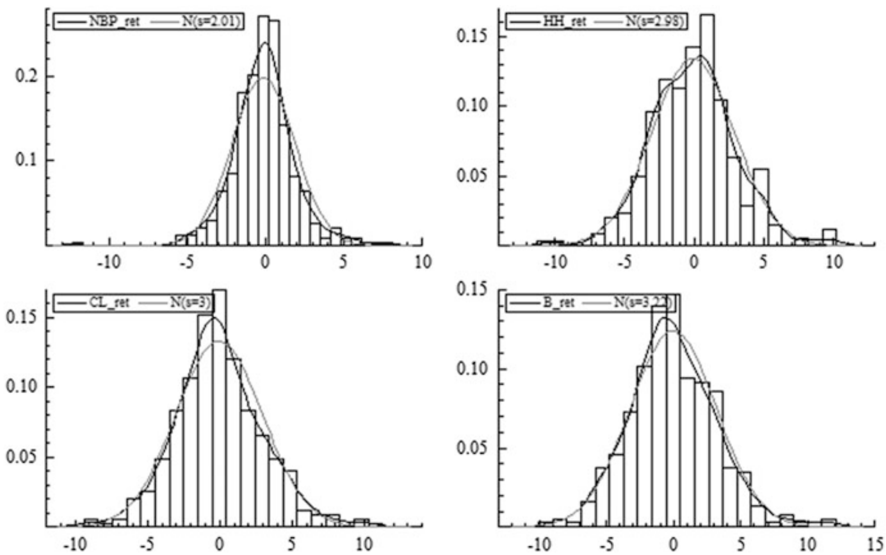

Fig. 3 The empirical distribution of returns of two natural gas and two crude oil futures contracts with normal reference

distribution is close to Normal but the results of the formal Jarque-Bera test (not reported here) indicate that the HH returns are not normally distributed.

We estimate the multivariate CCC-GARCH(1,1) model with Student's *t*-distribution. We choose constant conditional correlation model because of the relatively short time period that we take into consideration in our analysis. We use Student's *t*-distribution to account for leptokurtosis. After using various specifications of the univariate GARCH models for our series, the best fit is the GJR model for the NBP series and the basic GARCH model for other series. The γ parameter in the GJR model for NBP natural gas series is negative i.e. past positive shocks have greater impact on the volatility than the negative ones.

The value of the parameter $\rho_{NBP,HH}$ between the daily returns for two natural gas markets is insignificant and equals 0.0979. The more interesting result is that NBP and HH natural gas futures contract are both correlated with the listings of crude oil CL and B. The estimates of the correlation parameters $\rho_{NBP,CL}$, $\rho_{NBP,B}$ and $\rho_{HH,CL}$, $\rho_{HH,B}$ are significant. This suggests that investors from both natural gas derivative markets attach great importance to the situation on the crude oil futures markets. Our results confirm the role of oil price and the consequences of events in oil markets for the gas related market participants and investors. According to the sign of the correlation parameters, when oil price increases one can expect that on the same day the natural gas futures price will increase too.

The results of the Box-Pierce tests posted in Table 2 suggest that our model describes most of the existing dependencies. Only for the NBP returns series we still observe some ARCH effects in the standardized residuals.

We also check the validity of the assumption, that conditional correlations are constant in the selected period. Using the results of Tse (2000) and Engle and Sheppard (2001) tests posted in Table 3 we conclude that correlations are really time-invariant in the period from January 2015 to June 2016. There is no need to use a more sophisticated and parameterized dynamic conditional correlations DCC model developed by Engle (2002) or Tse and Tsui (2002). An attempt to fit DCC model (not reported here) confirms this conclusion.

4 Conclusions

The goal of the paper is to compare basic properties of selected time series and to investigate whether the listings of natural gas in the derivatives markets are linked. We checked that the probability distribution of returns is not normal and that there is a strong ARCH effect. Using the multivariate CCC-GARCH model we describe the linkages between several series. We are taking into account two returns series of natural gas futures contracts (Henry Hub and National Balancing Point) and two returns series of crude oil futures contracts (West Texas Intermediate and Brent) to measure the strength of linkages across two most important fossil fuels. We show that conditional correlation between the daily returns NBP and HH is constantly low. Instead, we found more intensive, constant linkages among the natural gas and crude oil returns.

Table 2 The estimation results of CCC-GARCH(1,1) model and the results of Box-Pierce tests on standardized residuals

Parameter	NBP	HH	CL	B
ω	0.3063 (0.1331)	1.7262 (0.9921)	0.4782 (0.2303)	0.4187 (0.1831)
α	0.2181*** (0.0835)	0.1276** (0.0573)	0.0746*** (0.0228)	0.0784*** (0.0293)
β	0.8060*** (0.0582)	0.6903*** (0.1372)	0.8754*** (0.0311)	0.8811*** (0.0315)
γ	−0.2010** (0.0910)	–	–	–
DF	8.9267 (1.4891)			
	Correlations $\rho_{i,j}$			
	HH	CL	B	
NBP	0.0979 (0.0606)	0.2449*** (0.0524)	0.2805*** (0.0513)	
HH		0.1727*** (0.0496)	0.1938*** (0.0509)	
CL			0.9200*** (0.0096)	
	P-values from Box-Pierce tests H0: No autocorrelation in standardized residuals			
lag = 5	0.9960	0.7154	0.5788	0.7277
lag = 10	0.9685	0.5393	0.7890	0.7185
	P-values from Box-Pierce tests H0: No autocorrelation in squared standardized residuals			
lag = 5	0.0128	0.9978	0.8937	0.2477
lag = 10	0.0868	0.9982	0.9713	0.5760

Note: The significance of the parameters α, β and γ estimates and correlations $\rho_{i,j}$ is tested. *** denotes the level of significance at 1%, ** denotes the level of significance at 5%, * denotes the level of significance at 10%

Table 3 The results of constant conditional correlation tests

Name of the test	Tse	Engle and Sheppard	
		lag = 5	lag = 10
p-value	0.3532	0.9928	0.7302

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Are Major Currencies Hedges or Safe Havens for Polish Stocks and Bonds?

Paweł Miłobędzki

Abstract I follow Baur and Lucey (Financ Rev 45:217–229, 2010) to examine whether the euro, the US dollar, the pound sterling, the Swiss franc and the Japanese yen are hedges or safe havens for Polish stocks and bonds. In doing so I use the daily sampled data on the major currencies exchange rates into the Polish zloty, the Warsaw Stock Exchange index WIG and the 10 year Polish government bonds covering the period 29 Nov 2005–31 Dec 2015. The analysis shows that all currencies are strong hedges for stocks and diversifiers for bonds in normal market conditions. When the markets extremely fall they serve as safe havens for stocks and either as diversifiers or weak hedges for bonds.

1 Introduction

In this paper I address the problem of whether the major currencies are hedges or safe havens for Polish stocks and bonds. I follow Baur and Lucey (2010) and Baur and McDermott (2010) who recognize an asset as a strong (weak) hedge if on average it is negatively (uncorrelated) correlated with stocks and bonds or their portfolio. An asset plays a role of strong (weak) save haven if it behaves in the same manner in times of market stress or turmoil. I argue that the demand for such assets in Poland stems from risks of its financial system and the dynamics of stocks and bonds markets. The major currencies can better serve as hedges and safe havens than precious metals do because they are stronger correlated than the latter with stocks and bonds in the normal and extreme market conditions. The analysis that follows is based on Baur and Lucey (2010) and is a novel for nothing has been known in this respect for Poland so far.

Secondary markets for stocks and bonds in Poland more than doubled in value in the last decade as illustrated by Fig. 1. The trade in stocks at the Warsaw Stock Exchange (WSE) rose from PLN 87.6 bn (21.8 billion euros) in 2005 to PLN 203.3 bn (47.4 billion euros) in 2015. The overall trade in bonds which include

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_5

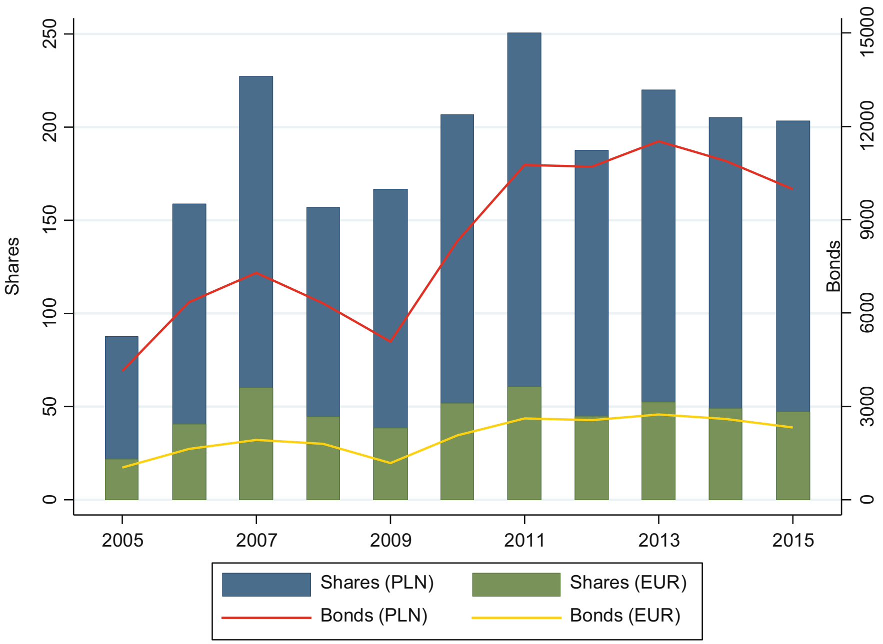

Fig. 1 Trade in shares (*left* axis) and government bonds denominated in a local currency (*right* axis) in Poland, 2005–2015 [Shares (PLN) and Bonds (PLN) are measured in billion of Polish zloty, Shares (EUR) and Bonds (EUR) in billion of euro. Data on trade in shares is extracted by the author from the WSE data bank (www.gpw.pl/analizy), data on trade in the Polish government bonds denominated in a local currency from the Ministry of Finance (www.finanse.mf.gov.pl/pl/web/wp/dlug-publiczny/rynek-wtorny-spw/struktura-inwestorow). Variables denominated in the Polish zloty are converted to euros using the exchange rates extracted from the Central Statistical Office of Poland (www.stat.gov.pl/wskazniki-makroekonomiczne/), all accessed on 27 Jul 2016]

the trade at the OTC, the Treasury BondSpot Poland and the WSE bond markets for the same period exhibited a sound rise from PLN 4148.6 bn (1030.6 billion euros) to PLN 9990.8 bn (2328.6 billion euros). This growth in value was interrupted by two country's recessions, however, and after that latter both markets have not fully recovered.[1] The primary reasons for their decline were restrictions set on the Polish pension funds system to cut gravely increasing debt of the public sector. The 2011 and 2013 amendments to the pension funds law significantly limited the amounts of money transferred to pension funds and their ability to invest in stocks and government bonds.[2] As the result the main WSE index WIG has stayed below its pre-recessions levels. Quite the opposite has evolved the opportunity cost of

[1]According to the OECD the recession periods for Poland include 2008M5–2009M11 and 2011M11–2013M4 (see data on the recession in Poland extracted from the Federal Reserve Bank of St. Louis, www.fred.stlouisfred.org/series/POLREC, accessed on 27 Jul 2016).

[2]Cf. Komisja (2016, ch IV.4, pp 46–57).

investing in bonds as measured by their mark-up over the German Bunds being a benchmark for the most liquid default free debt securities (see Fig. 2). Another important feature of the stock and bond markets in Poland manifested itself in many periods of increased volatility similar to that of the CBOE Volatility Index VIX based on the core index for US equities S&P 500 Index SPX which reflected the risks stemming from the US and other global markets. More interestingly, before the changes in pension funds system were introduced the stock market had been more volatile compared to its bond counterpart. Just after that the intense of market volatilities reversed and it has continued to be so until now. All these raised the risks of Polish financial system and established the need for a hedge and a safe haven for investors.

Most of the analyses in the field provided by the academia regard gold and other precious and commercial metals as either hedges or safe havens for various classes of assets listed on mature markets. Baur and Lucey (2010) find that gold is a safe

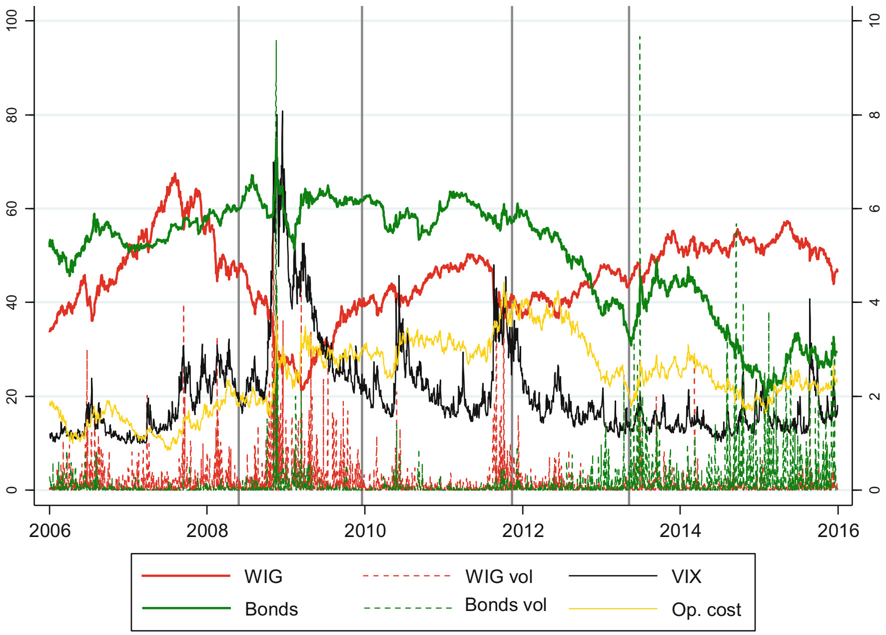

Fig. 2 WIG, VIX, volatility of the rate of return on WIG and 10 year Polish government bonds (*left* axis), the yield on 10 year Polish government bonds and the opportunity cost of investing in them (*right* axis), 29/11/2005–31/12/2015 [Data on WIG, the yield on 10 year Polish government bonds, the opportunity cost of investing in them, and the exchange rates are extracted by the author from Stooq (www.stooq.pl), data on VIX and the recession in Poland from the Federal Reserve Bank of St. Louis (www.fred.stlouisfred.org), all accessed on 27 Jul 2016. WIG ($\times$ 1000) and VIX are measured in points, the yield on 10 year Polish government bonds in percent. The opportunity cost of investing in the 10 year Polish government bonds is proxied by a difference between the yield on 10 year Polish government bonds and the German Bunds of the same maturity. Volatility is proxied by the daily squared returns of prices. The vertical solid lines indicate the recession periods for Poland (2008M5–2009M11 and 2011M11–2013M4)]

haven for stocks, but not for bonds, in the US, the UK and Germany. Baur and McDermott (2010) show that gold plays the same role in the US and major European countries, but not in Australia, Canada, Japan and some emerging stock markets, namely in Brazil, China, India and Russia. Creti et al. (2013) prove the safe haven role of gold for the US. Joy (2011) reveals that gold acts as a hedge for the major dollar-paired exchange rates. Reboredo (2013) notices that gold can be regarded as a safe haven against exchange rates in the US. Ciner et al. (2013) prove the same for the UK. The same role plays oil for stocks and bonds but for the specific periods like the 1987 stock market crash, the first Gulf War and after the 2007–2009 financial crisis. Agyei-Ampomah et al. (2014) reveal the role of metals for 13 sovereign debt bonds. They detect that gold is a (strong) hedge in the countries with serious debt issues, i.e. in Greece, Italy and Portugal, as well as that industrial metals offer a stronger hedge against the adverse movements in sovereign debt prices than gold or any other precious metal. Since the safe haven and hedge properties vary across bonds they recommend a bond-metal mix strategy to protect investors' wealth against extreme losses in the government bond markets. Finally, Grisse and Nitschka (2015) find a safe haven characteristics of the Swiss franc against major currencies except for the US dollar, the pound sterling and the Japanese yen.

In this paper I examine whether the euro, the US dollar, the pound sterling, the Swiss franc and the Japanese yen are hedges or safe havens for the Polish stocks and bonds. I use the major currencies instead of gold and other precious metals on almost pure empirical basis. The reason is twofold.

First, all currencies appear to be negatively correlated with the stock prices both in the whole analyzed period (2005–2015) and during the recessions so that they are ideal candidates for being either hedges or safe havens for stocks (see Fig. 3). The estimates of Spearman correlation coefficient among the rates of return on exchange rates and stock prices compared to that for stocks and gold, which is also negative, occur to be much stronger (see Table 1). The estimates of Spearman correlation coefficient for rates of return on stock prices and prices of such precious metals as silver, platinum and palladium are on average either positive (silver, 29/11/2005–31/12/2015; palladium, 29/11/2005–31/12/2015, 1/05/2008–30/11/2009, 1/11/2011–30/04/2013) or insignificantly differ from zero (platinum, 29/11/2005–31/12/2015, 1/05/2008–30/11/2009, 1/11/2011–30/04/2013; silver, 1/05/2008–30/11/2009, 1/11/ 2011–30/04/2013). That is why at most times the major currencies are supposed to better serve as either diversifiers or (weak) hedges for stocks. The estimates of Spearman correlation coefficient for rates of return on exchange rates and bond prices on average are medium positive so the major currencies may all serve as diversifiers. All other metal prices, which are positively albeit weaker correlated with the bond prices, may do the same job except for silver (29/11/2005–31/12/2015, 1/11/2011–30/04/2013) and palladium (29/11/2005–31/12/ 2015, 1/05/2008–30/11/2009).

Second, Calvo and Mendoza (2000) suggest that investors faced with losses in the emerging markets will tend to shift their portfolios towards the average portfolio. When doing so in Poland they will exit the stock and bond markets primarily

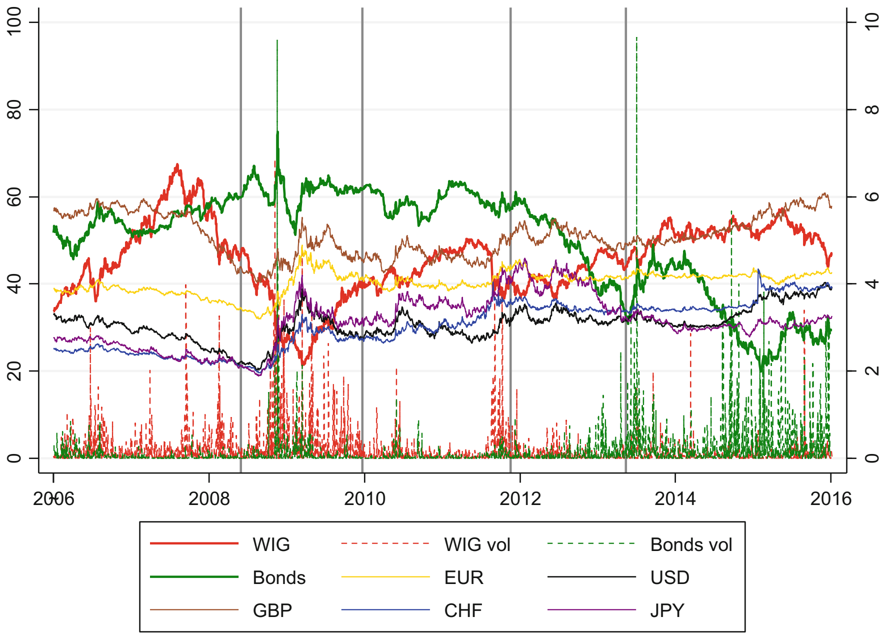

Fig. 3 WIG, volatility of the rate of return on WIG and 10 year Polish government bonds (*left* axis), the yield on 10 year Polish government bonds and the exchange rates of major currencies into the Polish zloty (*right* axis), 29/11/2005–31/12/2015 [Data on the exchange rates are extracted by the author from Stooq (www.stooq.pl), accessed on 27 Jul 2016. The exchange rates are measured in PLN for 1 unit of foreign currency except for the Japanese yen for which the unit of measurement is PLN/100 JPY]

Table 1 Estimates of the Spearman correlation coefficient[a]

	Sample period					
	29/11/2005–31/12/2015		1/05/2008–30/11/2009		1/11/2011–30/04/2013	
Currency/metal	Stocks	Bonds	Stocks	Bonds	Stocks	Bonds
Euro	**−0.3467**	**0.3087**	**−0.3527**	**0.3743**	**−0.4373**	**0.3525**
US dollar	**−0.3126**	**0.2435**	**−0.3860**	**0.3619**	**−0.4609**	**0.2827**
Pound sterling	**−0.2658**	**0.2333**	**−0.2768**	**0.2744**	**−0.3883**	**0.2821**
Swiss franc	**−0.3894**	**0.2441**	**−0.4167**	**0.3484**	**−0.4499**	**0.2919**
Japanese yen	**−0.3928**	**0.1886**	**−0.4664**	**0.3262**	**−0.4437**	**0.2274**
Gold	**−0.1198**	**0.0788**	**−0.2352**	**0.2545**	**−0.1759**	**0.1067**
Silver	**0.0718**	−0.0044	0.0289	**0.1328**	0.0400	−0.0301
Platinum	−0.0028	**0.0446**	0.0193	**0.1089**	−0.0233	*0.0918*
Palladium	**0.1016**	−0.0019	**0.0968**	0.0411	*0.0937*	*0.0937*

[a]Figures in bold (italics) indicate significance at the 5 (10)% significance level

throughout the FX market disturbing the exchange rate of a local currency and making it more volatile.[3] That might be the case since foreign investors are major players in both markets.[4]

The econometric analysis that follows is based on Baur and Lucey (2010). I run regressions in which exchange rate returns are regressed on stock and bond returns and two interaction terms and test whether the currencies serve as hedges or safe havens if the stock or bond markets fall or exhibit extreme negative returns. In doing so I use the daily sampled data on the major currencies exchange rates into the Polish zloty, the WSE index WIG and the 10 year Polish government bonds covering the period 29 Nov 2005–31 Dec 2015. The analysis shows that all currencies are strong hedges for stocks and diversifiers for bonds in normal market conditions. When the markets extremely fall they serve as safe havens for stocks and either as diversifiers or weak hedges for bonds.

The reminder of the paper is organized as follows. In Sect. 2 I introduce the econometric model that is used for testing the hedge and safe haven properties of major currencies for the stocks and bonds in Poland and show the way it is estimated and validated. Section 3 contains the empirical results. Section 4 briefly concludes.

2 Econometric Model

The regression model is

$$r_{k,t} = a + b_1 r_{stock,t} + b_2 r_{stock,t(q)} + c_1 r_{bond,t} + c_2 r_{bond,t(q)} + dg_t + e_t, \qquad (1)$$

where: $r_{k\,,\,t}$, $r_{stock\,,\,t}$, $r_{bond\,,\,t}$ are the returns on exchange rates, stock and bond prices, respectively. The terms $r_{stock\,,\,t(q)}$ and $r_{bond\,,\,t(q)}$ account for asymmetries of positive and negative extreme shocks stemming from the falling markets. In case the stock or bond return is in between the $q\%$ and $(q-p)\%$ quantiles the value of $r_{stock\,,\,t(q)}$ and $r_{bond\,,\,t(q)}$ is zero and it is one otherwise. I further assume that contemporaneous and lagged stock or bond prices can affect the exchange rates as well as there is any feedback from the exchange rates to the stock and bond prices. The term g_t is a

[3]According to BIS Triennial Central Bank Survey (2016) the April 2016 daily average of OTC foreign exchange turnover in Polish zlotys amounted to USD35.0 (9.1) bn out of which USD12.0 (2.083) and 18.0 (5.958) bn comprised spot transactions and fx swaps, respectively. Figures in brackets concern the domestic market. Data extracted by the author from the Bank of International Settlements (http://www.bis.org/publ/rpfx16.htm), accessed on 27 Jul 2016.

[4]In 2015 foreign investors traded at the WSE 51.81% of all stocks. As of the last trading day they also kept as much as 39.48% of all government bonds denominated in the local currency (figures extracted by the author from the WSE statistical data bank (www.gpw.pl/analizy) and the web site of the Mistry of Finance (www.finanse.mf.gov.pl/pl/web/wp/dlug-publiczny/rynek-wtorny-spw/struktura-inwestorow), both accessed on 27 Jul 2016).

dummy taking value one for 15 Jan 2015 when the Swiss National Bank removed a cap of 1.2 Swiss francs to the euro and allowed its currency to sharply appreciate. Finally, in order to better capture the arrival of new information into the markets I assume error term e_t follows the asymmetric GJR-GARCH(r , s) process of Glosten et al. (1993)

$$h_t = \alpha + \sum\nolimits_{i=1}^{r} \beta_i e_{t-i}^2 + \sum\nolimits_{i=1}^{r} \gamma_i e_{t-i}^2 D(e_{t-1} > 0) + \sum\nolimits_{j=1}^{s} \delta_j h_{t-j}. \tag{2}$$

Now that if coefficient b_1 (c_1) is zero or negative it implies that the currency is a hedge for stocks (bonds) since the assets are uncorrelated with each other on average. The test for a safe haven hangs on parameters b_2 and c_2. The currency plays such a role if the total effect in extremely falling stock or bond markets is nonpositive, i.e. $b_1 + b_2 \leq 0$ holds for the stock market and $c_1 + c_2 \leq 0$ for the bond market. In case parameters b_1 and c_1 or sums $b_1 + b_2$ and $c_1 + c_2$ are positive the currency serves as a diversifier.

Model (1)–(2) is estimated using the quasi maximum likelihood method in Stata SE 13. Decisions regarding its GARCH part are made upon the Akaike (AIC) and the Schwarz Bayesian information criterion (BIC) as well as the Ljung-Box portmanteau test applied to the standardized residuals from Eq. (1) and their squares. The IGARCH effect is tested as well.

3 Empirical Results

Table 2 presents the results for model in Eqs. (1) and (2). The asymmetric GJR-GARCH of various r and s chosen upon the information criteria nicely exhibits the nature of the data.[5] The coefficient estimates for the average effect of stocks on the exchange rates is −0.1201 for the euro, −0.1837 for the US dollar, −0.1299 for the pound sterling, −0.1863 for the Swiss franc and −0.2958 for the Japanese yen. All estimates are significant at the 1% significance level. The coefficient estimates for bonds are 0.0843 for the euro, 0.1198 for the US dollar, 0.1080 for the pound sterling, 0.0750 for the Swiss franc and 0.0433 for the Japanese yen. These estimates imply that the major currencies are hedges for stocks and diversifiers for bonds in normal market conditions. For extreme negative stock returns falling in between the 5% and 2.5%, 2.5% and 1% as well as into the 1% quantiles the coefficient estimates for all currencies are either negative or positive albeit they insignificantly differ from zero. The overall effect for any inter-quantile is given by the sum of coefficient b_1 (c_1) and the relevant b_2 (c_2). For example, the

[5]The mean and the variance equations for all currencies are properly specified since the Ljung-Box portmanteau test statistic computed on the standardized residuals from Eq. (1) and their squares shows that they are not auto correlated up to the 30th order. The IGARCH effect is found for the US dollar and the Swiss franc models. The results of tests are available from the author upon a request.

Table 2 Estimation results for model in Eqs. (1) and (2)[a]

Parameter	Currency														
	Euro			US dollar			Pound sterling			Swiss franc			Japanese yen		
	Coeff. est.	St. err.	*t*-Stat.	Coeff. est.	St. err.	*t*-Stat.	Coeff. est.	St. err.	*t*-Stat.	Coeff. est.	St. err.	*t*-Stat.	Coeff. est.	St. err.	*t*-Stat.
a	−0.0034	0.0082	−0.14	−0.0113	0.0147	−0.77	−0.0052	0.0121	−0.43	0.0026	0.0105	0.25	−0.0145	0.0161	−0.90
b_1	−0.1201	0.0091	**−13.13**	−0.1837	0.0158	**−11.60**	−0.1299	0.0133	**−9.79**	−0.1863	0.0119	**−15.64**	−0.2958	0.0192	**−15.41**
b_2 (1%)	−0.0147	0.0277	−0.53	−0.0167	0.0606	−0.28	−0.0012	0.0397	−0.03	0.0141	0.0329	0.43	−0.0558	0.0643	−0.87
b_2 (2.5%)	−0.0109	0.0352	−0.31	−0.0318	0.0535	−0.59	−0.0350	0.0465	−0.75	0.0081	0.0435	0.85	−0.0190	0.0688	−0.28
b_2 (5%)	0.0148	0.0284	0.52	−0.0032	0.0587	−0.05	0.0287	0.0522	0.55	0.0624	0.0394	1.58	−0.0248	0.0650	−0.38
c_1	0.0843	0.0090	**9.36**	0.1198	0.0179	**6.70**	0.1080	0.0138	**7.84**	0.0750	0.0105	**7.11**	0.0433	0.0164	**2.64**
c_2 (1%)	−0.0417	0.0186	**−2.24**	−0.0972	0.0415	**−2.34**	−0.0681	0.0333	**−2.05**	−0.0614	0.0232	**−2.65**	−0.0503	0.0379	−1.33
c_2 (2.5%)	−0.0474	0.0198	**−2.40**	−0.1397	0.0353	**−3.95**	−0.0687	0.0323	**−2.12**	−0.0338	0.0254	−1.33	−0.0597	0.0381	−1.57
c_2 (5%)	−0.0465	0.0216	**−2.16**	−0.0880	0.0368	**−2.39**	−0.0885	0.0346	**−2.56**	−0.0411	0.0256	−1.60	−0.0382	0.0414	−0.92
d										18.2396	1.0766	**16.93**			
	Conditional volatility														
α	0.0003	0.0002	*1.69*	0.0032	0.0015	**2.07**	0.0052	0.0024	**2.20**	0.0034	0.0014	**2.48**	0.0070	0.0039	*1.78*
β_1	1.6400	0.0710	**23.11**	0.5040	0.1217	**4.14**	0.4639	0.2021	**2.30**	0.9850	0.0856	**11.51**	0.4308	0.1449	**2.97**
β_2	−0.6513	0.0670	**−9.72**	0.4338	0.1169	**3.71**	0.4497	0.1940	**2.32**						
β_3													0.1097	0.0437	**2.51**
β_5										−0.5704	0.1833	**−3.11**	0.7075	0.0805	**8.79**
β_6										0.4981	0.1262	**3.95**	−0.3571	0.1578	**−2.26**
γ_1	0.1215	0.0398	**3.06**	0.0510	0.0165	**3.08**	0.0441	0.0218	**2.02**	0.0725	0.0285	**2.55**			
γ_2	0.0387	0.0129	**−3.01**												
δ_1	0.0623	0.0217	**2.87**	0.0326	0.0102	**3.19**	0.0543	0.0135	**4.03**	0.0452	0.0143	**3.15**	0.1031	0.0248	**4.16**
δ_2	−0.0547	0.0223	**−2.46**												

[a]The estimates of parameters pertaining one-period lagged right hand side variables in the mean equation for the US dollar exchange rate are omitted to save the space. Out of them only the estimate for b_2 (5%) is significant at the 5% significance level and equal to 0.0447. Figures in bold (italics) indicate significance at the 5 (10)% significance level

Table 3 Testing results for the role of major currencies for the Polish stocks and bonds[a]

	Overall	Hypothesis			
Currency	Effect	Null	Alternative	t-Stat.	Conclusion
Euro	−0.1201	$b_1 = 0$	$b_1 < 0$	**−13.13**	Strong hedge
	−0.1053	$b_1 + b_2(5\%) = 0$	$b_1 + b_2(5\%) < 0$	**−3.89**	Safe haven
	−0.1210	$b_1 + b_2(2.5\%) = 0$	$b_1 + b_2(2.5\%) > 0$	**−3.83**	Safe haven
	−0.1348	$b_1 + b_2(1\%) = 0$	$b_1 + b_2(1\%) > 0$	**−4.23**	Safe haven
	0.0843	$c_1 = 0$	$c_1 > 0$	**9.36**	Diversifier
	0.0378	$c_1 + c_2(5\%) = 0$	$c_1 + c_2(5\%) > 0$	**1.91**	Diversifier
	0.0369	$c_1 + c_2(2.5\%) = 0$	$c_1 + c_2(2.5\%) > 0$	**2.11**	Diversifier
	0.0426	$c_1 + c_2(1\%) = 0$	$c_1 + c_2(1\%) > 0$	**2.56**	Diversifier
US dollar	−0.1837	$b_1 = 0$	$b_1 < 0$	**−11.60**	Strong hedge
	−0.1869	$b_1 + b_2(5\%) = 0$	$b_1 + b_2(5\%) < 0$	**−3.27**	Safe haven
	−0.2155	$b_1 + b_2(2.5\%) = 0$	$b_1 + b_2(2.5\%) > 0$	**−4.20**	Safe haven
	−0.2004	$b_1 + b_2(1\%) = 0$	$b_1 + b_2(1\%) > 0$	**−3.48**	Safe haven
	0.1198	$c_1 = 0$	$c_1 > 0$	**6.70**	Diversifier
	0.0318	$c_1 + c_2(5\%) = 0$	$c_1 + c_2(5\%) > 0$	0.98	Weak hedge
	−0.0199	$c_1 + c_2(2.5\%) = 0$	$c_1 + c_2(2.5\%) > 0$	−0.66	Weak hedge
	0.0226	$c_1 + c_2(1\%) = 0$	$c_1 + c_2(1\%) > 0$	0.61	Weak hedge
Pound sterling	−0.1299	$b_1 = 0$	$b_1 < 0$	**−9.79**	Strong hedge
	−0.1012	$b_1 + b_2(5\%) = 0$	$b_1 + b_2(5\%) < 0$	**−3.19**	Safe haven
	−0.1649	$b_1 + b_2(2.5\%) = 0$	$b_1 + b_2(2.5\%) > 0$	**−3.69**	Safe haven
	−0.1311	$b_1 + b_2(1\%) = 0$	$b_1 + b_2(1\%) > 0$	**−3.53**	Safe haven
	0.1080	$c_1 = 0$	$c_1 > 0$	**7.84**	Diversifier
	0.0195	$c_1 + c_2(5\%) = 0$	$c_1 + c_2(5\%) > 0$	0.61	Weak hedge
	0.0393	$c_1 + c_2(2.5\%) = 0$	$c_1 + c_2(2.5\%) > 0$	*1.34*	Diversifier
	0.0399	$c_1 + c_2(1\%) = 0$	$c_1 + c_2(1\%) > 0$	*1.33*	Diversifier
Swiss franc	−0.1863	$b_1 = 0$	$b_1 < 0$	**−15.64**	Strong hedge
	−0.1239	$b_1 + b_2(5\%) = 0$	$b_1 + b_2(5\%) < 0$	**−3.27**	Safe haven
	−0.1782	$b_1 + b_2(2.5\%) = 0$	$b_1 + b_2(2.5\%) > 0$	**−4.23**	Safe haven
	−0.1722	$b_1 + b_2(1\%) = 0$	$b_1 + b_2(1\%) > 0$	**−5.62**	Safe haven
	0.0750	$c_1 = 0$	$c_1 > 0$	**7.11**	Diversifier
	0.0339	$c_1 + c_2(5\%) = 0$	$c_1 + c_2(5\%) > 0$	*1.44*	Diversifier
	0.0412	$c_1 + c_2(2.5\%) = 0$	$c_1 + c_2(2.5\%) > 0$	**1.78**	Diversifier
	0.0136	$c_1 + c_2(1\%) = 0$	$c_1 + c_2(1\%) > 0$	0.64	Weak hedge
Japanese yen	−0.2958	$b_1 = 0$	$b_1 < 0$	**−15.41**	Strong hedge
	−0.3206	$b_1 + b_2(5\%) = 0$	$b_1 + b_2(5\%) < 0$	**−5.01**	Safe haven
	−0.3148	$b_1 + b_2(2.5\%) = 0$	$b_1 + b_2(2.5\%) > 0$	**−4.67**	Safe haven
	−0.3516	$b_1 + b_2(1\%) = 0$	$b_1 + b_2(1\%) > 0$	**−5.48**	Safe haven
	0.0433	$c_1=0$	$c_1 > 0$	**2.64**	Diversifier
	0.0051	$c_1+c_2(5\%)=0$	$c_1 + c_2(5\%) > 0$	0.12	Weak hedge
	−0.0164	$c_1+c_2(2.5\%)=0$	$c_1 + c_2(2.5\%) > 0$	−0.49	Weak hedge
	−0.0070	$c_1+c_2(1\%)=0$	$c_1 + c_2(1\%) > 0$	−0.20	Weak hedge

[a]Figures in bold (italics) indicate significance at the 5 (10)% significance level

overall effect for the 1% quantile for stocks is equal to −0.1348 for the euro, −0.2004 for the US dollar, −0.1311 for the pound sterling, −0.1722 for the Swiss franc and −0.3516 for the Japanese yen. It implies that in case in which the stocks exhibit extreme negative returns that are in the 1% quantile, the exchange rates of the US dollar and the Japanese yen to the Polish zloty strongly increases. In the same situation the euro and the pound sterling exchange rates increase is only slight and the increase of the Swiss franc exchange rate is moderate. Since the sums of coefficient estimates are nonpositive it implies that the currencies serve as safe havens for shocks exceeding the 1% quantile threshold. These results are further validated using test statistic

$$t(b_1 + b_2) = (b_1 + b_2)/\left[S^2(b_1) + S^2(b_2) + 2\mathrm{cov}(b_1, b_2)\right]^{1/2}, \tag{3}$$

where $S^2(b_i)$ and $\mathrm{cov}(b_i, b_j)$ stand for the variance and the covariance of parameter estimators, and its appropriate counterpart for the bonds, both of which under the null of weak hedge ($b_1 + b_2 = 0$, $c_1 + c_2 = 0$) are distributed as $N(0, 1)$ in large samples. Since the alternatives of interest for stocks and bonds are $b_1 + b_2 < 0$ (safe haven) and $c_1 + c_2 > 0$ (diversifier), respectively, the test is one-sided. Its results for the major currencies are gathered in Table 3. They indicate that all currencies are strong hedges for stocks and diversifiers for bonds in normal market conditions. When the markets extremely fall they serve as safe havens for stocks and either as diversifiers or weak hedges for bonds.

4 Conclusion

This paper examines the role of major currencies (the euro, the US dollar, the pound sterling, the Swiss franc, and the Japanese yen) for stocks and bonds in Poland in the period 2005–2015. As the rates of return on their exchange rates into the Polish zloty are stronger negatively correlated with that on stocks than that of gold the currencies can better serve as hedges and save havens for stocks than gold does. Their correlations with the rates of return on bonds are positive so that the currencies are ideal candidates for being diversifiers for bonds. The econometric analysis using the asymmetric GJR-GARCH model shows that the euro, the US dollar, the pound sterling, the Swiss franc and the Japanese yen are strong hedges for stocks and diversifiers for bonds in normal market conditions. In the extreme market conditions, however, they serve as safe havens for stocks and either as diversifiers or weak hedges for bonds.

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Copper Price Discovery on COMEX, 2006–2015

Marta Chylińska and Paweł Miłobędzki

Abstract We estimate a VEC DCC-MGARCH model on the weekly sampled price series of 3 mostly traded copper futures on COMEX maturing within 2, 3 and 4 months in the period 4 Jan 2006–30 Dec 2015 and find that they are co-integrated and symmetrically revert to their long run equilibrium relation. We also reveal the existence of Granger causality running in both directions for all pairs of maturities. More interestingly, we observe 3 periods of an increased conditional volatility of the returns on copper futures resulting from the change of market sentiment that is due to the fall of risk appetite after the release of the April 2006 Global Financial Stability Report, the collapse of the Lehman Brothers Holdings Inc. in September 2008, as well as the next stage of the Greek financial crisis preceding the agreement to write-off 50% of the Greek debt in October 2011. At all times their conditional correlations remain almost stable and are close to one, however.

1 Introduction

In this paper we analyze the copper price setting mechanism on Commodity Exchange Inc. (COMEX), the third largest in volume world's futures copper market. Since we observed that despite of the Global Financial Crisis (GFC) and other crises the prices of copper futures traded there in the recent decade closely commoved over time we argue that they remained co-integrated. We also suppose that in times of market stress and turmoil they exhibited similar but increased volatilities and lowered correlations. The novel of the paper is that it reports on the COMEX copper price setting from the aftermath of the GFC perspective.

COMEX was founded in 1933 through the merger of four smaller exchanges: the National Metal Exchange, the Rubber Exchange of New York, the National Raw Silk Exchange and the New York Hide Exchange. Since 1994 it has been a subdivision of the New York Mercantile Exchange (NYMEX) which is owned by

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_6

the Chicago Mercantile Exchange & Chicago Board of Trade (CME Group), the world's leading derivatives marketplace. COMEX is now the primary market of such precious and base metals as gold, silver, copper, aluminum, zinc and lead. As the US is the fourth largest producer and the second largest consumer of copper in the world the New York market plays an important role in its price discovery competing with the London Metal Exchange (LME) and the Shanghai Futures Exchange (SHFE) to dominate in this process [see Li and Zhang (2009), Hua et al. (2010), Mou (2014), Figuerola-Ferretti et al. (2014)].

The price setting process at COMEX is a subject of intensive research. A more recent literature on the issue is rather voluminous albeit the conclusions arrived to are somehow vague and depend on the periods studied and the frequency of data analyzed.

Agostini (2006) acknowledges the existence of two different copper pricing systems in the US before and after 1978. He notices that in the earlier system most of the domestic production of copper and an important share of imports were traded at prices set by the major US producers. In the latter system it was the COMEX price of refined copper to serve as a benchmark price for the producers.

Krehbiei and Adkins (1993) show that the spot and future prices of copper are co-integrated but they reject the no-risk premium unbiased expectations hypothesis. Hardouvelis and Kim (1995) detect a negative influence from margin requirements to market participation. Schwartz (1997) finds a strong copper price mean reversion. Kocagil (1997) notes that an increased speculation in futures markets stabilizes the volatility of spot price. Nowman and Wang (2001) reveal that the volatility of copper prices is highly dependent on their level. Casassus and Collin-Dufrenese (2005) observe the dependence of copper spot price level in convenience yields and conclude that this is consistent with the theory of storage. Chan and Young (2006) find in the latter pricing regime common jumps across the daily and weekly sampled cash and futures series. Roberts (2009) reveals peaks and troughs in the inflation adjusted prices for copper in the period Jan 1947–Dec 2007 and shows that the durations of expansions, contractions and full cycles are not purely random and happen to have some degree of cyclicality.

Fung et al. (2003) show for copper that COMEX plays a dominant role in transmitting information to the SHFE. Fung et al. (2010) find structural breaks in the copper futures price series between 2006 and 2008 in both markets. They also demonstrate that the New York and Shanghai markets are co-integrated and comparably efficient on a daily basis. Hua et al. (2010) reveal co-integration of these markets with the LME which dominates in the price discovery process. Hammoudeh et al. (2010), using the threshold co-integration approach of Enders and Siklos (2001) and Hansen and Seo (2002), show that the spot and futures copper prices at COMEX are asymmetrically co-integrated and they revert to their long-run equilibrium relation faster from the above than below of threshold. Aruga and Managi (2011) prove the existence of a long-run relationship between the futures, primary and copper scrap markets. From the causality tests they determine that the futures market plays an important role in transmitting price information to other copper markets.

Liu and An (2011), based on both synchronous and non-synchronous trading information from the SHFE futures and spot markets, the NYMEX/COMEX, CBOT and CME Globex futures markets, find that there is a bidirectional relationship in terms of price and volatility spillovers between the US and Chinese markets with the effect from the US to Chinese markets being stronger than that the other way around.

Rutledge et al. (2013) notice a strong correlation across COMEX, the LME and the SHFE which maintain a long-run equilibrium relationship. They argue that each market impacts foreign returns with lagged information. The London and New York markets positively influence each other while their impact on the SHFE is reversed in direction. Finally, Figuerola-Ferretti et al. (2014) report that over the past two decades China has dominated international commerce in copper and in response to this development the importance of the SHFE has increased. They conclude, however, that it is COMEX, followed by the SHFE, not the LME, that plays the most important role in copper price discovery.

As shown above most of the referenced analyses end before or around the 2008 crisis in financial markets. In this paper we go far beyond that point and focus on the intra COMEX price setting in the recent decade. We advance the research in the field in two respects. First, we test for the existence of long-run equilibrium relationship among prices of the most traded futures copper contracts and their multidirectional causality. Second, we incorporate into the analysis information stemming from turbulent markets. To this end we estimate a combined vector error correction and dynamic conditional correlation multivariate GARCH model (VEC DCC-MGARCH) on the weekly sampled price series of 3 copper futures maturing within 2, 3 and 4 months in the period 4 Jan 2006–30 Dec 2015 to find whether they are co-integrated and, if so, what is the speed of their reversion to the long-run equilibrium. We also test for the existence and direction of Granger causality for all pairs of maturities as well as we examine the intense of market conditional volatilities and correlations. We perform computations using Microfit 5 and Stata 13 SE. The data come from the Thomson Reuters.

The remainder of the paper proceeds as follows. In Sect. 2 we sketch a VEC DCC-MGARCH model and show the way it is estimated, validated and used for inference about the copper price dynamics. In Sect. 3 we discuss the results we have arrived to. The last section briefly concludes.

2 Model

To specify a model for the copper futures contract price dynamics we set off from that of risk premium in which, assuming market efficiency and no-arbitrage conditions, the time t price of contract maturing at time $t+k$, $f_{t+k,t}$, is equal to its spot price expected for time $t+k$, s_{t+k}, increased by the expected risk premium, π_{t+k} (Watkins and McAleer 2006):

$$f_{t+k,t} = E_t(s_{t+k}) + E_t(\pi_{t+k}), \tag{1}$$

where $E_t(\cdot) = E(\cdot|I_t)$ is the expectations operator conditional upon the information set available at time t and $k = 0, 1, \ldots, n$. Now suppose that expectations are rational, i.e. $E_t(s_{t+k}) = s_{t+k} + \varepsilon^s_{t+k}$, $E_t(\pi_{t+k}) = \pi_{t+k} + \varepsilon^\pi_{t+k}$, ε^s_{t+k} and ε^π_{t+k} are nonsystematic innovations, orthogonal to each other as well as orthogonal to all copper prices and premiums. Then the econometric model for futures price contract maturing at time $t+k$ becomes:

$$f_{t+k,t} = \phi_{0k} + \phi_{1k}s_{t+k} + \phi_{2k}\pi_{t+k} + \varepsilon_{k,t}, \tag{2}$$

where ϕ_{lk} are such structural parameters that $\phi_{0k} = 0$, $\phi_{1k} = 1$ and $\phi_{2k} = 1$, and $\varepsilon_{k,t} = \varepsilon^s_{t+k} + \varepsilon^\pi_{t+k}$ is an aggregate innovation (expectations error).[1] Suppose further that copper prices and premiums are endogenous $I(1)$ and exogenous $I(0)$ variables, respectively. In case the aggregate innovations are stationary, the spot and futures prices are co-integrated. So are their all lags and leads. In such circumstance, applying the Granger representation theorem to the set of Eq. (2) yields a vector error correction model (VECM) in the form (Engle and Granger 1987)[2]

$$\begin{aligned} \Delta f_{t+k,t} &= \sum_{l=0}^{n}\sum_{j=1}^{p-1}\alpha^{(k)}_{l,j}\Delta f_{t+k,t-j} + \sum_{s=1}^{n}\delta^{(k)}_s\widetilde{\varepsilon}_{t+s,t-1} + \xi_{l,t} \quad (k = 0, 1, \ldots, n), \\ \widetilde{\varepsilon}_{t+s,t} &= f_{t+s,t} - \phi_{0s} - \phi_{1s}f_{t+0,t} \end{aligned} \tag{3a}$$

where $\xi_{l,t}$ stands for an error term. Coefficients $\delta^{(k)}_s$'s exhibit the time t price responses of contracts maturing at time $t+k$ to the time $t-1$ departures from their long-run equilibrium relations, coefficients $\alpha^{(k)}_{l,j}$'s exhibit their time t price responses to their own past price changes at time $t-j$ ($l = k$) or to the time $t-j$ price changes in contracts maturing at time $t+l$ ($l \neq k$). Of a particular interest is the hypothesis stating that the price of contract maturing at time $t+l$ does not Granger-cause the price of that maturing at time $t+k$, i.e. $\alpha^{(k)}_{l,j} = 0$ for $l \neq k$.

An extension of model (3a) that allows for the dependency of contract prices in variance is the DCC-MGARCH of Tse and Tsui (2002) exhibiting the dynamics of $\xi_{l,t}$ innovations:

$$\xi_t = H^{0,5}_t v_t, \quad H_t = D^{0,5}_t R_t D^{0,5}_t, \tag{3b}$$

$$R_t = (1 - \lambda_1 - \lambda_2)R + \lambda_1\Psi_{t-1} + \lambda_2 R_{t-1}, \tag{3c}$$

where $\xi_t = [\xi_{0,t}, \ldots, \xi_{n,t}]$, v_t is a vector of i.i.d innovations, $H^{0.5}_t$ is the Cholesky factor of the time-varying conditional covariance matrix H_t, D_t is a diagonal matrix

[1] In case $\phi_0 \neq 0$, $\phi_1 \neq 1$, and $\phi_2 \neq 1$ the expectations are biased.

[2] Note that $f_{t+0,t} = s_t$

of conditional variances in which each element σ_{kt}^2 evolves according to a univariate GARCH(p_k, q_k) processes $\sigma_{kt}^2 = s_i + \sum_{j=1}^{p_k} \alpha_j^{(k)} \xi_{j,t-j} + \sum_{j=1}^{q_k} \beta_j^{(k)} \sigma_{k,t-j}^2$, R_t is the matrix of means to which the dynamic process in Eq. (3c) reverts, Ψ_t is the rolling estimator of the correlation matrix of $\widetilde{\xi}_t$ which uses the previous $n+1$ observations, λ_1 and λ_1 are parameters that govern the dynamics of conditional correlations such that $0 \leq \lambda_1 + \lambda_2 < 1$.

We estimate Eqs. (3a)–(3c) in two steps. First, we test for the order of integration of copper futures price logs using the unit root ADF-GLS test and stationarity KPSS test [see Elliott et al. (1996) and Kwiatkowski et al. (1992)]. Next, we fix order p of the VAR underlying short term model (3a) and test for the number of co-integrating vectors. To this end we employ the Johansen procedure [see Lütkepohl (2005), Chaps. 6–8]. Finally, in the second step we use the residuals from co-integrating relations to estimate a full VEC DCC-MGARCH model by the maximum likelihood (ML).

3 Empirical Results

We begin the analysis by examining the volume of copper futures contracts traded at COMEX from that maturing within one month, $M1$, through that maturing in 11 months, $M11$. Their box-plots for a weekly sampled trade are depicted in Fig. 1. As shown investors are most concerned with those maturing within 2, 3 and 4 months and the remaining maturities happen to be traded only occasionally. Interestingly, the position of upper hinges and adjacent lines suggests that the contract volume distributions are extremely skewed to the right. From the plenitude of outliers we conclude that at many times the intensity of trade is extremely high.

We plot the logarithmic price series of 3 mostly traded futures contracts against time in Fig. 2. As demonstrated the prices sharply fall in September 2008 due to the world's financial crisis originated by the collapse of Lehman Brothers Holdings Inc. After the slower recovery they have rather rarely passed through their mean levels which suggests that they are not stationary. The results of the ADF-GLS, the KPSS and the Zivot-Andrews endogenous structural break tests support this conjecture.[3] All 3 copper price log series are integrated of order one variables.[4]

Next, using the AIC information criterion we set the lag order $p = 4$ of the VAR system. Then, based on the maximal eigenvalue and trace test statistics we identify the existence of 2 co-integrating vectors.[5] So the log prices of 3 most traded copper futures contracts at COMEX follow a common stochastic trend.

[3] The results of these tests are available from the authors upon a request.

[4] We have also tested for symmetric vs. asymmetric co-integration on copper futures spreads using the threshold co-integration approach of Enders and Siklos (2001) but cannot reject the null of symmetry for various adjustment processes. This yields that a symmetric VECM should properly exhibit the dynamics of copper futures prices.

[5] The results of these tests are available from the authors upon a request.

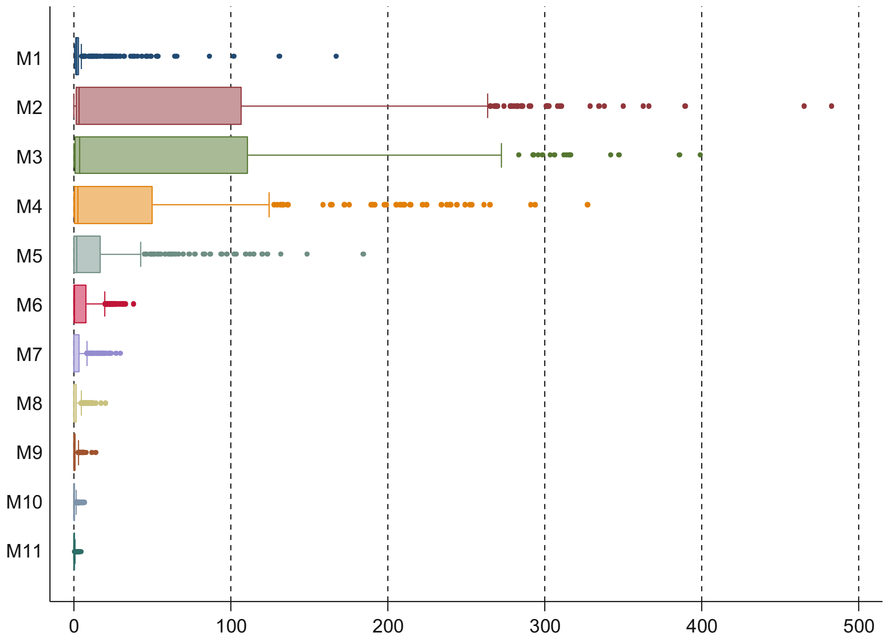

Fig. 1 Box-plots of copper futures volume traded at COMEX, 4/01/2006–30/12/2015 (x-axis is scaled in 1000s of lots per week)

We justify the co-integrating properties of copper price spreads setting over identifying restrictions on the parameters of both co-integrating vectors. Since the estimate of relevant likelihood ratio test statistic $LR(2) = 1.8022$ we do not reject this hypothesis at the 5% significance level. We also cannot reject the hypothesis stating that the intercept in second co-integrating vector exhibiting the risk premium for contract maturing in 4 months is zero for in this case $LR(3) = 2.0634$. So the estimated co-integrating vectors are: $\ln M2_t = 0.0003079 + \ln M3_t - \ln M4_t$ and $\ln M2_t = 0 - \ln M3_t + 0 \ln M4_t$.

Finally, using the residuals from co-integrating vectors we estimate model in Eqs. (3a)–(3c) by the ML. The results of utmost importance including those of validation and inference procedures are reported in Table 1. They are as follows:

1. The mean and variance equations of VEC DCC-MGARCH model are properly specified as the Ljung-Box portmanteau test applied on standardized residuals from Eq. (3a) and their squares shows that they are non-autocorrelated processes up to the 26th order (see the estimates of $LB(\cdot)$ test statistic).
2. In view of the data a dynamic version of VEC MGARCH is more likely than its constant correlation counterpart as the null hypothesis of $\lambda_1 + \lambda_2 = 1$ is rejected for its left-sided alternative. We do not reject the hypothesis of integrated MGARCH (see the estimates of IG and IG_k test statistics).

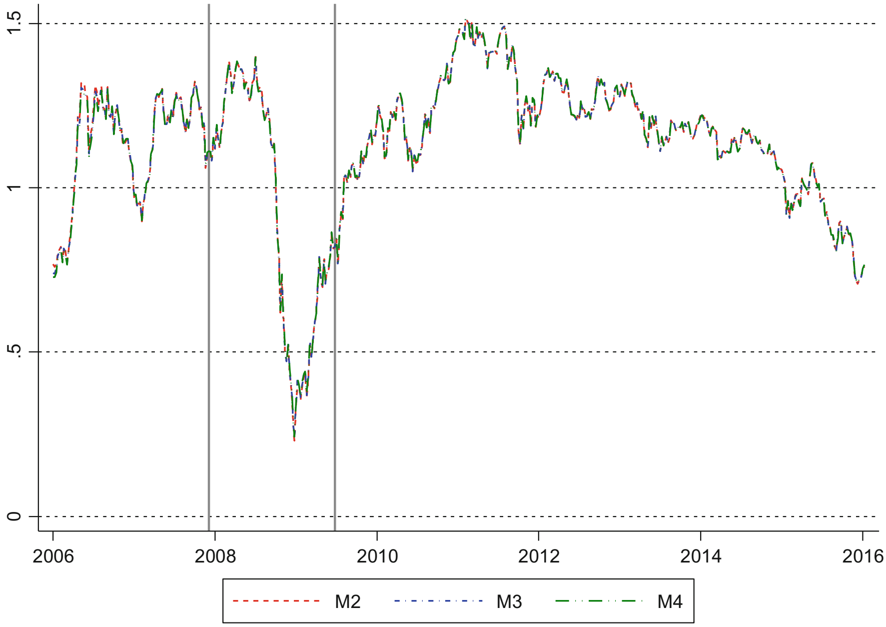

Fig. 2 Weekly logs of copper futures prices at COMEX, 4/01/2006–30/12/2015 [Wednesdays' close. The *vertical solid lines* indicate recession periods for the US (2007M12–2009M6), see the NBER's Business Cycle Dating Committee announcements on the US business cycle expansions and contractions dates at http://www.nber.org/cycles.html, accessed on 26 Jul 2016]

3. We reject the hypothesis stating that the past prices of futures copper contract maturing at time $t+k$ do not affect its time t price, $\alpha_{l,j}^{(k)}s = 0$ and $l = k$ (see the estimates of W_{kk} test statistic, $k = 2, 3, 4$).
4. For each pair (k, j) of maturities we reject the hypothesis stating that the price of copper futures contract maturing at time $t+j$ does not Granger cause the price of that maturing at time $t+k$, $\alpha_{l,j}^{(k)} = 0$ and $l \neq k$ (see the estimates of W_{kj} test statistic, $k \neq j$).
5. We reject the hypothesis stating that the price departures from their long run equilibrium relationship do not affect the time t price of copper futures contract maturing at time $t+k$, $\delta_1^{(k)} = \delta_2^{(k)} = 0$ (see the estimates of W_{k5} test statistic, $k = 2, 3, 4$).
6. We reject the hypothesis stating that the speed of contract maturing at time $t+k$ price reversion to the long-run equilibrium relationship is equal, $\delta_1^{(k)} = \delta_2^{(k)}$ (see the estimates of W_{k6} test statistic, $k = 2, 3, 4$).

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

Variable/ Test stat.	Equation					
	$\Delta \ln M2$		$\Delta \ln M3$		$\Delta \ln M4$	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
	Mean					
$\Delta \ln M2_{t-1}$	0.5550	0.0590	0.5147	0.0462	0.6550	0.0552
$\Delta \ln M2_{t-2}$	1.1057	0.0570	1.0820	0.0482	1.2072	0.0602
$\Delta \ln M2_{t-3}$	1.3403	0.0656	1.3027	0.0565	1.4238	0.0606
$\Delta \ln M3_{t-1}$	–2.2199	0.0950	–2.0540	0.0454	–2.1768	0.0643
$\Delta \ln M3_{t-2}$	– 2.2845	0.0849	–2.2392	0.0294	–2.4733	0.0638
$\Delta \ln M3_{t-3}$	1.1971	0.0939	1.1744	0.0433	0.9545	0.0629
$\Delta \ln M4_{t-1}$	1.6091	0.0920	1.4843	0.0576	1.4664	0.0625
$\Delta \ln M4_{t-2}$	1.2595	0.0783	1.2383	0.0458	1.3470	0.0563
$\Delta \ln M4_{t-3}$	– 2.5658	0.0785	–2.5037	0.0551	–2.4038	0.0649
$ecm_{1,t-1}$	3.8120	1.1063	2.9124	1.1001	3.2560	1.0833
$ecm_{2,t-1}$	– 2.0917	1.1475	–1.6170	1.1440	–1.8264	1.1352
	Variance					
e_{t-1}	0.1385	0.0386	0.1401	0.0394	0.1401	0.0393
σ_{t-1}	0.8225	0.0521	0.8213	0.0530	0.8214	0.0528
cons	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
	Validation					
Statistic	Estimate	*p*-value	Estimate	*p*-value	Estimate	*p*-value
IG_k	1.62	0.20	1.57	0.21	1.56	0.21
W_{k2}	835.95	0.00	1220.96	0.00	952.20	0.00
W_{k3}	1842.80	0.00	8477.68	0.00	3866.89	0.00
W_{k4}	1653.48	0.00	2685.47	0.00	3126.25	0.00
W_{k5}	13.36	0.00	7.82	0.02	10.10	0.01
W_{k6}	7.80	0.01	4.63	0.03	5.97	0.01
	Residuals					
$LB(1)$	0.6393	0.42	0.6604	0.42	0.5940	0.44
$LB(4)$	2.6492	0.62	2.4337	0.66	2.3363	0.67
$LB(13)$	15.6121	0.27	15.2200	0.29	15.1202	0.30
$LB(26)$	30.6438	0.24	29.7180	0.28	29.1612	0.30
	Sq. of residuals					
$LB(1)$	0.0253	0.87	0.0706	0.79	0.0190	0.89
$LB(4)$	0.7997	0.94	0.5683	0.97	0.5284	0.97
$LB(13)$	17.5390	0.18	16.9010	0.20	16.6686	0.21
$LB(26)$	22.1654	0.68	21.8921	0.69	21.9939	0.69

[a]IG_k—IGARCH in the variance equation for the price of contract maturing at time $t + k$, Wald test statistic under H_0 distributed as $\chi^2(1)$; W_{kj}—the price of contract maturing at time $t - j$ do not Granger cause the price of contract maturing at time $t + k$, Wald test statistic under H_0 distributed as $\chi^2(3)$; W_{ii}—the past prices of contract maturing at time $t + k$ do not affect its current price, Wald test statistic under H_0 distributed as $\chi^2(3)$; W_{k5}—the price of futures contracts departures from their long run equilibrium relationship do not affect the current price of contract maturing at time $t + k$, Wald test statistics under H_0 distributed as $\chi^2(2)$; W_{k6}—the speed of contract maturing at time $t + k$ price reversion to the long-run equilibrium relationship is equal, Wald test statistic under H_0 distributed as $\chi^2(1)$; $LB(k)$—Ljung-Box portmanteau test statistic for autocorrelation of order up to k, under H_0 distributed as $\chi^2(k)$; IG=1.95, GARCH(1) vs. IGARCH(1), Wald test statistic under H_0 distributed as $\chi^2(3)$; $VC1$=24736.32, VECM CCC-GARCH vs. VECM DCC-GARCH, Wald test statistic under H_0 distributed as $\chi^2(2)$; $VC2$= –3.15, no return of conditional variances to their mean levels, $\lambda_1 + \lambda_2 = 1$, t test statistic under H_0 distributed as $N(0,1)$ in large samples.

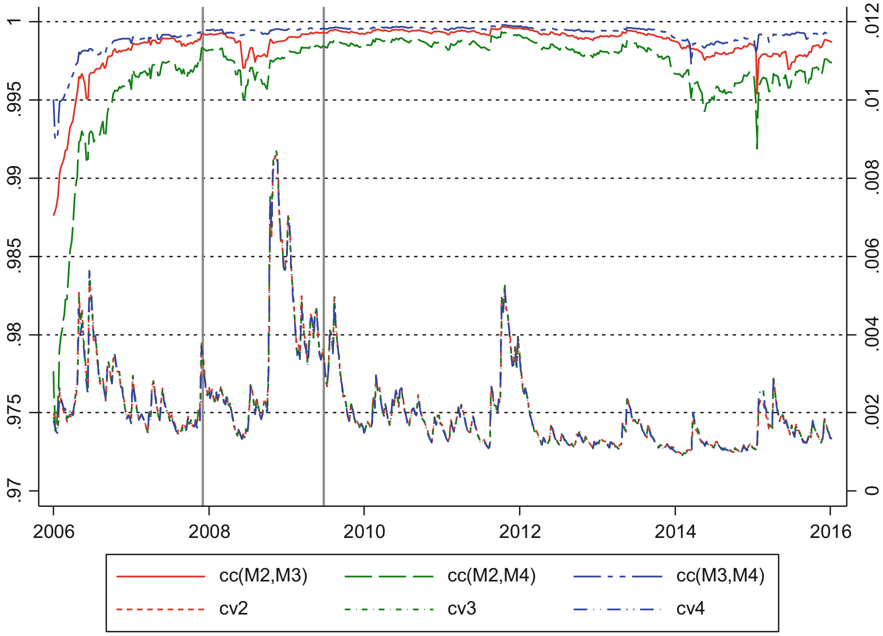

Fig. 3 Conditional correlations, $cc(\cdot)$, (*left* axis) and conditional variances, $cv(\cdot,\cdot)$, (*right* axis) of the weekly log rates of return on copper futures prices at COMEX, 4/01/2006–30/12/2015

We plot the conditional variances and covariances for the log rates of return on 3 most traded copper futures contracts at COMEX in Fig. 3. As shown there are 3 periods of an increased conditional volatility of the log returns resulting from the change of market sentiment that is due to the fall of risk appetite after the release of the April 2006 Global Financial Stability Report, the collapse of the Lehman Bros Holdings Inc. in September 2008, as well as the next stage of the Greek financial crisis preceding the agreement to write-off 50% of the Greek debt in October 2011. At all times their conditional correlations remain almost stable and are close to one, however.

4 Conclusion

This paper examines the price setting process for copper futures contracts at COMEX in the period 2006–2015. We find that investors are most concerned with trade of 3 contracts maturing within 2, 3 and 4 months. We show that the logs of their prices are co-integrated. Based on the VEC DCC-MGARCH model we reveal for all maturities that the past contract price influences its current price. From the Granger causality tests we conclude the existence of bidirectional causality running between all maturity pairs. We also observe 3 periods of an increased conditional volatility of the returns on copper futures resulting from the change of market sentiment that is due to the fall of risk appetite after the release of the April 2006 Global Financial Stability Report, the collapse of the Lehman Bros Holdings Inc. in September 2008, as well as the next stage of the Greek financial crisis preceding the agreement to write-off 50% of the Greek debt in October 2011. At all times their conditional correlations remain almost stable and are close to one.

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A Copula Approach to Backward-Looking Factors in Market Based Inflation Expectations

Piotr Płuciennik and Magdalena Szyszko

Abstract The paper presents an analysis of the dependences between inflation expectations extracted from inflation-linked swaps quoted for EUR and three other variables: exchange rate, oil prices and interbank rate. To determine the existence of the dependences, also for the outliners, the methodology based on the DCC-*t*-copula model is applied. Time span covers 2009–2015. Dynamic Kendall's τ and tail dependence coefficients for 2Y expectations prove to be negligible and counterintuitive. The explanations of the results can be found in the swap market features (illiquidity and negative inflation risk premium for some time) and the measure of expectations applied (being just the approximation of the expectations, highly volatile for daily quotations).

1 Introduction

The research presents the analysis of inflation expectations extracted from inflation-linked swaps (ILS) quotations for the Eurozone and three other variables: EUR/USD exchange rate, Brent oil prices and interbank rate (LIBOR 6M). Its novel contribution to the literature covers methodology that we apply: DCC-*t*-copula model (Patton 2006), and the use of daily market-based estimations of inflation expectations. The goal of this paper is to detect whether the inflation compensation extracted from ILS responds to the movements of the other economic variables. We decide to cover daily data as they should be more informative that any averaged data. To our best knowledge, this combination of data and the methodology is not presented in the literature.

According to the precrisis consensus on monetary policy, properly anchored expectations of future policy-maker actions are essential for successful conduct of

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_7

monetary policy (Clarida 2012). Expectations channel is, in turn, the most important way of affecting the economy (Woodford 2003). Regardless of vivid discussions on the drawbacks of modern theory and analytical models used by the central banks that re-erupted with the 2007 economic crisis, the importance of expectations have not faded. Moreover, as the new environment for monetary policy makers—zero lower bound (ZLB) appeared, further questions on expectations and their anchoring arise. This is why we decide to undertake the issue of expectations.

Theoretical (Mankiw and Reiss 2002) and empirical papers, including Forsells and Kenny (2004) research for the Eurozone, finds the expectations at least partially backward-looking. The existence of the backward-looking component in the expectations formation justifies the question on possible dependences of several macroeconomic variables and the expectations, especially during the outburst of economic crisis and enhanced application of the additional policy measures.

Central banks analyse inflation expectations of different economic agents: consumers, companies, professional economists or financial markets specialists. In order to gauge inflation expectations they refer to surveys (held among consumers, producers, specialists or professional forecasters) and market information. The best example of this practice is the heat map presented by the Bank of England (Domit and Jackson 2014). Each method of processing data in order to obtain quantified inflation expectations proxies has advantages and disadvantages broadly discussed in the literature (Ang et al. 2007; Cunningham et al. 2010).

In this paper we decide to analyse market information which represents inflation expectations, that is inflation-linked swaps quoted for EUR. We do not neglect the problems with this proxy of expectations but we find some encouraging features of this choice. Market measures do not depend on the model of the economy and its adequacy. They reflect immediate market response to the change of market conditions as they are high frequency data. Moreover, no a priori assumption about the pattern of expectations formation is needed. Market data which could serve as the approximation of expectations refer to actual economic decisions, while survey responses do not. In fact, corporations with revenues linked to the inflation (including utilities and retailers) use swap market to hedge against the risk of low inflation, while corporations with liabilities linked to the inflation (e.g. pension funds and life insurance corporations) use it to hedge against the risk of high inflation (ECB 2003). Moreover, inflation swaps are quoted for different maturities whereas surveys among consumers and businesses—if they are held—are usually conducted for 12M horizon. The variety of horizons opens the possibility to compare the results for short run inflation compesation and longer term inflation expectations.

In this research we analyse inflation-linked swaps together with three market prices: interbank rate, exchange rate and oil prices. We decided to analyse these variables as they are quoted daily (in contrast to many other macroeconomic indicators), and their possible impact on inflation and inflation expectations is confirmed in theory and empirical findings. Classical approach to monetary policy transmission mechanism via interest rates and exchange rates is well described in the literature and admitted by the central banks (BoE 1999; Kapuściński et al. 2016). The research confirms also the impact of the oil price changes on inflation process even if the it is dissipating or changing across-countries (Chen 2009). International factors, including oil prices, account for 35% of annual inflation variability (Neely and Rapach 2011). Empirical research on inflation expectations also confirms to some extent, the impact of oil prices on inflation expectations (Perez-Segura and Vigfusson 2016; Sussman and Osnat 2015). The effect depends on the shock and is different for precrisis and postcrisis period.

There are some research on factors influencing inflation expectations expressed by market measure that cover that financial market and monetary factors, cyclical conditions and some indicators of cost pressure in the economy (Ciccarelli and Garcia 2009; ECB 2011). The relation exists only for some variables and its strength depends on horizons. We admit complexity of these research, however we decide to focus on three factors that are curtail from standard monetary policy transmission point of view. We call them backward-looking as they are spot prices that should affect inflation rate in the future. Some research confirms their importance for formation of expectations amongst consumers (Szyszko and Płuciennik 2016).

This is why we hypothesize that the dependences between inflation expectations derived from ILS, exchange rate, oil prices and interest rate exist. Kendall's τ should be negative for the pairs of variables: exchange rate/inflation expectations and interest rate/inflation expectations. It should be positive for oil prices/inflation expectations. We expect that the strength of the dependence is time varying as the research period covers turbulent time for the Eurozone. Moreover, as crisis generates shocks, tail dependence coefficient (TDC) opens the possibility to analyses the dependences of extreme changes.

We selected these variables in order to examine their concordance with market-based measures of expectations with the use of DCC-*t*-copula. This is a novel methodological approach to explore this kind of data. In Antunes (2015) copulas are used to analyse the co-movement between daily revisions of short- and long-term inflation expectations expressed with market measures. But to our best knowledge, they were not use to analyse the relation of market based expectations and the other variables.

2 Methodology

An application of the multivariate GARCH model identifies no significant dependences between variables. As our time series are not normally distributed, this approach is not adequate. This is why we have decided to apply the DCC-*t*-copula model (Patton 2006). The following reasons justify the choice of the model:

- Time series are strongly leptokurtic. In multivariate GARCH models the dependence is detected with conditional correlation coefficient. The zero correlation indicates that there is no dependence, assuming the time series are normally distributed. If they are not, Pearson's correlation coefficient may lead to misleading conclusions (Lindscog 2000). Copula models give the possibility to use alternative measures of dependence. These measures are not sensitive to outliers.

- In dynamic copula models, in contrast to multivariate GARCH, the univariate innovation distributions do not have to be the same, and they need not to be elliptical. Table 1 shows that in our case empirical distributions vary across sample (kurtosis of EUR/USD equals only 4.89, whereas kurtosis of LIBOR 6M growths is 576). Actually, estimates of distribution parameters in univariate GARCH models suggest that the innovations are different for each time series. Furthermore, the optimal univariate model for the EUR/USD exchange rate has skewed Student t innovation distribution.
- Dynamic copula models give the possibility to investigate the dependences between extreme values by using tail dependence measures. We suppose that the linkages between variables can vary in response to extremal change of one variable.

The model is estimated in two steps. We use maximum likelihood method. In the first step, we fit the GARCH-type model to each univariate series $x_{i,t}$. Then we determine the $u_t = u_{1,t}, \ldots, u_{d,t}$, in which each $u_{i,t}$ is the value of cumulative distribution function for standardized residual series $\widetilde{\varepsilon}_{i,t}$. The model is described by the Eq. (1):

$$\begin{aligned} x_{i,t} &= \mu_{i,t} + y_{i,t}, \\ y_{i,t} &= \sigma_{i,t}\varepsilon_{i,t}, \\ \varepsilon_{i,t} &\sim iid(0,1), \\ u_{i,t} &= F_i(\widetilde{\varepsilon}_{i,t}), \end{aligned} \quad . \tag{1}$$

Conditional mean $\mu_{i,t}$ is modelled as an AR model. For every $\sigma_{i,t}$ we consider standard GARCH models (Bollerslev 1986), GJR-GARCH (Glosten et al. 1993) and the IGARCH (Engle and Bollerslev 1986) with Student t, or GED innovation distribution with κ degrees of freedom or skewed Student t with κ degrees of freedom and the skewness parameter ξ (Hansen 1994).

In the second step, we fit the conditional t copula to u_t series, where the copula correlation matrix R_t is driven by the DCC model of Engle (2002) given by the Eq. (2).

Table 1. Descriptive statistics of modelled series

	Minimum	Maximum	Mean	Standard deviation	Skewness	Kurtosis
Inf. Exp.	−0.215	0.96	−9.9E-4	0.0423294	5.87143	141.571
EUR/USD	−2.99992	3.45224	−0.0169142	0.707866	0.142128	4.88931
Oil	−15.4917	19.8772	−0.0423507	2.15347	0.384429	11.3102
LIBOR 6M	−0.93938	0.94125	−2.67E-3	0.0344683	0.172137	576.685

$$C_{\upsilon,R_t}^t(u_t) = \int_{-\infty}^{t^{-1}(u_1)} \cdots \int_{-\infty}^{t^{-1}(u_d)} \times \frac{\Gamma\left(\frac{\upsilon+d}{2}\right)}{\Gamma\left(\frac{\upsilon}{2}\right)\sqrt{(\pi\upsilon)^d |R_t|}} \left(1 + \frac{\begin{pmatrix} x_1 \\ \vdots \\ x_d \end{pmatrix}^T R_t^{-1} \begin{pmatrix} x_1 \\ \vdots \\ x_d \end{pmatrix}}{\upsilon}\right)^{-\frac{\upsilon+d}{2}} dx_1 \cdots dx_d, \quad (2)$$

where $\Gamma(x)$ is the gamma function, $R_t = diag(Q_t)^{-1/2} Q_t diag(Q_t)^{-1/2}$. The positive-definite matrix Q_t is described by Eq. (3).

$$Q_t = \left(1 - \sum_{m=1}^{M} \alpha_m - \sum_{n=1}^{N} \beta_n\right)\bar{Q} + \sum_{m=1}^{M} \alpha_m \widetilde{u}_{t-m} \widetilde{u'}_{t-m} + \sum_{n=1}^{N} \beta_n Q_{t-n}, \quad (3)$$

where $\widetilde{u}_t = (\widetilde{u}_{1,t}, \ldots, \widetilde{u}_{d,t})$, and $\bar{Q}$ is the empirical correlation matrix e $\widetilde{u}_{i,t} = t_\upsilon^{-1}(u_{i,t})$ for each i and $t_\upsilon(\cdot)$ is the Student t cumulative distribution function with υ degrees of freedom.

3 Data

Four time series are considered:

1. **Inflation expectations**: fixed leg of ILS—the spread between inflation-linked interest rate swap and typical interest rate swap (both with two years maturity). It is our approximation of euro area inflation expectations in 2Y horizon[1]. This approach is applied in ECB (2003, 2011). We derive this data from Thomson Reuters database.
2. **Exchange rate**: the EUR/USD spot exchange rate (stooq.pl).
3. **Oil prices**: Brent spot oil price in US dollars (Thomson Reuters database).
4. **Interbank rate**: LIBOR 6M rate for Euro (stooq.pl).

The number of observations is 1943. Exchange rate, oil prices and interbank rate quotations are one day lagged. It makes it possible for the counterparties of swap transaction to account the information of their prices in the price of the contract. Time series are transformed into first differences as their levels are non-stationary. Table 1 presents their descriptive statistics.

[1]We tried estimated the model also for different swap maturities but no relation was detected.

Table 2. Estimation of univariate GARCH-type models

	Inf. exp.	EUR/USD	Oil	LIBOR 6M
Model	GARCH(1,1)	IGARCH(1,1)	GJR-GARCH(1,1)	IGARCH(1,1)
ω	0.050188 (−)	0.000442 (−)	0.007084 (−)	0.063464 (−)
α	0.050629 (0.0000)	0.040213 (0.0000)	0.020093 (0.0334)	0.842869 (0.0000)
β	0.944321 (0.0000)	0.959787 (−)	0.956853 (0.0000)	0.157131 (−)
γ	–	–	0.044881 (0.0009)	–
κ	1.443969 (−)	8.675737 (−)	1.241501 (−)	3.037941 (−)
ζ	–	−0.06132 (0.0555)	–	–

Parameter estimates and p-values in parentheses

Table 3. Estimation results of DCC-t-copula model

	Estimate	Std. error	t-Value	p-Value
υ	31.0071	7.603	–	–
α_1	0.0071	0.002	4.1339	0.0000
β_1	0.9862	0.004	263.8309	0.0000

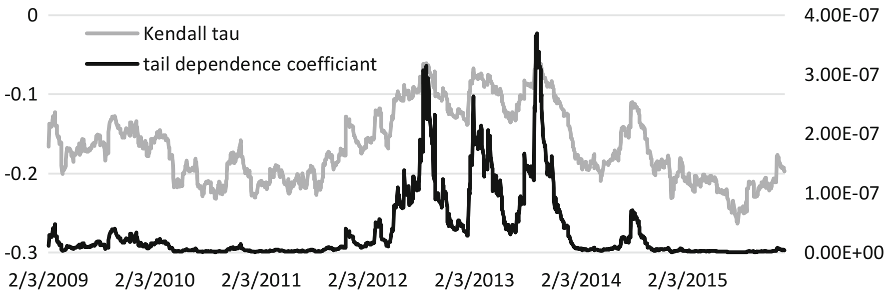

Fig. 1. Kendal's τ (*left* axis) and tail dependence coefficient (*right* axis): inflation expectation and EUR/USD exchange rate

4 Results

In Table 2 we present the results of the estimation of univariate GARCH-type models. After estimating their parameters, we determine the u_t on the basis of standardized residuals. The Student t copula with conditional covariance matrix explained by DCC(1,1) model is fitted to the $u_{i,t}$ series. The estimation results are presented in Table 3. Figures 1, 2 and 3 present the estimated Kendall's τ and tail dependence coefficients describing the interrelationships between inflation

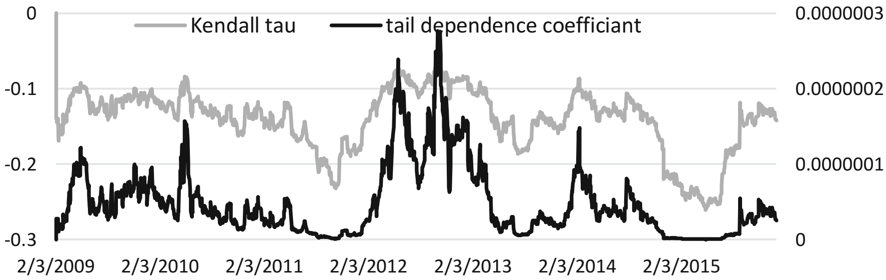

Fig. 2. Kendal's τ (*left* axis) and tail dependence coefficient: (*right* axis) inflation expectation and oil price

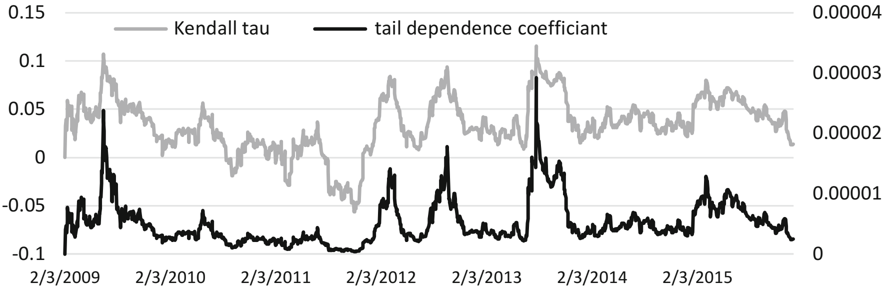

Fig. 3. Kendal's τ (*left* axis) and tail dependence coefficient (*right* axis): inflation expectation and LIBOR 6M for euro

expectations and EUR/USD exchange rate, oil price, and LIBOR 6M for EUR respectively.

5 Interpretation and Conclusion

The results do not confirm the hypothesis. The strength of dependences amongst three market prices and inflation expectations is negligible—if expressed formally by DCC. Moreover, their direction is counterintuitive. Due to extremely low level of TDC, it is also uninterpretable. Our conclusion is that the measure of inflation expectations which we apply cannot be interpreted as their proxy, if daily data are considered.

Central banks, while analysing this proxy of expectations, smooth and average daily quotations as inflation compensation based on swaps is volatile. Some research referring to averaged, lower frequency data proves that market-based measures of inflation expectations are informative predictors of future HICP developments (Grothes and Meyler 2015). So our inconclusive results bring as to the next possible step of the research—the use of averaged time series.

Other possible interpretation of the results covers the fact that market-based inflation expectations are influenced mainly by other factors: possibly financial market related. Ciccarelli and Garcia (2009) and ECB (2011) do not find predominant relation with market based measures of inflation expectations and our variables.

The final explanation of the results covers the characteristics of the swap market. It is quite illiquid even in regular circumstances. From the other hand, it does not discourage the ECB to consider market-based measures as informative, at least to some extent, as they are presented and analysed in its official documents. Moreover, the market can be dominated by speculative transaction rather than hedging. The premises of pricing the ILS contract could be far away from these arising from macroeconomic analysis.

The time span of our research covers quite turbulent time for financial markets and therefore the turnover and the characteristics of transactions may not reflect the standard situation. Some research shows that liquidity effects arising after the Lehman Brothers collapse have already faded. But the market is in unusual situation due to the negative inflation risk premium for the Eurozone (ECB 2014).

The research does not bring expected answers but we still see the potential in the data and the methodology. This is why the extension of the analysis with averaged data and some different time spans is in our current research agenda.

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Part II
Stock Market Investments

Risk Parity Portfolios for the Grouped Stocks

Agata Gluzicka

Abstract Portfolios in which the contribution of all assets are equally weighted are called the risk parity portfolios. Very often, the idea of risk parity is considered as a special type of diversification strategy. This approach had become very popular among investors, after the last economic crisis. At that time many portfolios perceived as well-diversified suddenly had become undiversified portfolios. Usually the risk parity is calculated for the individual stocks. In this article, the method of estimating the risk parity portfolios for grouped stocks was discussed. The presented model was applied to selected stocks belonging to different groups (sectors) and quoted on the Warsaw Stock Exchange. The main goal of empirical research was the analysis of risk parity portfolios calculated for the groups of stocks and also for the individual stocks. Additionally the risk parity portfolios were compared with the naive portfolios and minimum variance portfolios. All portfolios were compared according to the risk, rate of return and future profits.

1 Introduction

Most often the investment's portfolios are constructed in such a way that to receive the maximum profits with the minimum possible risk. However in many cases this method turns out to be ineffective. Numerous studies have shown that during the rapid changes on the investment market, we can receive better effects when we create portfolios concentrated on the risk contribution. A good example of such an approach are the risk parity portfolios, called also equal risk contribution portfolios. The most important property of these portfolios is that in parity portfolios not appear the dominant stock or group of stocks so we have portfolios with the maximum level of diversification (Qian 2005, 2006; Braga 2015).

The risk parity portfolios were analysed mainly because of the applied method to construct these portfolios (Chaves et al. 2011, 2012; Lohre et al. 2012; Maillard et al. 2010; Meucci 2009). Also the comparative research of the most important characteristics of risk parity portfolios were carried out. In these analysis the risk

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_8

parity portfolios were compared with the mean-variance portfolios, naive portfolios or most diversified portfolios (Chaves et al. 2011, 2012; Braga 2015). The methods of selection of stocks to equal risk contribution portfolios and the case of multi-period portfolios for the risk parity were also analysed (Gluzicka 2015a, b). Also the risk parity for selected linear measures of risk was analyzed (Gluzicka 2016).

In this article the problem of risk parity for groups of stocks was analyzed. In the second part, the definition of the risk parity for the single stock and the optimization model to construct the risk parity portfolios were presented. The next part is a description of the method how to construct the risk parity portfolios for the groups of stocks. The proposed method was applied to the selected groups of stocks from the Stock Exchange in Warsaw. The results of these research were discussed in the fourth part.

2 Risk Parity Portfolios for Individual Stocks

Risk parity portfolios are perceived as a compromise between well-diversified portfolios and equally weighted portfolios (naive portfolios). The idea of risk parity portfolios isn't new and by some researchers this method is seen as a special type of diversification strategy. Usually the investors' aim is to achieve the diversification in the sense of the capital allocation. However in the case of risk parity portfolios, diversification is achieved on the level of risk (risk contribution). This is due to the fact that in this approach we don't use any information about the volatility of the assets nor about the correlations between them.

Initially the risk parity portfolios were defined as portfolios of shares proportional to the inverse of the standard deviation of given stocks. Presently, these portfolios are called naive risk parity portfolios and can be apply only in one case—when all pairs of rates of return have the same correlation coefficient. As is well known, such a situation does not exist in real investment conditions (Qian 2005, 2006).

The another example of parity portfolios are a 60/40 portfolios. These portfolios consist of 60% of equity and 40% of bonds. Usually application of this approach guarantees portfolio with the high rate of return. However volatility of this portfolio can be dominated by the risk of equity. For this reason 60/40 portfolios are not portfolios with equal risk contribution in the standard meaning (Qian 2005, 2006; Bai et al. 2016).

Formally, risk parity portfolio is defined as a portfolio for which the total risk is divided equally on all components. Denote by x_i—the share of the i-th stock in portfolio, r_i—the rate of return of the i-th stock in portfolio, N—the number of stocks in portfolio. Moreover let's assume that the risk of portfolio is measured by the standard deviation defined as:

$$\sigma_p = \sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N} x_i x_j \sigma_{ij}} \tag{1}$$

where σ_{ij}—covariance between i-th and j-th stocks, $\sigma_{ii} = \sigma_i^2$—variance of the i-th stock and σ_p—standard deviation of portfolio.

Usually, to construct the risk parity portfolios the two following measures are used: the marginal risk contribution and the total risk contribution. Marginal risk contribution for the i-th stock (MRC_i) is defined as (Maillard et al. 2010; Chaves et al. 2011, 2012):

$$MRC_i = \frac{\partial \sigma_p}{\partial x_i} = \frac{\sum_{j=1}^{N} x_j \sigma_{ij}}{\sigma_p} \tag{2}$$

Total risk contribution (TRC_i) is equal to the product of the share of i-th stock in portfolio and the marginal risk contribution for this stock:

$$TRC_i = x_i \frac{\partial \sigma_p}{\partial x_i} = \frac{\sum_{j=1}^{N} x_i x_j \sigma_{ij}}{\sigma_p} \tag{3}$$

For a portfolio consisting of N stocks, if the marginal risk contribution is equal for all N components of the portfolio:

$$\frac{\partial \sigma_p}{\partial x_i} = \frac{\partial \sigma_p}{\partial x_j} \qquad \text{for } i, j = 1, 2, \ldots, N \tag{4}$$

then this portfolio is a minimum variance portfolio. Whereas in the case if the total risk contribution is the same for all N stocks in portfolio:

$$x_i \frac{\partial \sigma_p}{\partial x_i} = x_j \frac{\partial \sigma_p}{\partial x_j} \qquad \text{for } i, j = 1, 2, \ldots, N \tag{5}$$

we receive the risk parity portfolio.

We can use different methods to construct the risk parity portfolios. Some examples of these methods have been described by Chaves et al. (2011, 2012) and Lohre et al. (2012). Most often risk parity portfolios are constructed by using the optimization model proposed by Maillard et al. (2010). This model is following:

$$
\begin{aligned}
& \sum_{i=1}^{N}\sum_{j=1}^{N}\left(x_i\frac{\partial\sigma_p}{\partial x_i}-x_j\frac{\partial\sigma_p}{\partial x_j}\right)^2 \to \min \\
& \sum_{i=1}^{N}x_i = 1 \\
& 0 \le x_i \le 1 \qquad \text{for } \ i = 1, 2, \ldots, N
\end{aligned}
\tag{6}
$$

The above model is an example of the problem of sequential quadratic programming. The solution of such problems is possible among others in the Matlab software. The application of this model to the set of N stocks leads to the construction of portfolio composed of N non-zero shares. The contribution of risk for all components is approximately equal. So far conducted research indicate that the risk parity portfolios have a lower risk than naive portfolios (Braga 2015). Furthermore, portfolios with equal risk contribution have higher Sharpe ratio than the minimum variance portfolios (Chaves et al. 2011).

3 Risk Parity Portfolios for Grouped Stocks

Generally the risk parity concerns the individual stocks. It means that we are looking a portfolio whose risk is equally divided on all components. However, in the situation where we have a lot of potential components to portfolio, the more useful approach is to use the risk parity for groups of stocks (grouped risk parity). As a group we can take the stocks belonging to the same sector (like banks, telecommunications, industry etc.) or, for example, stocks with a specified market value. This approach is also useful in the situations when the investor describes the upper limit of the number of stocks in the portfolio or when the transaction costs are considered (Bai et al. 2016).

The risk parity portfolios for groups of stocks should fulfill the following condition: the total risk contribution is the same for all groups of stocks in portfolio. This condition can be expressed by the formula:

$$
\sum_{i\in G_s} x_i\frac{\partial\sigma_p}{\partial x_i} = \sum_{j\in G_t} x_j\frac{\partial\sigma_p}{\partial x_j} \qquad \text{for all groups of stocks } \ G_s \ \text{ and } \ G_t \tag{7}
$$

The grouped risk parity portfolio can be constructed by solving the following optimization problem:

$$
\begin{aligned}
&\sum_{s=1}^{k-1}\sum_{t=s+1}^{k}\left(\sum_{i\in G_s} x_i\frac{\partial\sigma_p}{\partial x_i}-\sum_{j\in G_t} x_j\frac{\partial\sigma_p}{\partial x_j}\right)^2 \to \min \\
&\sum_{i=1}^{N} x_i = 1 \\
&0 \le x_i \le 1 \quad \text{for } i = 1, 2, \ldots, N
\end{aligned}
\tag{8}
$$

where k is the number of groups of stocks, G_s—is the s-th group of stock. When we use model (8), two assumptions should be made: we invest in all groups of stocks and each stock can belong to only one group. The above model is a reformulation of the model (6), so it can be also solve by using the sequential quadrating programming.

The problem of risk parity portfolios for groups of stocks was also considered by the Bai et al. (2016). To solve this problem authors proposed the least-square approach.

4 Risk Parity Portfolios for Warsaw Stock Exchange

The model (8) has been applied to different groups of stocks from the Warsaw Stock Exchange. The aim of these research was an empirical analysis of the grouped risk parity portfolios on the background the other investment strategies. For each group of stocks four portfolios were constructed: grouped risk parity portfolio (GRPP), risk parity portfolio for the individual stocks (RPP), equally weighted portfolio (EWP) and the minimum variance portfolio (MVP). All portfolios were compared in terms of the level of risk (measured by the standard deviation), rates of return, Sharpe ratio and the future profits.

Below are presented only exemplary results for portfolios constructed for the daily rates of return of selected stocks from the 02 January 2010 to 30 June 2016. From among all stocks quoted on the Warsaw Stock Exchange 40 stocks were selected. All these stocks were quoted without breaks throughout the analysed period. These stocks represented different sectors: banks (11), energy (9), capital market (3), hotels and restaurants (4), media (8) and telecommunications (5).

Two cases were considered. In the first case, on the base of the data from 2010 two groups of stocks were selected. The first group consisted of the 20 stocks with the highest rates of return in 2010. To the second group 20 stocks with the lowest risk in 2010 (standard deviation) were selected. Portfolios were calculated for these two groups for the daily rates of return from the period 2011–2015. The data from 2016 were used to calculate the future profits. These portfolios were denoted as portfolios 2011–2015. In the second case the portfolios were constructed for each year separately—yearly portfolios. In every year also two groups of stocks were regarded. The first portfolios were constructed for the 20 stocks with the highest rates of return in the previous year. The second portfolios were constructed for the

Table 1 Characteristics of portfolios 2011–2015 (stocks with the highest rates of return)

Portfolio	Risk	Rate of return	Sharpe ratio
GRPP	0.000108	0.999672	3.23
RPP	0.000116	0.999653	3.18
EWP	0.000237	0.999651	1.46
MVP	9.0040E-05	0.999850	3.07

Table 2 Characteristics of portfolios 2011–2015 (stocks with the lowest risk)

Portfolio	Risk	Rate of return	Sharpe ratio
GRPP	9.4362E-05	0.999689	4.09
RPP	0.000100	0.999599	2.95
EWP	0.000237	0.999581	1.17
MVP	7.6858E-05	0.999720	2.43

Table 3 Characteristics of yearly portfolios 2015 (stocks with the highest rates of return)

Portfolio	Risk	Rate of return	Sharpe ratio
GRPP	7.4540E-05	0.999775	18.00
RPP	8.0904E-05	0.999267	13.56
EWP	0.000237	0.999262	4.67
MVP	6.1756E-05	0.999741	10.21

Table 4 Characteristics of yearly portfolios 2015 (stocks with the lowest risk)

Portfolio	Risk	Rate of return	Sharpe ratio
GRPP	9.2372E-05	0.998814	16.86
RPP	9.8099E-05	0.998752	16.51
EWP	0.000237	0.998737	6.88
MVP	7.6983E-05	0.999076	16.38

30 stocks with the lowest risk in the previous year. The future profits were calculated for the data from the next year. In every cases the number of groups (sectors) was equal 5 or 6.

First the value of risk, rates of return and the Sharpe ration for analyzed portfolios were compared. For all yearly portfolios the results were similar so as an example the results only for portfolios from 2015 were discussed. Received results for selected portfolios were presented in the Tables 1, 2, 3, and 4.

First of all we received the confirmation of properties characteristic for the risk parity portfolios. These portfolios are usually less risky than the naive portfolios. What's more the risk parity portfolios have a higher Sharpe ratio than the naive portfolios and the minimum variance portfolios. Both relations are true for portfolios constructed for each groups of data.

The comparison of both type of risk parity portfolios indicates that the risk parity portfolios for groups are a little less risky and have a higher rate of return and also higher Sharpe ratio than the risk parity portfolios for individual stocks. It should be notice that in the risk parity portfolios for individual stocks, all components have non-zero shares. While in the grouped risk parity portfolios we can received one or two shares equal zero. It means that these portfolios have lower level of diversification.

Additionally for all portfolios the future profits were calculated. It was assumed that 100,000 zł was invested in each selected portfolio in the last day of the year when the portfolio was constructed. Portfolio could be sold in any day of the next year. The Tables 5, 6, 7 and 8 present the ratio of the value of portfolios from the selected days of sells compared to 100,000 zł (value of portfolio in the day of purchase).

Similarly like in the previous comparison, the risk parity portfolios for groups are better than the risk parity portfolios for individual stocks. For most days of sale the value of portfolios for groups are a little high than the value of portfolios for

Table 5 Future profits of portfolios 2011–2015 (stocks with the highest rates of return)

Portfolio	04/01/16	11/01/16	18/01/16	25/01/16	01/02/16	08/02/16
GRPP	0.9805	0.9880	0.9797	1.0154	1.0119	0.9978
RPP	0.9740	0.9868	0.9688	1.0219	1.0100	0.9973
EWP	0.9747	0.9871	0.9692	1.0216	1.0103	0.9973
MVP	0.9717	0.9823	0.9821	1.0078	1.0122	0.9983

Table 6 Future profits of portfolios 2011–2015 (stocks with the lowest risk)

Portfolio	04/01/16	11/01/16	18/01/16	25/01/16	01/02/16	08/02/16
GRPP	0.9828	0.9859	0.9707	1.0030	1.0164	0.9976
RPP	0.9798	0.9904	0.9668	1.0124	1.0134	1.0014
EWP	0.9769	0.9893	0.9633	1.0124	1.0141	0.9988
MVP	0.9894	0.9891	0.9823	1.0070	1.0075	1.0041

Table 7 Future profits of yearly portfolios 2015 (stocks with the highest rates of return)

Portfolio	04/01/16	11/01/16	18/01/16	25/01/16	01/02/16	08/02/16
GRPP	0.9894	0.9896	0.9896	0.9986	1.0058	0.9841
RPP	0.9905	0.9934	0.9917	0.9930	0.9993	0.9805
EWP	0.9909	0.9933	0.9924	0.9937	0.9999	0.9821
MVP	0.9890	0.9907	0.9974	0.9942	1.0080	0.9852

Table 8 Future profits of yearly portfolios 2015 (stocks with the lowest rates of return)

Portfolio	04/01/16	11/01/16	18/01/16	25/01/16	01/02/16	08/02/16
GRPP	0.9927	0.9963	0.9910	0.9872	0.9948	0.9784
RPP	0.9921	0.9963	0.9909	0.9852	0.9936	0.9751
EWP	0.9935	0.9959	0.9917	0.9878	0.9959	0.9806
MVP	0.9804	0.9921	0.9957	0.9899	0.9982	0.9820

individual stocks. However in most cases the best future profits we received for minimum variance portfolio.

The above presented results were compared with the results obtained for the other groups of data. In these studies portfolios were constructed for different investment periods in the years 2005–2016. Considered portfolios were constructed for both daily and weekly rates of return. In the research different sets of potential components of portfolios were used. Among others the stocks of the mWIG40 index or sWIG80 index were analyzed and also the random selections of all stocks listed on the WSE were conducted several times. The results obtained in all these research is that we get better results by using the grouped risk parity instead of risk parity for individual stocks. Although the differences between the results for the analyzed investment's strategies proved to be statistically insignificant (appropriate statistical test were carried out), the conclusions of these study can be seen as an introduction to the further research on risk parity portfolios.

5 Summary

In the article the model for the grouped risk parity portfolios was proposed. This model was applied to selected data from the Stock Exchange in Warsaw. These empirical research indicated that grouped risk parity portfolios gave a better results than the parity portfolios for the individual stocks. Portfolios with equal risk for groups characterized higher rate of return and Sharpe ratio and the lower risk than the corresponding portfolios for individual risk. These portfolios are better even according to the future profits. The received results indicates to the further research concerning the risk parity for groups of stocks. These research will be concerning to the other measure of risk than the standard deviation and for the multi-period case. Also the portfolios with the short sales will be analyzed.

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Order Imbalance Indicators in Asset Pricing: Evidence from the Warsaw Stock Exchange

Sabina Nowak

Abstract The paper is devoted to the description of rates of return for stocks listed on the Warsaw Stock Exchange (WSE) basing on the information of order imbalance. The model employed in the research is a modified version of Fama and French (J Financ Econ 33(1):3–56, 1993) asset pricing model including additionally the 'order imbalance factor' built on the basis of the original imbalance indicators proposed by Nowak (Order imbalance on the Warsaw Stock Exchange, 2000–2012. Paper presented at the International Conference Financial Investments and Insurance – Global Trends and Polish Market, Wrocław University of Economics, Wrocław, 17–19 September 2014). The order imbalance is assumed as the temporary imbalance between buy and sell orders. Its estimation is preceded by an indication which side of the market was initiating the transaction, and a distinction between the so-called buyer- and seller-initiated trades [Lee and Ready (J Financ 46 (2):73–746, 1991), Ellis, Michaely and O'Hara (J Financ Quant Anal 35 (4):529–551, 2000)]. The imbalance indicators are calculated using the high frequency intraday data. The research hypothesis states that the proposed asset pricing model has good descriptive properties. The analysis is conducted for the selected stocks—index WIG20 constituents listed on the WSE over the period of 2000 to 2016. The model is validated using i.a. the underidentification test and the weak identification test [Kleibergen and Paap (J Econom 133(1):97–126, 2006)], overidentification test of all instruments [Hansen (Econometrica 50 (4):1029–1054, 1982)] and endogeneity test of endogenous regressors.

1 Introduction

The paper is devoted to the problem of asset pricing on the basis of high frequency data. We propose the model describing one single asset's rate of return which is a modified version of Fama and French (1993) asset pricing model, including additionally the 'order imbalance factor'. The order imbalance is assumed as a temporary imbalance between buy and sell orders. Its estimation is preceded by an

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_9

indication which side of the market was initiating each transaction. In the research the original imbalance indicators proposed by Nowak (2014) are employed.

The empirical analysis is conducted for the selected stocks, index WIG20 constituents, listed on the Warsaw Stock Exchange (WSE) over the period of 2000 to 2016. The research hypothesis states that including in the asset pricing model the explanatory variable reflecting the imbalance of the single asset's market improves the descriptive properties of the model.

The model is validated using i.a. the underidentification test and the weak identification test (Kleibergen and Paap 2006), overidentification test of all instruments (Hansen 1982) and endogeneity test of endogenous regressors.

The remainder of the paper is organized as follows. Sect. 2 provides a brief literature review. Section 3 presents the definition of the order imbalance and describes the different methods of classification the transactions for buyer- and seller-initiated ones. It also reminds the original conceptualization of the imbalance indicators presented in the previous work of the author (Nowak 2014). Section 4 introduces the proposed three-factor asset pricing model, including the market factor, the factor reflecting the size of the company and the order imbalance factor. Section 5 presents the empirical research methodology and procedure. Section 6 reports the major results, briefly summarizes the survey and indicates the areas for the future research.

2 Brief Literature Review

The contributions of the paper are twofold. First, it contributes to the literature of market microstructure, since the temporary imbalance between buy and sell orders plays an important role in the stock prices formation process. Second, it contributes to the broad strand of literature related to asset pricing.

The relation between the order imbalance and the rates of return of individual stocks listed on the NYSE in the period of 1988–1998 was discussed in the paper of Chordia and Subrahmanyam (2004). The authors discovered the significant impact both of the lagged and contemporaneous order imbalances on the daily rates of return in the short-term horizon. They emphasized the accuracy of using order imbalance as a measure of trading activity, instead of volume, which '*alone is absolutely guaranteed to conceal some important aspects of trading*' (Chordia et al. 2002). It is pertinent to note that in both papers mentioned above the aggregate market-wide order imbalance measures are employed. On the contrary, we propose the order imbalance indicators estimated for each stock individually. However, all the papers represent the market microstructure literature based on the high frequency data and reflect order imbalance' contribution to the stock prices formation process.

The literature referring to asset pricing using multifactor asset pricing models is large and comprehensive. Nonetheless, Fama and French in one of their most recent works (Fama and French 2015) argue that there is still a place for some extensions:

the authors add two new factors to the well-known three factor model, reflecting respectively the profitability and investment opportunities of the company. Empowering by their findings and discussion of the previous results [see Fama and French (2015) and the references therein] we propose an original approach basing on the high frequency intraday data and the concept of order imbalance as an innovative factor of the company's activity and performance.

3 Definition of Order Imbalance

There are two major reasons of the stock price changes described in the literature: arrival of the new information, either public or private, on the financial market and the temporary imbalance between buy and sell orders. The latter reason is frequently ignored: some academic researchers argue that there is no imbalance (in volume) since the volume bought by some traders is always equal to the volume sold by others (Hopman 2007). Thus, in order to measure the imbalance existing on the market, the indication of the side initiating the transaction and a distinction between the so-called buyer- and seller-initiated trades should be made (Lee and Ready 1991; Ellis et al. 2000). Counting the number of buyer- and seller-initiated transactions enables to indicate which part of the market—the buyer or the seller—is more eager to trade. It is worth to note that such a distinction is useful only on the markets where limit orders predominate. Many submitted orders remain then unexecuted, hence the existence of an imbalance (in volume) is understood in terms of submission, and not execution (Nowak 2014).

There are four main trade classification rules discussed in the literature: quote rule, tick rule, Lee-Ready rule (Lee and Ready 1991) and Ellis et al. rule (Ellis et al. 2000). Those rules allow to distinguish between the buyer- and seller-initiated trades. They were described in detail and compared to each other in the work by Nowak (2014). In the same paper three groups of the original imbalance indicators were proposed (compare the summary in Table 1).

The imbalance indicators within group I reflect respectively: ratio of a number of transactions initiated both by buyers and sellers in the whole number of executed trades (*imb1*), ratio of number of buyer-initiated transactions in the number of trades initiated either by buyers or sellers (*imb2*), ratio of difference between buyers- and sellers-initiated transactions in the number of trades initiated either by buyers or sellers (*imb3*). The indicators within the groups II and III were constructed analogously referring respectively to the volume and the value of trades. Estimation of the ratios' values demanded counting the whole number of transactions initiated by both sides of the market and indeterminate within each day.

The side initiating a transaction was denoted according to the quote rule, which classifies the trades by comparing the transaction price to the mid-point price at time t. The transaction price was approximated by close price. The mid-point price was calculated as the arithmetic mean of the lowest price P_t^l and the highest price

Table 1. Imbalance indicators proposed by Nowak (2014)

Group	Name and formula of indicators
I	$imb1 = \frac{d1+d2}{d1+d2+d3}$, $imb2 = \frac{d1}{d1+d2}$, $imb3 = \frac{d1-d2}{d1+d2}$
II	$imb4 = \frac{v1+v2}{v1+v2+v3}$, $imb5 = \frac{v1}{v1+v2}$, $imb6 = \frac{v1-v2}{v1+v2}$
III	$imb7 = \frac{w1+w2}{w1+w2+w3}$, $imb8 = \frac{w1}{w1+w2}$, $imb9 = \frac{w1-w2}{w1+w2}$

Explanations: *d1* (*d2*, *d3*)—number of transactions initiated by the buyers (sellers, not classified) during one trading day, *v1* (*v2*, *v3*)—volume of transactions initiated by the buyers (sellers, not classified) during one trading day, *w1* (*w2*, *w3*) —value of transactions initiated by the buyers (sellers, not classified) during one trading day. The value of each transaction (*w*) was calculated as the product of the volume of the transaction (*v*) and the mid-point price. Such products were summed up within each transaction day.
Source: Author's own

P_t^h which were the approximations for the best ask price $P_t(a)$ and the best bid price $P_t(b)$, respectively.[1] Trades with transaction prices higher (lower) than the mid-point price were classified as the buyer- (seller-) initiated. The trades executed at the mid-point price were not classified.

4 The Three-Factor Asset Pricing Model with Imbalance Indicator

The research hypothesis is verified on the basis of the model for the rate of return specified on the grounds of three theories: asset pricing theory, efficient market hypothesis and rational expectations theory. The general form of the model can be written as follows:

$$R_{i,t+1} - R_{f,t+1} = \gamma_0 + \boldsymbol{\gamma}'\mathbf{Y}_{t+1} + \boldsymbol{\alpha}'\mathbf{Z}_{it} + \varepsilon_{i,t+1}, \tag{1}$$

where $R_{i,t+1}$—the rate of return on asset *i* at time *t+1*, (*t=1,2,. . .,T-1*), $R_{f,t+1}$—risk-free rate of return, $\mathbf{Y}_{t+1}$—vector of variables reflecting factors proposed by the asset pricing theory, referring to the market as a whole, $\mathbf{Z}_{it}$—vector of variables reflecting factors proposed by the efficient market theory, referring to the individual risky asset in the market, γ_0—intercept term, $\boldsymbol{\gamma}$', $\boldsymbol{\alpha}$'—vectors of parameters, $\varepsilon_{i,t+1}$—error term. Since the daily risk-free rates of return for the whole examined period were unavailable, the $R_{f,t+1}$ variable was eventually neglected.

The model is based on the modified version of Fama and French model (1993) therefore there are two variables included in the vector $\mathbf{Y}_{t+1}$: the market factor and size factor. The first one is approximated by the rate of return of market portfolio,

[1]The approximation of the best ask and best bid prices was done due to the fact that they are not given to public information on the WSE.

whereas the second one is reflected by the difference of the rates of return of diversified portfolios built of the big and small companies.

The third factor in the model belongs to vector $\mathbf{Z}_{it}$, refers to the individual asset and reflects the imbalance (disequilibrium) magnitude of the WSE single asset's market. In order to measure such magnitude, the own original indicators *imb1–imb9* described in Sect. 3 can be employed. As was pointed out in the paper of Nowak (2014), the average values of the following pairs of indicators: *imb4* and *imb7*, *imb5* and *imb8*, *imb6* and *imb9* turned out to be on the very similar level, which led to the conclusion that they may contain the same information. This resulted in resignation of using *imb7*, *imb8* and *imb9* imbalance indicators. Moreover, considering that only the ratios within the first group incorporate all the trades executed, it appeared to be reasonable to apply only *imb1* and *imb4* indicators in the research.

However, both *imb1* and *imb4* variables turned out to be nonstationary and could not be used directly in the model. Therefore, the 'day with imbalance' of the single asset's market was defined as the day when the number (volume) of trades initiated by the buyers and sellers in the whole number (volume) of trades was higher than 1%, 2.5%, 5%, 10% and 20% respectively. Such a situation was reflected by the dummy variable *lxx*_1 (*lxx*_4) taking the value 1 in the case of the 'day with imbalance' and value 0 in other cases, namely:

$$l10\_1 = \begin{cases} 1 \text{ when } imb1 > 0.01 \\ 0 \text{ when } imb1 \le 0.01 \end{cases}, \quad l25\_1 = \begin{cases} 1 \text{ when } imb1 > 0.025 \\ 0 \text{ when } imb1 \le 0.025 \end{cases},$$

$$l50\_1 = \begin{cases} 1 \text{ when } imb1 > 0.05 \\ 0 \text{ when } imb1 \le 0.05 \end{cases}, \quad l100\_1 = \begin{cases} 1 \text{ when } imb1 > 0.1 \\ 0 \text{ when } imb1 \le 0.1 \end{cases},$$

$$l200\_1 = \begin{cases} 1 \text{ when } imb1 > 0.2 \\ 0 \text{ when } imb1 \le 0.2 \end{cases}.$$

Dummy variable *lxx*_4 was constructed analogously, basing on indicator *imb4*. In consequence, the model (1) was written as

$$r_{i,t+1} = \gamma_0 + \gamma_1 lwig_{t+1} + \gamma_2 lbs_{t+1} + \alpha \cdot I_{it} + \varepsilon_{i,t+1}, \tag{2}$$

where $r_{i,t+1}$—logarithmic rate of return for i^{th} asset at time $t+1$, $lwig_{t+1}$—logarithmic rate of return for market portfolio, reflected by index WIG, lbs_{t+1}—the difference of the logarithmic rates of return of diversified portfolios built of the big and small companies, approximated by the WIG20 and sWIG80 indices respectively, I_{it}—variable reflecting the imbalance on the i^{th} asset's market at time t, defined as a dummy *lxx*_1 (*lxx*_4), γ_0, γ_1, γ_2, α— structural parameters, $\varepsilon_{i,t+1}$—disturbance term.

5 Research Methodology and Procedure

Due to the fact that model (2) is an errors-in-variables model, in order to estimate its parameters the method of instrumental variables (IV) was employed. Additionally, the Newey-West autocorrelation and heteroskedasticity consistent covariance matrix estimator was used (with Bartlett kernel function).

For the variable I_{it} we can indicate minimum two following sources of errors:

1. The side initiating the transaction remains unknown and its identification basing on the chosen trade classification rule results in randomness of the variables *imb1* and *imb4*.
2. The variables *imb1* and *imb4* are based on the high frequency data which, however, does not reflect all the transactions, but is 'rounded to the nearest second'.

The variables I_{it-1} and I_{it-2} were used as the instrumental variables.

The research sample covers 10 selected stocks listed on the WSE and included in the WSE index WIG20 in the period of November 17, 2000—June 30, 2016. The intra-day data of the transactions executed are 'rounded to the nearest second' and available at www.bossa.pl. The selection of the stocks was made on the basis of three criteria: assignment to index WIG20, liquidity and uninterrupted trading in the research period.

The list of shares with the number of intra-day and daily observations is presented in Table 2.

The first stage of the research was conducted basing on the intra-day data. The side of the market initiating each transaction was indicated and the values of the original imbalance indicators *imb1*–*imb9* were estimated. In the second stage of research the daily data was employed. At first, the nonstationarity of *imb1* and *imb4* variables was demonstrated.[2] Consequently, the dummy variables *lxx*_1 and *lxx*_4 were calculated. Subsequently, the model (2) was estimated using the IV method. The following three versions of the dependent variable—logarithmic rate of return $r_{i,t+1}$—were applied[3]:

1. The rate of return calculated for close prices: $r_{1i,t+1} = close_{i,t+1} - close_{it}$
2. The 'intra-day' rate of return: $r_{2i,t+1} = close_{i,t+1} - open_{i,t+1}$
3. The 'night' rate of return: $r_{3i,t+1} = open_{i,t+1} - close_{it}$.

The results of estimation and validation of model (2) including variable *imb1* calculated for the KGHM share, are summarized in Table 4 in Appendix.[4] The

[2] Due to a limited number of pages of the paper, the results of the calculation will be revealed on request.

[3] In each case the asset pricing factors $lwig_{t+1}$ and lbs_{t+1} were calculated appropriately.

[4] Due to page restriction, both the findings obtained for the KGHM share using *imb4* indicator and the detailed results obtained for the other 9 companies will be revealed on request.

Table 2. Research sample

No.	Share	First observation	Last observation	Number of intra-day	Number of daily observations
1	ASSECOPOL	17.11.2000	30.06.2016	1 000 116	3912
2	BZWBK	25.06.2001	30.06.2016	1 022 435	3761
3	KGHM	17.11.2000	30.06.2016	4 620 254	3912
4	LOTOS	09.06.2005	30.06.2016	1 326 839	2770
5	MBANK	17.11.2000	30.06.2016	1 000 706	3910
6	ORANGEPL	17.11.2000	30.06.2016	2 704 033	3912
7	PEKAO	17.11.2000	30.06.2016	2 314 673	3912
8	PGNiG	20.10.2005	30.06.2016	1 796 581	2676
9	PKN ORLEN	17.11.2000	30.06.2016	2 955 615	3912
10	PKOBP	10.11.2004	30.06.2016	3 626 365	2915

Source: Author's own

values of the following statistics with the corresponding p-values are put in the points 1–8 listed in Table 4:

1. Kleibergen-Paap underidentification test, under H_0 (excluded instruments are not correlated with the endogenous regressor, in other words: the equation is underidentified), distributed as $\chi^2(2)$ (Kleibergen and Paap 2006)
2. Kleibergen-Paap weak identification test, under H_0 (correlations between the excluded instruments and endogenous regressors are nonzero but 'weak'), distributed as Wald F-statistic F(2.3904) (Baum et al. 2007)
3. Sargan-Hansen test (test of overidentifying restrictions), under H_0 (instruments are correlated with the error term and the excluded instruments are correctly excluded from the estimated equation), distributed as $\chi^2(1)$
4. Endogeneity test for endogenous regressor $r_{i,t+1}$, under H_0 (endogenous regressor can be treated as exogenous), distributed as $\chi^2(1)$
5. Cumby and Huizinga test of first-order autocorrelation, under H_0 (the regression error has no first-order correlation), distributed as $\chi^2(1)$ (Cumby and Huizinga 1992)
6. Cumby and Huizinga test of up to fifth-order autocorrelation, under H_0 (the regression error has no up to fifth-order correlation), distributed as $\chi^2(5)$
7. Pesaran-Taylor RESET test heteroskedastic and autocorrelation robust, under H_0 (there are no neglected nonlinearities in the choice of a functional form), distributed as $\chi^2(1)$ (Pesaran and Taylor 1999)
8. Pagan-Hall test, under H_0 (the disturbance term is homoskedastic), distributed as $\chi^2(4)$ (Pagan and Hall 1983).

6 Empirical Results

The main results of empirical research can be summarized as follows.

1. In the research 300 models were estimated, including 30 models for each share and 150 models containing a dummy variable basing on the indicator *imb1* and *imb4* respectively.
2. The choice of the IV method of estimation was appropriate according to the results of the both Kleibergen-Paap tests. For the overwhelming number of regressions, the null hypothesis of underidentification of the model was rejected (apart from the models based on *l*200_1 variable built for 3 assets: ORANGEPL, PGNiG and PKOBP).
3. The instruments in the IV estimation method were chosen properly. In Sargan-Hansen test only in the case of 7 (4) models including a dummy variable based on *imb1* (*imb4*) indicator the null hypothesis was rejected. However, in the endogeneity test $r_{i,t+1}$, the null hypothesis was rejected in the case of 13 (18) models respectively.
4. In the light of results of Pesaran-Taylor RESET test we can confirm that for the majority of regressions the choice of an equation functional form was appropriate. The null hypothesis was rejected only for 14 (12) models based on indicator *imb1* (*imb4*).
5. For c.a. 50% of estimated regressions the null hypothesis in Cumby and Huizinga test of first-order (up to fifth-order) autocorrelation was rejected. The null hypothesis of no first-order correlation was rejected in the case of 70 (79) models built on the basis of *imb1* (*imb4*) indicator, whereas the null hypothesis of no up to fifth-order correlation was rejected in the case of 88 (82) models.
6. For about 60% of regressions the null hypothesis in Pagan-Hall test was rejected. The disturbance test was not homoskedastic in the case of 91 (94) models including a dummy based on indicator *imb1* (*imb4*).
7. The market factor turned out to be statistically significant in the case of 145 (150) models based on *imb1* (*imb4*) indicator.
8. The size factor was statistically significant in the case of 121 (125) models including a dummy variable constructed basing on *imb1* (*imb4*) indicator.
9. The variable reflecting the imbalance on the single asset's market was statistically significant for a considerably smaller number of cases. The number of the models is presented in Table 3.

The imbalance factor was most frequently statistically significant in the case of the models estimated for the 'night' rate of return $r_{3i,t+1}$ (36 and 42 cases with a dummy variable based on the *imb1* and *imb4* indicator respectively), more rarely for the 'intra-day' rate of return (19 and 27 cases). In contrast, in all models describing the rate of return calculated on the basis of close prices, $r_{1i,t+1}$, the imbalance factor turned out to be statistically insignificant. Comparing the findings obtained for the models basing on *imb1* and *imb4* indicators, we can notice that the

Table 3. The number of models (2) with significant variable reflecting the imbalance

Rate of return	*imb1*					*imb4*				
	l10_1	*l25_1*	*l50_1*	*l100_1*	*l200_1*	*l10_4*	*l25_4*	*l50_4*	*l100_4*	*l200_4*
$r_{1i,t+1}$	0	0	0	0	0	0	0	0	0	0
$r_{2i,t+1}$	6	5	4	2	2	6	6	6	5	4
$r_{3i,t+1}$	10	9	7	6	4	9	10	9	9	5

Source: Author's own

variables constructed on the basis of *imb4* were more frequently statistically significant (69 cases, 46%) than those constructed on the basis of *imb1* indicator (55 cases, 37%).

Summarizing concisely the obtained findings we can state that there is no reason to reject the research hypothesis claiming that the inclusion of the additional explanatory variable in the asset pricing model, reflecting the information of order imbalance of the single asset's market, improves the descriptive properties of such a model. Nevertheless, the hypothesis cannot be rejected regarding the 'intra-day' rate of return and the 'night' rate of return calculated for stocks listed on the WSE in the period of 2000–2016. It is worth pointing out that in the case of a model describing the rate of return calculated on the basis of close prices, the research hypothesis was rejected.

The further investigation will concern the predictability of the WSE stock market returns basing on the information of order imbalance. The research hypothesis will refer to the good predictive properties of the asset pricing model including the imbalance indicator. Those properties will be assessed on the basis of the traditional measures of forecast accuracy and the results of the selected statistical tests, including Diebold and Mariano (1995) test, Pesaran and Timmermann (1992) test and the forecast encompassing test.

Appendix

Table 4 Results of IV estimation and validation of model (2) basing on indicator *imb1*, share KGHM

	$r_{ji,t+1}$	$(j=1)$	$r_{ji,t+1}$	$(j=2)$	$r_{ji,t+1}$	$(j=3)$		$r_{ji,t+1}$	$(j=1)$	$r_{ji,t+1}$	$(j=2)$	$r_{ji,t+1}$	$(j=3)$
	Parameter	p-Value	Parameter	p-Value	Parameter	p-Value		Parameter	p-Value	Parameter	p-Value	Parameter	p-Value
$l10\_1_t$	−0.000	0.767	**−0.001**	0.000	**0.001**	0.000	$l25\_1_t$	−0.000	0.789	−**0.001**	0.003	**0.001**	0.000
$lwig_{j,t+1}$	**1.445**	0.000	**1.377**	0.000	**1.516**	0.000	$lwig_{j,t+1}$	**1.444**	0.000	**1.366**	0.000	**1.518**	0.000
$lbs_{j,t+1}$	**0.185**	0.000	**0.147**	0.005	**0.232**	0.000	$lbs_{j,t+1}$	**0.185**	0.000	**0.163**	0.002	**0.236**	0.000
Test	Statistic	p-Value	Statistic	p-Value	Statistic	p-Value	Test	Statistic	p-Value	Statistic	p-Value	Statistic	p-Value
1	*341.374*	0.000	*336.043*	0.000	*340.409*	0.000	1	*270.291*	0.000	*269.760*	0.000	*270.873*	0.000
2	*28000.000*		*28000.000*		*28000.000*		2	*2800.000*		*2800.000*		*2800.000*	
3	0.042	0.838	0.180	0.671	1.805	0.179	3	0.420	0.517	1.591	0.207	0.895	0.344
4	0.026	0.873	1.010	0.315	1.350	0.245	4	0.076	0.783	0.107	0.744	0.002	0.968
5	*4.389*	0.036	*13.661*	0.000	*5.171*	0.023	5	*14.322*	0.000	*11.723*	0.001	*6.095*	0.014
6	*13.736*	0.017	*25.322*	0.000	7.940	0.160	6	*18.259*	0.003	*31.287*	0.000	8.745	0.120
7	2.140	0.143	0.200	0.657	*4.550*	0.033	7	2.150	0.142	0.580	0.448	*5.530*	0.019
8	*13.237*	0.010	*37.420*	0.000	*30.297*	0.000	8	*13.922*	0.008	*34.981*	0.000	*29.372*	0.000
	Parameter	p-Value	Parameter	p-Value	Parameter	p-Value		Parameter	p-Value	Parameter	p-Value	Parameter	p-Value
$l50\_1_t$	−0.000	0.786	**−0.001**	0.019	**0.001**	0.001	$l100\_1_t$	0.001	0.528	−0.001	0.189	**0.002**	0.000
$lwig_{j,t+1}$	**1.444**	0.000	**1.365**	0.000	**1.507**	0.000	$lwig_{j,t+1}$	**1.447**	0.000	**1.365**	0.000	**1.535**	0.000
$lbs_{j,t+1}$	**0.184**	0.000	**0.161**	0.002	**0.247**	0.000	$lbs_{j,t+1}$	**0.184**	0.000	**0.162**	0.002	**0.227**	0.000
Test	Statistic	p-Value	Statistic	p-Value	Statistic	p-Value	Test	Statistic	p-Value	Statistic	p-Value	Statistic	p-Value
1	*227.637*	0.000	*227.922*	0.000	*228.484*	0.000	1	*94.628*	0.000	*95.007*	0.000	*95.782*	0.000
2	*1900.000*		*1900.000*		*1900.000*		2	*1173.409*		*1177.852*		*1171.774*	
3	0.339	0.561	0.001	0.970	1.214	0.271	3	0.185	0.667	0.923	0.337	3.340	0.068
4	0.114	0.736	0.141	0.708	0.963	0.326	4	2.738	0.098	0.410	0.522	*9.814*	0.002
5	3.284	0.070	*6.355*	0.012	*5.772*	0.016	5	*7.934*	0.005	*23.738*	0.000	*5.044*	0.025
6	*13.942*	0.016	*18.643*	0.002	8.069	0.152	6	*14.233*	0.014	*26.366*	0.000	7.321	0.198
7	2.130	0.145	1.010	0.314	*6.530*	0.011	7	2.990	0.084	1.370	0.242	*5.520*	0.019
8	*17.358*	0.002	*34.836*	0.000	*29.735*	0.000	8	*23.568*	0.000	*78.363*	0.000	*30.836*	0.000

	Parameter	p-Value	Parameter	p-Value	Parameter	p-Value
$l200\_1_t$	0.001	0.543	−0.003	0.164	**0.004**	0.000
$lwig_{j,t+1}$	**1.450**	0.000	**1.366**	0.000	**1.519**	0.000
$lbs_{j,t+1}$	**0.182**	0.000	**0.164**	0.000	**0.249**	0.000
Statistic	p-Value	Statistic	p-Value	Statistic	p-Value	Statistic
1	*16.393*	0.000	*16.389*	0.000	*16.427*	0.000
2	*201.881*		*200.445*		*202.148*	
3	0.499	0.480	0.148	0.700	0.157	0.692
4	1.837	0.175	0.609	0.435	*15.018*	0.000
5	*5.581*	0.018	*17.147*	0.000	*4.597*	0.032
6	*14.391*	0.013	*23.554*	0.000	6.165	0.291
7	2.030	0.154	1.830	0.177	*6.790*	0.009
	5.335	0.255	*37.397*	0.000	*29.122*	0.000

Statistically significant parameters are indicated **in bold**. Statistics of the tests listed in points 1–8 are indicated *in italics* in the cases when the null hypothesis is rejected. The significance level $\alpha = 0.05$.

Source: Author's own calculation using Stata 12 (IV methods of estimation, Newey-West estimator, Bartlett kernel bandwidth selected on the basis of Schwert (1989) criterium).

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Interaction Between Market Depth and Market Tightness on the Warsaw Stock Exchange: A Preliminary Study

Joanna Olbryś

Abstract The nature of market liquidity is multidimensional. According to the literature, the majority of researchers follow Kyle (1985) and they distinguish between three dimensions of market liquidity as special liquidity characteristics: market depth, market tightness, and market resiliency. The paper presents a preliminary study of interaction between market depth and market tightness on the Warsaw Stock Exchange (WSE). The order ratio (*OR*) is employed as a proxy of market depth, while market tightness is approximated using the relative spread (*RS*). The 20 most liquid WSE-listed big companies are investigated. The high-frequency intraday data covers the period from January 3, 2005 to June 30, 2015. Moreover, the paper provides a robustness analysis of the obtained results with respect to the whole sample period and three adjacent subsamples of equal size: the pre-crisis, crisis, and post-crisis periods. The hypothesis concerning the statistical significance of the Fisher's z-transformed correlation coefficients between daily values of the *OR* and *RS* indicators for each stock is tested. The empirical results reveal that although, in general, low daily order ratios are accompanied by narrow daily relative spreads (as both indicate high liquidity), and high daily order ratios are accompanied by wide daily relative spreads, the majority of correlation coefficients between daily values of the *OR* and *RS* indicators are not significantly different from zero. Furthermore, the results turn out to be robust to the choice of the sample. Our findings indicate that both ratios seem to capture various sources of market liquidity, which is consistent with the literature.

1 Introduction

Liquidity in a financial market is not a one-dimensional variable but it includes several dimensions. In his seminal work, Kyle (1985) distinguished the following three dimensions of market liquidity as special liquidity characteristics: (1) depth—the size of an order flow innovation required to change prices a given amount;

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_10

(2) tightness—the cost of turning around a position over a short period of time; (3) resiliency—the speed with which prices recover from a random, uninformative shock. von Wyss (2004) emphasized the following four aspects: (1) trading time—the ability to execute a transaction immediately at the prevailing price; (2) depth—the ability to buy or to sell a certain amount of an asset without influence on the quoted price; (3) tightness—the ability to buy and to sell an asset at about the same price at the same time; (4) resiliency—the ability to buy or to sell a certain amount of an asset with little influence on the quoted price. Market depth has been investigated more extensively than other dimensions of liquidity, e.g. (Lee et al. 1993; Engle and Lange 1997; Chordia et al. 2000a, b, 2005; Huberman and Halka 2001; Ranaldo 2001; Wong and Fung 2002; von Wyss 2004; Lin et al. 2012). Moreover, there has been quite extensive research on spread which may be treated as a measure of market tightness, e.g. (Levin and Wright 1999; Chordia et al. 2000a, b; Huberman and Halka 2001; Ranaldo 2001; Acker et al. 2002; Piwowar and Wei 2003; von Wyss 2004; Chordia et al. 2005; Lesmond 2005; Olbrys and Mursztyn 2017).

The goal of this paper is a preliminary study of interaction between market depth and market tightness on the Warsaw Stock Exchange (WSE). The 20 most liquid WSE-listed big companies are investigated. The high-frequency intraday data covers the period from January 3, 2005 to June 30, 2015. The proxies of market depth and market tightness are calculated. The order ratio is employed as a proxy of market depth, while market tightness is approximated using the relative spread. As the data set does not identify a trade direction on the WSE, firstly the trade classification Lee and Ready (1991) algorithm is employed to infer trade sides and to distinguish between the so-called buyer- and seller-initiated trades (Olbryś and Mursztyn 2015). Moreover, the paper provides a robustness analysis of the obtained results with respect to the whole sample and three adjacent sub-samples of equal size: the pre-crisis, crisis, and post-crisis periods. The Global Financial Crisis (GFC) on the WSE is formally set based on the papers (Olbrys and Majewska 2014, 2015), in which the Pagan and Sossounov (2003) method for formal statistical identification of market states was employed. The hypothesis concerning the statistical significance of the z-transformed correlation coefficients (Fisher 1921) between daily values of the *OR* and *RS* indicators for each stock is tested. The empirical results reveal that although, in general, low daily order ratios are accompanied by narrow daily relative spreads (as both indicate high liquidity), and high daily order ratios are accompanied by wide daily relative spreads, the majority of correlation coefficients between daily values of the *OR* and *RS* indicators are not significantly different from zero. Furthermore, the results turn out to be robust to the choice of the sample. Our findings indicate that both ratios seem to capture various sources of market liquidity and they are consistent with the literature, e.g. (Chordia et al. 2000a).

To the best of the author's knowledge, the presented empirical results are novel and have not been reported in the literature thus far.

The remainder of the study is organized as follows. Section 2 describes the methodological background concerning the measurement of market depth and market tightness. Section 3 presents and discusses the empirical results of the initial assessment of interaction between two liquidity dimensions on the WSE. The last section encompasses the conducted research with a brief summary.

2 Dimensions of Market Liquidity

The majority of researchers follow Kyle (1985) and they distinguish between three dimensions of market liquidity: depth, tightness and resiliency. Wong and Fung (2002) emphasized that another commonly used concept is immediacy, but it incorporates elements of all three dimensions, and therefore it could be not considered as a separate dimension. Bernstein (1987) mentioned the following three dimensions: depth, breadth, and resiliency. He stressed that these three attributes are generally accepted as the basic requirements for good markets. Harris (2003) pointed out that when people think about liquidity, they may think about trading quickly, about trading large size, or about trading at low cost. However, people rarely distinguish among liquidity dimensions when discussing liquidity. In this paper market depth and market tightness are explored as two out of three market liquidity dimensions on the Polish stock market.

2.1 Measuring of Market Depth

The value of market depth could be approximated by various methods, but in this paper we employ the order ratio (*OR*) as a refined measure of market depth, e.g. (Ranaldo 2001). It compares depth measured as market order imbalance to cumulated daily trading volume:

$$OR = \frac{\left|\sum_{i=1}^{m} VBuy_i - \sum_{j=1}^{k} VSell_j\right|}{\sum_{n=1}^{N} V_n}, \tag{1}$$

where the sums:

$$\sum_{i=1}^{m} VBuy_i, \sum_{j=1}^{k} VSell_j, \sum_{n=1}^{N} V_n, \tag{2}$$

denote daily cumulated trading volume related to transactions classified as buyer- or seller-initiated trades, and daily cumulated trading volume for all transactions, respectively. The *OR* indicator (1) captures imbalance in the market since it rises as the difference in the numerator becomes large. A high order ratio denotes low market depth and low liquidity. Conversely, a small order ratio denotes high market depth and high liquidity. Moreover, the daily order ratio is defined as equal to zero in two cases: (1) when all transactions within a day are unclassified, or (2) when total daily trading volume is equal to zero.

To calculate the *OR* indicator it is essential to recognize the side initiating the transaction and to distinguish between the so-called buyer- and seller-initiated trades. The WSE is classified as an order-driven market with an electronic order book, but the information of the best bid and ask price is not publicly available. In fact, even the non-proprietary financial databases that provide information on trades and quotes do not identify the trade direction. As a consequence, the researchers rely on indirect trade classification rules to infer trade sides. There are some trade classification procedures described in the literature, but the Lee and Ready (1991) algorithm (LR) remains the most frequently used (Chakrabarty et al. 2012, p. 468).

In this paper, the LR method is employed as Olbryś and Mursztyn (2015) indicated that the LR algorithm performs quite well on the WSE, the empirical results turn out to be robust to the choice of the sample and rather do not depend on firm size.

2.2 Measuring of Market Tightness

The related literature indicates that different versions of the bid/ask spread are the proper measures for tightness because they approximate the cost of immediate execution of a trade. In this paper, we employ the relative spread (*RS*) as a measure of market tightness, e.g. (von Wyss 2004). This measure is sometimes referred to as inside bid/ask spread, e.g. (Levin and Wright 1999; Acker et al. 2002). Considering that the bid and ask prices are not public information on the WSE, the best bid price is approximated by the highest price at time *t*, while the best ask price is approximated by the lowest price at time *t*. Then the relative spread *RS* is given by Eq. (3):

$$RS_t = \frac{2 \cdot \left(P_t^H - P_t^L\right)}{P_t^H + P_t^L}, \tag{3}$$

where P_t^H, P_t^L are the highest and lowest prices at time *t*, respectively (Olbryś and Mursztyn 2015, p. 43).

The relative spread is the measure most extensively used, as it is quite easy to estimate and it makes tightness of different stocks comparable to each other. A wide relative spread denotes high market tightness and low liquidity. Conversely, a narrow relative spread denotes low market tightness and high liquidity. The relative spread at time *t* is equal to zero when $P_t^H = P_t^L$.

3 Data Description and Empirical Results on the WSE

In this research, we utilize a database containing high-frequency data 'rounded to the nearest second' (available at www.bossa.pl) for the WSE-listed stock, in the period from January 2, 2005 to June 30, 2015. The 20 most liquid WSE-listed big companies are investigated (Nowak and Olbryś 2016). To verify the robustness of the obtained empirical results, an assessment of relations between market depth and market tightness on the WSE is provided over the whole sample (2626 trading days) and three adjacent sub-samples of equal size (436 trading days): (1) the pre-crisis period September 6, 2005–May 31, 2007, (2) the crisis period June 1, 2007–February 27, 2009, and (3) the post-crisis period March 2, 2009–November 19, 2010 (Olbryś and Mursztyn 2015). The Global Financial Crisis on the WSE is formally set based on the papers (Olbryś and Majewska 2014, 2015), in which the Pagan and Sossounov (2003) method for formal statistical identification of market states was employed.

3.1 *Summarized Results of Daily Market Depth and Daily Market Tightness Estimates*

The procedure of estimating daily order ratio (*OR*) consists of three steps. In the first step, all transactions are classified using the LR (1991) algorithm to distinguish between the buyer- and seller-initiated trades, as well as the unclassified trades. In the second step, daily cumulated trading volume related to transactions classified as buyer- and seller-initiated trades, as well as daily cumulated trading volume for all transactions (also those unclassified) are calculated for each company. In the third step, daily market depth is approximated using the formula (1).

The *RS* indicator is utilized to measure daily market tightness for each stock. In the first step, the relative spread related to each transaction (at time t) is estimated based on the formula (3). In the second step, daily market tightness is calculated as the average of relative spreads for all transactions within a day. The daily relative spread is defined as equal to zero when daily trading volume is equal to zero. To avoid numerical problems, the daily data are rescaled by multiplying by 10^2.

Table 1 presents empirical results of the *OR* and *RS* estimates for selected stocks. Several results in this table are worth a comment. The values of the *OR* indicator vary between 0.17 and 0.53. We observe the lower values of the *OR* (i.e. the higher market depth) for the most liquid companies with the largest market capitalization (namely KGH, OPL, PEO, PKN, PKO), regardless of the subsample choice. Otherwise, the results reveal that the largest values of the *OR* indicator (i.e. not less than 0.45) occur for several companies (namely BHW, BDX, DBC, ECH, KTY). Such big values of the *OR* inform about low market depth and low liquidity in these cases. The *RS* estimates vary between 0.005 and 0.10 and, in line with the expectations, they are especially low for the most liquid companies with the largest

Table 1 The average daily market depth (*OR*) and average daily market tightness (*RS*) for selected 20 WSE-listed big companies

	Average daily order ratio (*OR*)					Average daily relative spread (*RS*)				
	Company	P_1	P_2	P_3	P_4	Company	P_1	P_2	P_3	P_4
1	BHW	0.38	0.47	0.47	0.49	BHW	0.02	0.02	0.03	0.02
2	BPH	0.40	0.33	0.41	0.40	BPH	0.05	0.01	0.04	0.05
3	BOS	0.34	0.31	0.28	0.35	BOS	0.07	0.09	0.10	0.10
4	BDX	0.43	0.53	0.47	0.45	BDX	0.03	0.05	0.04	0.03
5	BZW	0.31	0.32	0.25	0.26	BZW	0.02	0.01	0.02	0.02
6	DBC	0.44	0.41	0.49	0.41	DBC	0.05	0.04	0.05	0.06
7	ECH	0.45	0.48	0.40	0.43	ECH	0.04	0.04	0.04	0.05
8	GTN	0.27	0.26	0.29	0.25	GTN	0.02	0.02	0.02	0.02
9	GTC	0.30	0.33	0.25	0.26	GTC	0.02	0.02	0.02	0.02
10	KTY	0.46	0.44	0.51	0.49	KTY	0.04	0.02	0.05	0.04
11	KGH	0.17	0.17	0.19	0.19	KGH	0.01	0.01	0.01	0.01
12	MBK	0.29	0.40	0.28	0.24	MBK	0.02	0.02	0.02	0.02
13	MIL	0.35	0.38	0.39	0.30	MIL	0.02	0.02	0.03	0.02
14	NET	0.36	0.29	0.42	0.39	NET	0.02	0.01	0.03	0.02
15	OPL	0.21	0.20	0.20	0.22	OPL	0.01	0.005	0.009	0.01
16	PEO	0.21	0.24	0.21	0.21	PEO	0.009	0.008	0.01	0.01
17	PKN	0.19	0.19	0.19	0.20	PKN	0.008	0.006	0.01	0.01
18	PKO	0.20	0.23	0.21	0.20	PKO	0.007	0.006	0.01	0.01
19	SNS	0.32	0.41	0.38	0.34	SNS	0.02	0.04	0.02	0.02
20	TVN	0.27	0.28	0.25	0.26	TVN	0.02	0.01	0.02	0.02
	Mean	0.32	0.33	0.33	0.32	Mean	0.03	0.02	0.03	0.03

The table is based on: (1) the whole sample period P_1 (3.01.2005–30.06.2015); (2) the pre-crisis period P_2 (6.09.2005–31.05.2007); (3) the crisis period P_3 (1.06.2007–27.02.2009); (4) the post-crisis period P_4 (2.03.2009–19.11.2010). Ticker symbols are in alphabetical order according to the company's full name

market capitalization (e.g. KGH, OPL, PEO, PKN, PKO). This evidence confirms low market tightness and high stock liquidity in these cases. Moreover, all findings turn out to be robust to the choice of the sample. Specifically, we do not observe that the *OR* and *RS* estimates are quantitatively different in the crisis period (P_3) compared to the other periods.

3.2 Correlation Analysis Between Market Depth and Market Tightness for Selected Big Companies

The empirical results presented in Table 1 reveal that, in general, low daily order ratios (*OR*) are accompanied by narrow daily relative spreads (*RS*). Otherwise, high daily order ratios are accompanied by wide daily relative spreads.

Table 2 The Fisher's z-transformed correlation coefficients between daily order ratio (*OR*) and daily relative spread (*RS*) for selected 20 WSE-listed big companies

	BHW	BPH	BOS	BDX	BZW	DBC	ECH	GTN	GTC	KTY
P_1	−0.021	**−0.105**	−0.006	−0.036	−0.035	−0.010	0.003	**−0.065**	−0.027	0.001
P_2	−0.044	0.008	0.086	−0.039	−0.027	−0.064	0.065	−0.076	−0.009	0.053
P_3	−0.027	−0.015	−0.074	0.050	0.031	**0.095**	−0.075	0.011	**−0.114**	−0.041
P_4	−0.054	−0.021	−0.044	−0.025	0.023	**−0.097**	0.022	−0.073	−0.055	−0.026
	KGH	MBK	MIL	NET	OPL	PEO	PKN	PKO	SNS	TVN
P_1	0.015	**−0.099**	−0.001	0.006	**−0.114**	−0.017	**−0.092**	−0.017	−0.013	−0.037
P_2	−0.068	−0.077	−0.011	−0.062	0.081	−0.065	−0.082	0.000	0.000	0.079
P_3	−0.053	−0.001	0.005	−0.005	0.003	−0.023	−0.093	−0.028	−0.040	−0.064
P_4	0.077	**−0.116**	**−0.140**	**−0.143**	0.004	−0.033	−0.034	0.066	−0.003	−0.001

See Table 1 for explanation. The correlation critical value is equal to 0.038 (the whole sample period P_1; 2626 daily observations) or 0.094 (the pre-, post-, and crisis periods P_2, P_3, P_4; 436 daily observations), at the 5% significance level. The significant coefficients are marked in bold

In order to carry out an initial assessment of interaction between market depth and market tightness on the WSE, the hypothesis concerning the statistical significance of the Fisher's z-transformed correlation coefficients (Fisher 1921) between daily values of the *OR* and *RS* indicators for each stock is tested.

The results reported in Table 2 are generally consistent with the literature. The majority of correlation coefficients between daily values of the *OR* and *RS* indicators are not significantly different from zero. Moreover, the results are rather robust to the choice of the period.

4 Conclusion

The goal of this paper was to perform an initial assessment of interaction between market depth and market tightness on the WSE. The hypothesis concerning the statistical significance of the Fisher's z-transformed correlation coefficients between daily values of the *OR* and *RS* indicators for each stock was tested. The empirical results revealed that although, in general, low order ratios were accompanied by narrow relative spreads and high order ratios were accompanied by wide relative spreads, the majority of the obtained correlation coefficients were not significantly different from zero. Moreover, all findings presented in the paper turned out to be robust to the choice of the period.

The results indicate that both ratios seem to capture various sources of market liquidity, which is in accord with the existing literature, e.g. (Chordia et al. 2000a; Huberman and Halka 2001; Ranaldo 2001; von Wyss 2004). Therefore, they might be utilize in further research as liquidity measures on the WSE.

Another possible direction for further investigation would be a deeper analysis of the interaction between market depth and market tightness for the WSE-listed stocks by examining short- and long-term relations under appropriate methodology.

Acknowledgements The present study was supported by a grant S/WI/1/2014 from Bialystok University of Technology and founded from the resources for research by Ministry of Science and Higher Education.

Moreover, I am grateful to Michał Mursztyn, a computer science student at the Faculty of Computer Science, Bialystok University of Technology, for expert C++ programming assistance.

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Investment Opportunities in the WSE: Bull *Versus* Bear Markets

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Abstract This paper investigates how mispriced equity in emerging economies is. To do so, we test for abnormal excess returns using classic and modern asset pricing models. We document that size, investment, and momentum effects are not unequivocal enough to advertise them as trading opportunities. Abnormal returns of profitability and value anomalies are statistically and economically significant and they are persistent throughout different investment climates. Further, we report higher degree of mispricing at an aggregated level, and thus higher abnormal investment opportunities, in the period of bear market and stable macro-conditions (2000–2006) than during and after the recent global financial crisis (2007–2013). We advocate that in emerging stock markets, like the Warsaw Stock Exchange, investors' asset pricing skills outweigh the effect of international portfolio rebalancing in the process of asset pricing. Investors might benefit from acknowledging these findings in formulating their investment policies. For instance, they may consider switching towards less aggressive portfolio allocations during bear markets.

1 Introduction

The purpose of this paper is to establish which investment strategies prevail in the WSE regardless of bull and bear market, i.e. during the period 2000–2013. Hereto, we analyze the performance of portfolios formulated in accordance with five generic trading strategies i.e. portfolio formation rules designed to capture anomalous returns related to: size (small and big market capitalization), value (high and low book-to-market), momentum (past winners and past losers), profitability

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_11

(robust and weak operating profitability), and investment (aggressive and conservative investment policy). Portfolio creation is rooted in the asset pricing theory and is performed in line with the conventional procedures of the asset pricing tools' empirical application.

Considering that our sample period encompasses both bullish (2000–2006) and bearish (2007–2013) market, we then divide it into two sub periods respectively. Intuitively, due to the changing investment climate and the rapid development of the Polish stock market (WSE 2014), we expect that in these two periods the level of mispricing, and thus investment opportunities in the WSE would be different.

2 Study Background

The process of capturing new anomalies has been closely observed by academics, but foremost by market practitioners. Reflecting on the phenomenon of anomalies, one may conclude that each has immanent self-destructing tendency—as the new anomaly is discovered, sophisticated investors, with help of academic research on asset pricing, learn how to identify its existence and benefit from trade on securities. Ultimately, potential profits are distributed among those investors, and equity becomes less mispriced. Importantly, the process of reaching equilibrium via arbitrage trading is conditional on how strong limits to arbitrage is, as described in Grossman and Stiglitz (1980). However, the general tendency is always towards more precise pricing.

Additionally, the investors' composition strongly affects asset pricing in emerging financial markets. On the one hand, investors from advanced stock markets tend to have higher asset pricing skills. On the other hand, they treat their investment in emerging equity as secondary priority. Behavior of foreign investors can distort pricing in emerging markets particularly in times of economic distress. In the event of global crisis, international investors tend to withdraw their funds from markets they consider riskier. Their behavior is the element of crisis contagion mechanism—the irrational fears leads to high the comovement of prices resulting from withdrawals (King and Wadhwani 1990). The effect will be particularly pronounced on the downside, creating price pressure in the result of asset fire sales. Alternatively, international shock transmission may have somewhat more rational justification. According to Longstaff (2010) global investors may be particularly limited in making their portfolio allocation decisions by the restricted access to funding. Thus, they will tend to withdraw their investments because of insufficient liquidity. In addition to higher perceived riskiness and lower liquidity, limited information is said to be another major difficulty in investing in emerging markets (Chuhan 1994), potentially strengthening motivation for withdrawals. Also, since the increased number of speculators generally contributes to market efficiency by improving pricing accuracy (Grossman 1995), the diminishing activity of international investors may likely cause the opposite effect. Therefore, it seems reasonable to expect higher pricing distortions (as evidenced by the enhanced abnormal returns) during the times of global market turmoil in the emerging stock exchanges with large (yet volatile) representation of foreign investors.

3 Identification Strategy

3.1 Asset Pricing Models

We employ the Capital Asset Pricing Model of Sharpe (1964) and Lintner (1965) (thereafter CAPM)—a single-factor model that uses only the excess market return (Eq. 1):

$$R_i(t) - Rf(t) = \alpha_i + b_i MKT(t) \tag{1}$$

where $R_i(t)$ is the actual monthly return on a given portfolio i at time t, $Rf(t)$ is the return on the risk-free asset, α_i is the intercept and $MKT_i(t)$ is the market excess return and the corresponding factor sensitivity b_i. The market factor is the difference between a proxy for market return and the risk-free rate. The assumptions of the model are outlined in Sharpe (1964) and Lintner (1965), Fernandez (2015) explains how the assumptions are not met in practice.

As an alternative to the CAPM, we also employ the Fama and French three-factor model of (1993) (thereafter FF3F) is a multi-factor model that uses three distinct risk factors (Eq. 2):

$$R_i(t) - Rf(t) = \alpha_i + b_i MKT(t) + s_i SMB(t) + h_i HML(t) \tag{2}$$

where the original CAPM regression is enhanced with two additional factors: size factor $SMB(t)$ (small minus big market cap), meant to mimic the risk factor in returns related to size, and $HML(t)$ (high minus low book-to-market) used to represent the risk factor in returns related to book-to-market equity (B/M) and the corresponding factor sensitivities, denoted s_i and h_i. The model is empirically-motivated and thus lacks formal background.

3.2 LHS Portfolios

Despite founding our inference on time-series regressions, we still acknowledge the cross-sectional character of our research. To address this aspect, stocks are first sorted into left-hand side (hereafter 'LHS') portfolios.

In our study, we employ five different sorting categories, resembling the generic strategies we consider, which also meet the case of the empirical evidence provided by Edelen et al. (2016). Table 1 briefly describes the LHS portfolios used in the study and summarizes relevant formation rules.

Table 1 LHS portfolios description

Portfolio	Description
Small	LHS Small-stock portfolio; value-weighted return on all stocks in the bottom 30% of stocks sorted on market capitalization.
Big	LHS Big-stock portfolio; value-weighted return on all stocks in the top 30% of stocks sorted on market capitalization.
High	LHS High-book-to-market stock portfolio; value-weighted return on all stocks in the bottom 30% of stocks sorted on book-to-market ratio.
Low	LHS Low-book-to-market stock portfolio; value-weighted return on all stocks in the top 30% of stocks sorted on book-to-market ratio.
Winner	LHS Winner-stock portfolio; equally-weighted return on all stocks in the top 30% of stocks sorted on prior returns.
Loser	LHS Loser-stock portfolio; equally-weighted return on all stocks in the bottom 30% of stocks sorted on prior returns.
Robust	LHS Robust-profitability stock portfolio; value-weighted return on all stocks in the top 30% of stocks sorted on operating profitability (*OP*).
Weak	LHS Weak-profitability stock portfolio; value-weighted return on all stocks in the bottom 30% of stocks sorted on operating profitability (*OP*).
Aggressive	LHS Aggressive-investment stock portfolio; value-weighted return on all stocks in the top 30% of stocks sorted on operating profitability (*Inv*).
Conservative	LHS Conservative-investment stock portfolio; value-weighted return on all stocks in the bottom 30% of stocks sorted on operating profitability (*Inv*).

3.3 Testing for Model's Robustness

The straightforward way to verify model's robustness is to test the statistical significance of its intercept α. This can be done for every portfolio separately (using basic statistical inference) or jointly for all intercepts using the GRS test (Gibbons et al. 1989).

We present the findings regarding models' performance and we conclude on investment opportunities yield by each model, accounting for all limitations that apply. Last but not least, we conclude on investment opportunities in different market climates (bull vs. bear market) by examining regression parameters, intercepts in particular, for two periods separately: 2000–2006 and 2007–2013. Hereto, we present results only at an aggregated level.

4 Findings

4.1 Excess Returns for the Set of Univariate LHS Portfolios

Table 2 presents summary statistics for 10 univariate portfolios formed separately on size, B/M, momentum, profitability, and investment. We report average

Table 2 Summary statistics for the LHS portfolio excess returns

	Small	Big	High	Low	Winner	Loser	Robust	Weak	Conservative	Aggressive
Mean	0.20	−0.65	−0.60	−1.49	1.41	0.91	0.53	−1.65	−1.18	−0.83
Std dev	9.45	7.68	8.32	10.19	8.27	8.63	6.81	11.79	10.13	10.33
t-Mean	0.28	−1.09	−0.93	−1.90	2.21	1.36	1.02	−1.81	−1.51	−1.04
N_max	123	117	119	116	119	120	112	118	124	115
N_min	28	24	28	22	21	22	18	24	27	21

portfolio's return, standard deviation, and t-statistic of its return, minimum and maximum count of stocks in each portfolio.

Inspection of Table 2 provides some interesting conclusions. First, LHS portfolios produce a wide range of average monthly excess returns, from −1.65% per month for Weak profitability firms up to 1.41% per month for Winner stocks. All LHS portfolio returns are accompanied by notably high variation in their values (average Std dev on all 10 univariate portfolios of 9.16%). Our study provides another proof of De Santis (1997) observation that emerging stock markets are characterized by persistently higher volatility than advanced markets are. Second, in each sort the LHS portfolios have returns that work in line with the pre-assumed anomaly, i.e. Small stocks outperform Big stocks, High B/M stocks outperform Low B/M stocks, etc. The only exception are portfolios in the investment sort—they perform counterintuitively since in our sample Aggressive-investment firms outperform Conservative-investment ones. This is against the conventional view on investment anomaly, according to which firms characterized by conservative investment (usually associated with value stocks) outperform firms aggressively investing (usually associated with growth stocks).

4.2 Abnormal Returns in the WSE

The time-series regressions with two sets of risk factors on 10 LHS portfolios deliver a multitude of insights about stock performance and anomaly persistence in the stock market of Poland. We discuss them together with the general APM's performance (Table 3).

The performance of size anomaly of Banz (1981) disappoints. Although Small-stock portfolio clearly delivers higher alpha than the corresponding Big-stock portfolio (0.72% vs. −0.03%) in terms of CAPM, the results are not statistically significant, as evidenced by small t-stats (1.34 and −0.48). FF3F validates these conclusions. Controlling for size effect on the right hand side of the regression makes almost any indication of size anomaly disappear. The intercept estimates equal to merely 0.01% and 0.05%, and the corresponding t-stats are negligible (0.02 and 1.12). Regarding value anomaly, there is some evidence for risk-adjusted abnormal performance, however restricted to growth stocks and negative in sign. Low-stock portfolio yields a CAPM alpha of −0.73%, and a FF3F alpha of −0.85%. Both estimates are statistically significant (t-stats of −2.46 and −3.46 respectively). Our results imply increased reliance on shorting in any attempt to capture superior profits.[1] Interestingly, both momentum-portfolios deliver strong,

[1]Short sales are severely restricted on the Polish stock market. Only limited number of issues is allowed for shorting, as specific, generally very restrictive, criteria must be met. See *New rules of short selling on GPW in the light of European Union regulations* (GPW 2016), available at: https://www.gpw.pl/krotka_sprzedaz_i_pozyczki_papierow_en

Table 3 Intercept estimates for CAPM and FF3F regressions on 10 LHS portfolios individually, 2000−2013

	Small	Big	High	Low	Winner	Loser	Robust	Weak	Conservative	Aggressive
α_{CAPM}	0.72	−0.03	−0.20	−0.73	1.88	1.46	0.98	−0.82	−0.51	−0.17
t (α_{CAPM})	1.34	−0.48	−0.38	−2.46	4.16	3.62	3.08	−1.78	−1.13	−0.34
α_{FF3F}	0.01	0.05	−0.06	−0.85	1.26	0.98	1.12	−1.05	−0.47	−0.42
t (α_{FF3F})	0.02	1.12	−0.16	−3.46	3.20	2.84	3.61	−2.28	−1.02	−0.84

Table 4 Summary statistics for CAPM and FF3F regressions on 10 LHS portfolios at an aggregated level, 2000–2013

APM	GRS	GRS (p value)	A|α|	A s(α)	SR (α)	A(R^2)	A(adj. R^2)
CAPM	5.96	0.000	0.750	0.399	0.61	0.65	0.65
FF3F	5.14	0.000	0.626	0.358	0.58	0.74	0.73

positive risk-adjusted returns. In accordance with CAPM, Winner-portfolio yields an alpha of 1.88%, whereas Loser-portfolio produces an alpha of 1.46%. Both estimates are statistically significant, as confirmed by t-stats of 4.16 and 3.62, respectively. Noteworthy, winners offer the highest alpha across all portfolios. FF3F model further validates the anomalous performance of both portfolios. The corresponding FF3F's alphas are 1.26% for Winners and 0.98% for Losers. Again, both estimates are statistically significant (t-stats of 3.20 and 2.84). Although each of the two momentum-related portfolios yield significant alphas regardless of the pricing model used, the inference and implications are to some extent ambiguous because both portfolios share the same sign (compare Jegadeesh and Titman 1993). The profitability anomaly is by far more pronounced. Robust-stock portfolio delivers 0.98% CAPM alpha ($t = 3.08$), while Weak-stock portfolio yields negative -0.82 ($t = -1.78$). FF3F estimates support these results. Robust-profitability equities produce an alpha of 1.12% ($t = 3.61$), which is again remarkably higher than Weak-profitability stocks' alpha of -1.05% ($t = -2.28$). As it transpires, both models provide empirical evidence of the profitability anomaly. With respect to the investment sorts, the results are weak in terms of statistical significance (Table 4).

According to the major tests for the robustness of an asset pricing model, on a sample of the WSE stocks FF3F model performs slightly better than CAPM. The GRS statistic equals to 5.14 for the three-factor model and to 5.96 for the one-factor model. Average absolute alpha is higher for CAPM (0.750%) than for FF3F (0.626%). Our results confirm a stylized fact that in general a one-factor model produces larger anomalous returns. Therefore, we argue that despite being less popular in the investment practice in the CEE region (Zaremba and Konieczka 2015), FF3F better explains common variation in stock returns in the WSE, thus its intercept is a more reliable measure of the local investment opportunities.

4.3 Abnormal Returns in the WSE

Last but not least, we verify how abnormal returns change once we account for the different macroeconomic conditions and investment climate. Therefore, we divide our sample into two subperiods that reflect the bull (Table 5, Panel A) and the bear market (Table 5, Panel B).

The evidence in Table 5 implies that the estimates of abnormal returns are materially different between the two subsamples. We report higher abnormal profits for the bull than for the bear period. Average absolute alphas for the 2000–2006

Table 5 Summary statistics for CAPM and FF3F regressions on 10 LHS portfolios at an aggregated level, separately for the bull (2000–2006) and the bear (2007–2013) market

APM	GRS	GRS (p value)	A|α|	A s(α)	SR (α)	A(R^2)	A(adj. R^2)
Panel A: 2000–2006							
CAPM	4.86	0.00	0.94	0.01	0.81	0.58	0.57
FF3F	3.56	0.00	0.76	0.01	0.73	0.71	0.70
Panel B: 2007–2013							
CAPM	2.38	0.02	0.65	0.00	0.57	0.74	0.73
FF3F	2.52	0.01	0.57	0.00	0.59	0.81	0.80

sample are 0.94% and 0.76% for CAPM and FF3F respectively. GRS test statistically supports these estimates. Mirroring the decline in average absolute alphas, Sharpe ratios decrease accordingly. Since the Sharpe ratio is itself primary component of the GRS test, it is bound to be higher for FF3F model. The goodness of fit, as measured by the average R^2 and average adjusted R^2, is noticeably higher for the later period.

5 Conclusions

By investigating particular trading strategies in a time-varying investment environment, we deliver sound empirical conclusions concerning two important aspects of asset pricing in the WSE.

First, we report that size anomaly is not statistically supported both under CAPM and FF3F model. Once SMB factor is included in model's specification, abnormal returns decline to virtually 0%. We document negative risk-adjusted performance of growth (Low book-to-market) stocks, however trading strategy based on value effect relies foremost on shorting. Momentum anomaly is ambiguous as both extreme strategies yield positive, statistically significant returns and, once employed in each asset pricing models, they produce positive and statistically significant alphas. Profitability-based portfolios are not the top-performers, but the anomaly itself is the most evident and statistically supported. Investment-related abnormal returns are not significant.

Second, we document that CAPM performs well in the emerging stock market of Poland. As expected, FF3F's performance is more robust, but there is only marginal improvement over CAPM in the full sample.

Further, our findings clearly indicate a stark decline in abnormal investment opportunities between the two subperiods: bull and bear market. For investor policy, this implies the need to shift towards less aggressive portfolio allocations.

A potentially interesting area for future research would be to exploit if, given the specific characteristics of post-transition economies and their financial markets, the results obtained for the WSE are representative to other emerging markets in the Central and Eastern Europe.

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Part III
Macrofinance

Development of Financial Systems in 1995–2014: A Factor Analysis

Małgorzata Iwanicz-Drozdowska and Paweł Smaga

Abstract The aim of the research was to analyze financial system development patterns for both 19 post-communist and 21 non-post-communist counties over the 1995–2014 period. The use of a factor analysis allowed us to identify two unobservable factors. Those factors account for most of the variance of the nine observed variables characteristic of the economic and financial development, the banking sector's financial position and the structure of the financial sector. We manage to identify factors representing variables correlated with financial system development and growth of the banking sector, but factors' roles differ among the analyzed groups of countries. The development of the banking sector is significantly associated with the economic development in both groups. Yet, in advanced economies some importance might be also attached to the stock market, which is not the case for post-communist countries. The results show that there is higher homogeneity in the financial system development patterns in post-communist countries, while the roles of both factors are more heterogeneous among advanced economies. Lastly, we provide evidence that the global financial crisis did not cause a permanent structural change in the correlation patterns of variables associated with both factors.

This is a summary of results of statutory research entitled "Size and structure of financial sectors in selected Central and Eastern European countries and developed countries. Convergence or own path?" funded by the Collegium of Management and Finance (No. KZIF/S/12/15) at Warsaw School of Economics (SGH) carried out in 2015. The opinions expressed herein are those of the authors and do not reflect those of the associated institutions. The statistical annex to the report from statutory research was prepared by: Bazy 3000, Marek Karwański (NIP 113-080-13-83, Regon 010162551). We are grateful to dr Marek Karwański for helpful discussions and valuable comments to the earlier version of the paper. All remaining errors are our own.

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_12

1 Introduction

In beginning of the 1990s the differences in the level of economic and financial development between post-communist economies and advanced economies were significant. However, as convergence and financial integration processes started to speed up, the financial systems in post-communist economies grew in size and became more diverse in terms of their structure.

The aim of our research is to analyze the driving forces behind the financial systems' development in post-communist economies after about 20 years of the transformation process and non-post-communist economies as a kind of a benchmark. The analysis covers the period from 1995 to 2014 for 19 post-communist European countries and 21 advanced countries. We applied a factor analysis to identify similarities and common factors driving the financial system development in those groups of countries.

Our contribution to the literature is twofold. First, we address the hitherto unresearched gap concerning an analysis of financial system development of post-communist economies using post-2007 data, which—to our knowledge—has not been studied in detail. Second, our results also contribute to understanding of the convergence process in both groups of countries, by providing insights that the catching-up process in financial system development of post-communist economies is far from over.

The paper is structured as follows. In Sect. 2 we briefly review relevant literature. In Sect. 3 we present the research methodology and data. Section 4 focuses on the empirical results. The conclusions are presented in the last section.

2 Review of Literature

There are still major differences in the size and structure of the financial systems in post-communist and non-post-communist countries. On average, the banking systems are significantly larger, yet less profitable, less capitalized and slightly less concentrated in advanced economies, as compared to post-communist countries. Also the size of the insurance sector and the capitalization of the stock market is higher in advanced economies, while the structure of the post-communist financial systems is significantly dominated by their banking sectors.

There are only few empirical studies on the growth and finance nexus in CEE countries with younger and relatively less developed financial systems, where the contribution of the financial sector to economic growth is found to be relatively weak (Mehl and Winkler 2003; Dawson 2003; Fink et al. 2008). This was mainly due to the high level of NPLs and banking crisis experiences mostly in mid 1990s (Petkovski and Kjosevski 2014). The financial sectors in former EU accession countries were similar, with a relatively low financial deepening level, underdeveloped stock market, the dominant role of banks and a high degree of foreign presence (Caviglia et al. 2002; Firescu 2012). However, using longer panel data for 27 transition economies over the period of 1989–2004 Akimov et al. (2009) found contrasting evidence—there is strong and positive link between financial development and economic growth. Similarly, Yu et al. (2012) confirms the strength of this link (over the 1980–2009 period) in high-income countries, but not in emerging market countries, including Eastern Europe. Thus, the change in this relationship may be attributed to developments in recent years.

3 Methodology and Data

The data were analyzed in order to identify drivers that determine financial system development of the countries in our sample. A common problem in such an analysis is the dimensionality. The most useful methods to mitigate it are the factor analysis (FA) and the principal component analysis (PCA). They assume that the observed measures are affected by a small number of underlying factors. The difference between these methods is the way they extract the factors. The aim of the factor analysis is to identify common and idiosyncratic factors. Based on correlations between observed variables, small numbers of the latent factors are extracted. It is convenient for interpretation purposes to identify latent factors which are uncorrelated linear combinations of weighted observed variables that explain the maximal amount of variance in the data (Suhr 2005). The factors correlate highly with a given group of the observed variables (jointly representing an underlying variable we want to identify) but poorly with other observed variables. The factors act as a reference frame when interpreting the results.

The factor analysis was chosen as the extension of principal components analysis. It allowed to omit the dependence between observed variables in a way very similar to the copula approach. PCA has been applied to analyze financial development by e.g. Saci and Holden (2008). FA and PCA have been used for instance by Klomp and de Haan (2012) to analyze the bank risk and regulations. Due to the fact that the objective of our analysis is to find similarities in the financial system development of post-communist and non-post-communist countries we decided to apply FA.

We use data collected for nine variables[1] demonstrating the financial system development in both groups of countries. The sources of both sectoral and country-level data include the ECB Statistical Data Warehouse, World Bank and Helgi Library databases, as well as databases and data from reports of respective national

[1]We use: *GDP_pc* (in EUR)—GDP per capita, *bank_assets*—deposit money bank assets to GDP, *dep_cred*—deposits to credits ratio, *ROE*—return on equity, *CAR*—capital adequacy ratio, *C5*—concentration ratio for five banks in the assets of the banking sector, *credit*—domestic credit to private sector to GDP, *insurance*—life and non-life insurance premiums to GDP and *stock_market*—stock market capitalization to GDP.

central banks. The missing values were imputed with the use of IVEware (Imputation and Variance Estimation Software) algorithm.

The total variance of the observed variables can be accounted for by means of factors, as the error variance exists. We use exploratory factor analysis, as we do not have a pre-defined hypothesis of the structure or the number of dimensions in our set of variables.

The correlation matrix (see Table 1)[2] shows that the GDP p.c. is highly positively correlated with the size of the banking system, domestic credit to private sector, insurance premiums and stock market capitalization (all measured as % of GDP). This also translates into a relatively high correlation of bank assets to credit activity, the size of the insurance sector and the stock market. Moreover, credit to the private sector exhibits also a noticeable positive correlation to the size of the insurance sector and the stock market, hence suggesting interdependencies in the joint growth of particular financial sectors. On the contrary, the deposits to credits ratio, ROE, CAR and C5 do not seem to be significantly correlated with other variables.

The next step determines the number of factors to be retained out of the initial nine observed variables. The most common criteria for extracting given number of factors are just empirical guideline and suggest (Kootstra 2004):

1. Retaining only those factors with an eigenvalue larger than 1 (Guttman-Kaiser rule).
2. Keeping those consecutive factors which, in total, account for about (at least) 80% of the common variance.
3. Making a scree-plot (scree test) and keep all the factors before the breaking point or "elbow" of the plot.

Using the criteria above (see Table 2 and Fig. 1), we choose to extract two factors, as one factor model would not allow for a reasonable interpretation. It seems that the first factor on its own explains the significantly larger proportion of the variance (and the structure of the correlations) than the second factor, thus the first factor is much more important.

As a next stage, we compute the factor rotation using standard type of orthomax rotation to achieve rotated component matrix presenting the loadings of the observed variables on the extracted two factors. The rotation of axes does not change the observation space but is very helpful in identifying significant factors forming the basis and it made the factors more easily interpretable. The higher the factor loading of the given variable, the higher the correlations between that variable and the respective factor (see Table 3). As a rule of thumb, we can interpret only those factor loadings with values close to 0.5.

[2]We inspect the correlation coefficients with values over 0.30.

Table 1 Correlation matrix (full sample)

	GDP_pc	*bank_assets*	*dep_cred*	*ROE*	*CAR*	*credit*	*insurance*	*stock_market*	*C5*
GDP_pc	1								
bank_assets	0.5901	1							
dep_cred	0.0616	−0.0322	1						
ROE	0.0208	−0.1391	0.1277	1					
CAR	−0.2545	−0.3281	0.0816	0.0631	1				
credit	0.5564	0.9350	−0.1457	−0.1301	−0.3490	1			
insurance	0.6426	0.6223	−0.1219	−0.0213	−0.2675	0.6371	1		
stock_market	0.6335	0.4724	0.1031	0.0994	−0.1822	0.4971	0.6049	1	
C5	−0.1164	−0.1933	−0.0636	0.0067	0.0450	−0.1556	−0.2290	−0.0720	1

Note: Based on statistical annex to report "Size and structure of financial sectors in selected Central and Eastern European countries and developed countries. Convergence or own path?"

Table 2 Eigenvalues of the reduced correlation matrix (full sample)

	Eigenvalue	Difference	Proportion of variance	Cumulative percentage of variance
1	**3.3713**	2.7523	**0.8569**	**0.8569**
2	**0.619**	0.3791	**0.1573**	**1.0142**
3	0.2399	0.1284	0.061	1.0752
4	0.1115	0.0983	0.0283	1.1035
5	0.0131	0.0347	0.0033	1.1069
6	−0.0216	0.0552	−0.0055	1.1014
7	−0.0768	0.0466	−0.0195	1.0819
8	−0.1234	0.0754	−0.0314	1.0505
9	−0.1988	0	−0.0505	1

Note: Based on statistical annex to report "Size and structure of financial sectors in selected Central and Eastern European countries and developed countries. Convergence or own path?". Figures in bold mark the characteristics of extracted factors

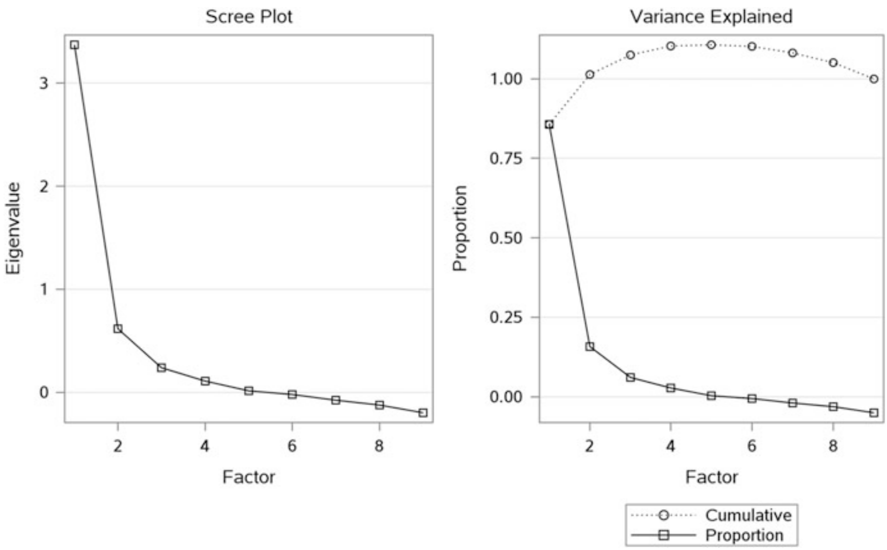

Fig. 1 Scree plot (full sample). Note: Based on statistical annex to report "Size and structure of financial sectors in selected Central and Eastern European countries and developed countries. Convergence or own path?"

4 Discussion of Empirical Results

We can identify two latent factors in the full sample of countries (see Table 3). The first factor is associated with the variables signifying the growth of the whole financial system (*GDP_pc, credit, bank_assets, insurance, stock_market*), hence we call it the "financial system development" factor. The second factor is associated

Table 3 Rotated factor pattern (full sample)

	Factor1	Factor2
bank_assets	**0.85235**	**0.38615**
credit	**0.84652**	**0.44208**
insurance	**0.78594**	−0.0066
GDP_pc	**0.7685**	−0.17102
stock_market	**0.70993**	−0.28184
C5	−0.19494	−0.01047
CAR	−0.33122	−0.16226
ROE	−0.01564	−0.30518
dep_cred	0.00054	−0.33782

Note: Based on statistical annex to report "Size and structure of financial sectors in selected Central and Eastern European countries and developed countries. Convergence or own path?". Figures in bold mark the variables with highest factor loadings

with the variables characteristic for the "role of the banking sector" (*credit, bank_assets*).[3]

Further we analyze relative importance of the variables most correlated with the factors, including changes over time (1995–2014) and cross-country comparisons:

- The relative association of GDP p.c. has been (apart from the crisis) shifting from the second to the first factor. This means that as economies developed, the economic growth might have been more conductive towards the growth of all the financial sectors, not only to the growth of the banking sector itself.
- The domestic credit to private sector (*credit*) and (or) the size of the banking sector (*bank_assets*) have been the leading variables associated with the financial system development prior and after the crisis.
- Throughout the whole period (except for 2005) the proxy for the insurance sector has, on average, been correlated with both factors to a similar extent.
- The role of the stock market has been correlated with the financial system development between 1999–2007 and 2011–2014. During the crisis the relative weight of the stock market was balanced between both factors.

As a result, we may conclude that the global financial crisis (2008–2010) has altered the impact of the analyzed variables for the financial system and the banking sector's growth, but only temporarily.

As concerns the cross-country analysis, there are strong differences in the structure of the financial systems in post-communist and advanced economies,

[3]The development of the financial system depends on the economic growth (*GDP_pc*) through investments and financing channels. Also the consumption of private households contributes to the growth of bank loans (*credit*), which in turn supports the growth of the banking sector (*bank_assets*) being the major part of most financial systems in our sample. Additionally, the growth of both the insurance sector (*insurance*), and the stock market (*stock*_market) benefit the economic growth through intertemporal allocation of savings (allocating capital more efficiently) and by performing an intermediation role in the economy.

Table 4 Rotated factor pattern (both groups separately)

	Factor1	Factor2		Factor1	Factor2
Advanced			Post-communist		
credit	**0.915**	−0.0795	*bank_assets*	**0.8269**	−0.2869
bank_assets	**0.9001**	−0.0399	*credit*	**0.7881**	−0.4876
C5	−0.1181	−0.0903	*GDP_pc*	**0.7139**	0.1344
ROE	−0.233	0.2291	*insurance*	0.3869	−0.128
stock_market	0.1737	**0.6427**	*CAR*	−0.4512	−0.0234
GDP_pc	0.0314	**0.5906**	*dep_cred*	−0.0932	0.4803
CAR	−0.0676	0.4597	*ROE*	0.0123	0.4106
dep_cred	−0.0365	0.3887	*C5*	0.0049	−0.0805
insurance	0.3461	0.3612	*stock_market*	0.162	−0.2108

Note: Based on statistical annex to report "Size and structure of financial sectors in selected Central and Eastern European countries and developed countries. Convergence or own path?". Figures in bold mark the variables with highest factor loadings

but the role of the banking systems remains similar. The role of both latent factors is on a comparable level for all post-communist countries and does not change significantly over the sample period, while its significance is more varied among the advanced economies. The relative importance of the financial system development factor has been steadily rising among the advanced economies over 1995–2014, which is not characteristic of the post-communist countries. This might imply higher homogeneity in the growth of the financial system, including the banking sector in the post-communist countries and higher heterogeneity among the advanced countries.

The dynamics of trajectories of each country in the factor space throughout the analyzed period reveal no clear common trends of particular countries. However, the comparison of trajectories dynamics for both groups of countries shows that the factor trajectories are far more widespread and less consistent in the advanced economies, as opposed to more similar and concentrated patterns among the post-communist ones.

We also analyzed factors separately for each group of countries (see Table 4). For the advanced countries alone two factors can be clearly distinguished, i.e. the role of the banking sector (very high factor loadings for *credit* and *bank_assets*) and the stock market development (high factor loadings for *stock_market* and *GDP_pc*). However, for the post-communist countries only the first factor has meaningful factor loadings for *bank_assets*, *credit* and *GDP_pc*, i.e. the role of the banking sector. This confirms that the economic development might be strongly driven by the banking sector in both groups of countries, but in the advanced economies somehow also by the stock market, which is in turn rather a missing pillar in the post-communist countries.

5 Conclusions

With the use of the factor analysis over 1995–2014, we have provided evidence that there are two processes driving the development of both groups of countries, i.e. the financial system development (for non-post-communist countries) and the growth of the banking sector only (for post-communist). The economic development is strongly correlated with the banking sector in both groups, while in the advanced economies some role is also played by the stock market. There is higher homogeneity in the development patterns of the financial system, including the banking sector, in the post-communist countries, while the role of both factors is more heterogeneous among the advanced economies. Moreover, the global financial crisis did not cause a permanent structural change in the impact on those two processes.

The following policy implications might be drawn from our analysis. First, there are significant differences in the paths of financial development and the structure of the financial sector. Therefore, financial stability policies should not be fully harmonized. Second, the development of the stock market should be especially fostered in order to create the second driving force for the economic development ("a spare wheel") in post-communist economies. However, the important lesson from the crisis is that the development of the stock market should be accompanied by proper regulations and monitoring of risks in order to increase financial system resilience.

Further research should widen the scope of the observed variables and cover, in more detail, the financial system structure and a factor analysis might be applied to other emerging markets.

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Measuring Systemic Risk with *CoVaR* Using a Stock Market Data Based Approach

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Abstract The aim of the paper is to present and discuss an alternative method of calculating the CoVaR of the banking system. The authors build and empirically utilise the measure of systemic risk, which is based on the traditional CoVaR approach, as proposed by Adrian and Brunenmeier (*CoVaR*. Staff Report No. 348, Federal Reserve Bank of New York, 2008 [revised September 2014]; *CoVaR*. NBER Working Paper No. 17454, National Bureau of Economic Research, 2011; Am Econ Rev 106:1705–1741, 2016), but uses market-based data (instead of the book values) for calculation. The assumptions of this method, among all else are that 1) the aspects of systemic risk which closely relate to financial system stability, for relatively small financial systems, where the banking sector is the main provided of funding and liquidity, may be modelled with banking-sector-based methods; and 2) the stock market is efficient enough to price the risk related to those financial institutions, whose stocks are quoted on the relevant stock exchange. The empirical research is carried on the example of Poland, as in the authors opinion, also following the literature, the two mentioned assumptions hold for this particular country. The paper concludes with ideas for future research, including further development of the proposed method to include institutions other than banks, and a range of other central European countries for which this method is applicable.

1 Introduction

The aim of the paper is to add to the research on systemic risk measurement by presenting and discussing an alternative method of calculating CoVaR of the banking system, which may be, under certain conditions being fulfilled, treated as a good method of measuring the level of financial stability for a given country. In order to obtain this goal, we build and empirically utilise the measure of systemic risk, which is based on the traditional CoVaR approach, as proposed by Adrian and Brunenmeier (2008, 2011, 2016), but uses market-based data (instead of the

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_13

book values) for calculation. The assumptions of this method, among all else, are that:

1. The aspects of systemic risk which closely relate to financial system stability, for relatively small financial systems, where the banking sector is the main provider of funding and liquidity, may be modelled with the banking-sector-based methods; and
2. The stock market is efficient enough to price the risk related to those financial institutions, whose stocks are quoted on the relevant stock exchange. Moreover, using market-based data allows to retain the information about market sentiment and its behavioural reactions to information, which significantly affects the amplification and contagion mechanisms relevant for systemic risk, as discussed by Benoit et al. (2015).

The empirical research is done on the example of Poland, as in the authors' opinion, also following the literature, the two mentioned assumptions hold for this particular country. The authors' view is, however, that *CoVaR* should be used as one of many complementary measures, when financial stability monitoring is carried, as the complexity of financial systems as such renders any single method empirically ineffective in allowing for a complete view of systemic risk.

The paper concludes with ideas for future research, including further development of the proposed method to include institutions other than banks, and a range of other central European countries for which this method is applicable.

2 Alternative Approach to Calculating *VaR* and *CoVaR*

Value at Risk (*VaR*) is a standard statistical risk measure recommended by The Basel Committee on Banking Supervision and market regulators and supervisors of financial institutions, especially banks and insurance companies. It measures the potential loss in the value of a relevant risky asset or a portfolio, over a defined period of time and for a given confidence interval, as a one summarized and easy to understand number relating to the downside risk of the given institution, due to the relevant financial market variables (Jorion 2006).

If X^i is the F distributed random variable of institution i returns, then the given confidence level of (1–q)% *VaR* is defined as:

$$VaR_q\left(X^i\right) = \inf\{x : F(x) \geq q\}. \tag{1}$$

$$P\left(X^i \leq VaR_q^i\right) = q. \tag{2}$$

From formula (2) follows that *VaR* equals:

$$VaR_q^i = F^{-1}(q). \tag{3}$$

Conditional Value at Risk (*CoVaR*) is a systemic risk measure, as introduced by Adrian and Brunnermeier (2008, 2011, 2014, 2016) to capture value of risk of the financial system, conditional on an institution, being under distress. The "*Co*" prefix stands for *contribution* and *contagion,* as well. *CoVaR* measures financial institutions' contribution to systemic risk and their contribution to the risk of other financial institutions, as well as to the contagion effect.

If X^j is the return of the financial system j and X^i is the return of bank i, $CoVaR_q^{j|i}$ for quantile q of financial system j conditional on bank i being in distress at its VaR_q^i level, is defined as:

$$P\left(X^j \le CoVaR_q^{j|i} | X^i \le VaR_q^i\right) = q. \tag{4}$$

In order to measure contribution of bank i to the financial system value at risk during stressful time Adrian and Brunnermeier (2008, 2011, 2014, 2016) proposed to calculate *deltaCoVaR* of the system Value at Risk, conditional on bank i being at the relevant *VaR* level minus the system value at risk conditional on bank i being at its medial level:

$$\Delta CoVaR_q^{j|i} = CoVaR_q^{j|\mathrm{X}^i = VaR_q^i} - CoVaR_q^{j|\mathrm{X}^i = VaR_{50\%}^i}. \tag{5}$$

2.1 Quantile Regression and Estimation of CoVaR

The method applied to estimate *CoVaR* is quantile regression. The financial system j is related to bank i return variables by a linear model:

$$X^j = \alpha_q^i + \beta_q^i X^i + \varepsilon. \tag{6}$$

The conditional quantile function is estimated by solving for the relevant α and β parameters which minimize:

$$\min_{\alpha_q^i, \beta_q^i} \sum_t \begin{cases} q\left|X^j - \left(\alpha_q^i + \beta_q^i X^i\right)\right| & if \quad X^j - \left(\alpha_q^i + \beta_q^i X^i\right) \ge 0 \\ (1-q)\left|X^j - \left(\alpha_q^i + \beta_q^i X^i\right)\right| & if \quad X^j - \left(\alpha_q^i + \beta_q^i X^i\right) \ge 0 \end{cases}, \tag{7}$$

$$CoVaR_q^{j|\mathrm{X}^i = VaR_q^i} = \widehat{\alpha}_q^i + \widehat{\beta}_q^i VaR_q^i, \tag{8}$$

$$CoVaR_q^{j|X^i=VaR^i_{50\%}} = \widehat{\alpha}_q^i + \widehat{\beta}_q^i VaR^i_{50\%}. \tag{9}$$

Finally, contribution of bank i to the financial system j may be derives as:

$$\Delta CoVaR_q^{j|i} = \widehat{\beta}_q^i \left(VaR_q^i - VaR^i_{50\%} \right). \tag{10}$$

2.2 Stock Market Data

Adrian and Brunnermeier (2014) estimated *CoVaR* and *Delta CoVaR* based on market value of total asset returns for financial institutions. The growth rate of market valued total assets X for bank i at time t is defined as:

$$\begin{aligned} X_t^i &= \frac{ME_t^i\left(\frac{BA_t^i}{BE_t^i}\right) - ME_{t-1}^i\left(\frac{BA_{t-1}^i}{BE_{t-1}^i}\right)}{ME_{t-1}^i\left(\frac{BA_{t-1}^i}{BE_{t-1}^i}\right)} = \frac{ME_t^i LEV_t^i - ME_{t-1}^i LEV_{t-1}^i}{ME_{t-1}^i LEV_{t-1}^i} \\ &= \frac{MA_t^i - MA_{t-1}^i}{MA_{t-1}^i} \end{aligned} \tag{11}$$

where:

ME_t^i is the market value of total equities of institution i at time t,

BA_t^i is the book value of total assets of institution i at time t,

BE_t^i is the book value of total equities of institution i at time t,

LEV_t^i is the leverage, i.e. ratio of total book assets to book equity of institution i at time t,

MA_t^i is the market value of total financial asset of institution i at time t.

In this approach, the price-to-book equity value is used to transform book-valued total assets into market-valued total assets. The growth rate of market valued total assets for the financial system at time t is defined as the average growth rate of market valued total assets.

This traditionally proposed approach is problematic in application for many countries. This is either due to short time series—for instance, when the data is available only about 10 years back, and its frequency is upmost quarterly, this gives us merely 40 observations. Moreover, there exists difficult/privileged and time-delayed access to data for the market participants, especially when it comes only in the monthly or even quarterly reports prepared for the regulating bodies. The problem exists for many countries, especially in case of the less developed and emerging economies, but also in case of some smaller countries, which are not yet so strictly regulated. Finally, there is an issue of possible window-dressing of the book-value data by financial institutions which are in distress.

Table 1 10 top banking institutions in Poland

Institution	Assets	Liabilities	Leverage	Debt	Capitalization
PKO BP	266,038,274	235,773,361	7.90	34,978,365	34,162,520
Pekao SA	167,870,363	146,421,585	4.89	11,662,710	37,664,430
BZWBK	138,456,892	117,888,762	5.42	11,172,319	26,653,590
MBank	123,156,933	110,881,969	9.36	43,253,311	13,263,020
INGBank	108,833,600	98,153,100	7.44	4,990,100	15,241,220
Millennium	65,997,644	59,554,479	9.83	3,211,606	6,744,930
Handlowy	49,345,206	42,494,550	5.52	7,152,066	9,394,420
Getin	22,617,379	19,906,227	23.31	2,748,666	892,110
BPH	31,090,094	27,013,140	12.45	850,421	2,359,840
BOS	20,875,846	19,407,290	50.65	3,134,559	390,900

Source: Thomson Reuters DataStream (access: 31-12-2015)

For the abovementioned reasons, we propose to carry the CoVaR-method-based analysis on the basis of the market data, in the form of rates of return from the stock exchange. A by-product of such approach is taking into account the market sentiment reflected in the market pricing of stocks, including systemically important events such as runs on instruments and market freezes.

3 *CoVaR* Based on the Stock Market Data: Empirical Results for Poland

For empirical analysis we take the weekly logarithmic rates of return from the period: 05-01-2006 until 31-12-2015 (521 observations)[1] on the sub-index of the Warsaw Stock Exchange called WIG-Banking, which is built on the returns of the biggest banks in Poland quoted on the national stock exchange.[2] Following the assumptions mentioned at the beginning of this paper, the WIG-Banking Index is taken as a proxy for the banking system in Poland. Importantly, 10 banks selected for analysis compose the most significant portion of the total banking system by the size of assets and consist 92% of the total share in the index (Table 1).

Individual value at risk of institutions and the system was calculated as a quantile of loss distribution based on the Eq. (2) (see: Table 2). In general, the level of stability of the Polish banking sector seems relatively high. The highest individual value at risk, obtained empirically from the studied period equals −20.86% at the 99% confidence level, refers to Millennium Bank, which has a share in the index at the level of 4.48% (i.e. it is not amongst the most systemically

[1]Maximum period where the data is available for all the studied institutions.

[2]Weights in the index are the same as in the WIG index portfolio. It is an income-based index and thus it accounts for both prices of underlying shares and the dividend, as well as the pre-emptive rights income.

Table 2 *VaR* and CoVaR of the Polish banking system and institutions as at 31-12-2015

Bank i	VaR^j, $q = 50\%$	VaR^j, $q = 99\%$	*CoVaR* 99% (System|Bank)	*ΔCoVaR* (System| Bank)	CoVaR 99% (Bank| System)	ΔCoVaR (Bank| System)
PKO BP	0.33%	−14.94%	−19.07%	−14.76%	−15.49%	−11.38%
Pekao SA	−0.12%	−11.88%	−15.05%	−10.64%	−19.40%	−14.48%
BZWBK	0.22%	−13.25%	−17.60%	−11.31%	−18.63%	−11.20%
MBank	0.25%	−16.41%	−16.94%	−10.03%	−23.87%	−15.07%
INGBank	0.13%	−11.86%	−16.54%	−7.92%	−20.84%	−12.71%
Millennium	0.18%	−20.86%	−16.49%	−9.25%	−28.46%	−14.64%
Handlowy	0.37%	−15.93%	−17.41%	−9.44%	−20.02%	−11.03%
Getin	0.00%	−16.55%	−16.57%	−8.57%	−24.40%	−14.19%
BPH	−0.28%	−17.43%	−16.87%	−6.34%	−24.00%	−7.14%
BOS	−0.36%	−10.13%	−13.02%	−3.42%	−15.41%	−5.70%
WIG-Banking	**0.16%**	**−11.62%**				

important Polish banking institutions). The lowest *VaR* refers to a small banking institution, i.e. it equals −10.13% for the BOS Bank (Bank Ochrony Środowiska) with the participation in the index of only 0.2%. *VaR* of the biggest market institutions—in terms of capitalization and thus share in the index—PKO BP and Pekao SA, amounts respectively to −14.94% and −11.88%, which points to moderate levels of risk borne by these banks. The fact that the span of the VaR for all studied institutions is within the range of up to −20% is another observation pointing to relative stability of the banking sector in Poland.

In Table 2, we also present the results of estimating the conditional expected $CoVaR_{99\%}{}^{j|i}$ of the system j, provided that bank i will realize a loss of individual *VaR* for $q = 99\%$ and the contribution of i to the risk of the entire system of $\Delta CoVaR_{99\%}{}^{j|i}$. Highest conditional value at risk equals to −19.07% and refers to the case of PKO BP, the lowest −13.02% relates to the case of a BOS Bank. Similar relations can be observed in the case of the contribution to the total value at risk of the system, the highest value of −14.76% is due to PKO BP bank, the lowest −3.42% to BOS. These results are not surprising given the disparity in the size of the Polish banking institutions in terms of market capitalization and value of assets. Figure 1 (left) illustrates the discussed relationship. While the largest individual VaR of −20.86% exists in the case of Millennium Bank, the greatest contribution to risk of the entire system is generated by PKO BP.

So captured, the information does not identify the institutions which generate risk higher than others in comparison to their size (i.e. the riskiest banks), yet this information seems crucial form the prudential perspective. Therefore, to increase the information value of the proposed measurements, we introduce a simple modification which allows for relating the value of i to the size of its share in the index (see: Fig. 1 (right)). This simple indicator allows to identify the institutions

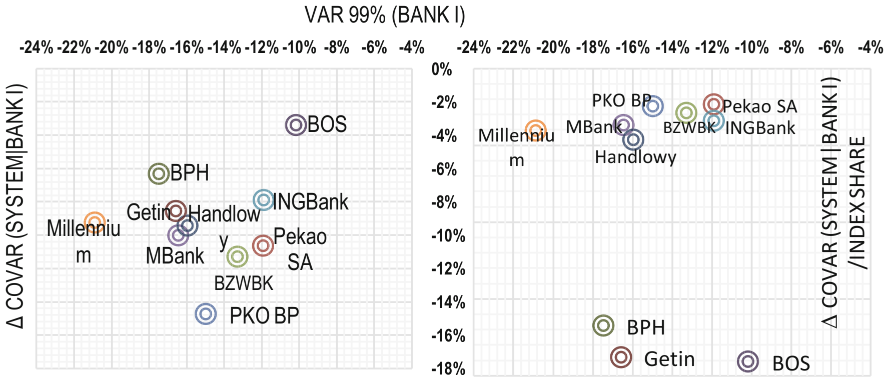

Fig. 1 Risk of bank *i* in isolation and ratio of contributions of bank *i* to systemic risk, uncorrected values (*left*) and values corrected by index share (*right*)

such as BOS, Getin and BPH which generate the highest levels of risk, i.e. they are the weakest links in the chain of the banking sector in Poland.

Table 2 also shows the estimation of the risk of individual institutions conditional on the loss of the entire system of weekly *VaR* equal to -11.62% (understood as a systemic event). The highest loss of -28.46% is recorded by Millennium Bank, marking it the most vulnerable of all institutions in the Polish banking system to the negative external conditions. As presented by Fig. 2, other banks which are most susceptible to a systemic event are also MBank, Pekao and Getin.

Finally, we illustrate the two-way relationship of risk contribution between the banks and the system (see: Fig. 3).

It has a significant meaning in the context of the feedback effect present in complex systems, such as the financial one, as each systemic event increases the likelihood of putting more (next) banks in distress, in this way generating a potential knock-on effect. As may be observed, the twofold relationships are not in every case proportional. More specifically, some institutions contribute more risk to the system than they are prone to from it themselves. In general, the majority of banks are currently prone to higher loss, in case of financial system destabilisation, than they bring to the table themselves. Nevertheless, we see that currently the system is relatively stable and no apparent serious risks are identifiable.

4 Conclusions

The paper presented a study of systemic risk prevailing in the banking sector, focusing empirical analysis on Poland, as the most important theoretical assumptions necessary for implementation of the proposed method seem to be fulfilled for this country. The proposal consisted in alternative data approach to calculating of a well-established systemic risk measure, i.e. *CoVaR*.

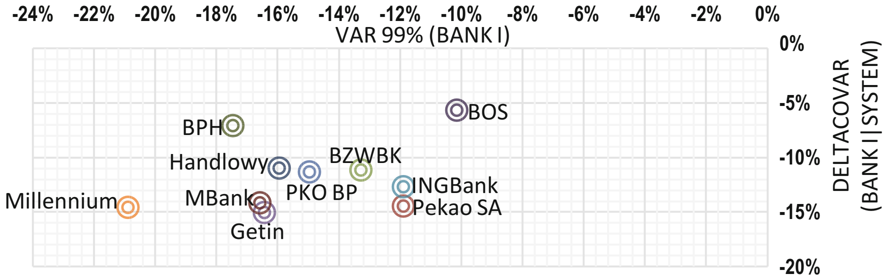

Fig. 2 Risk of bank *i* in isolation and contributions of system *j* to total risk of bank *i*

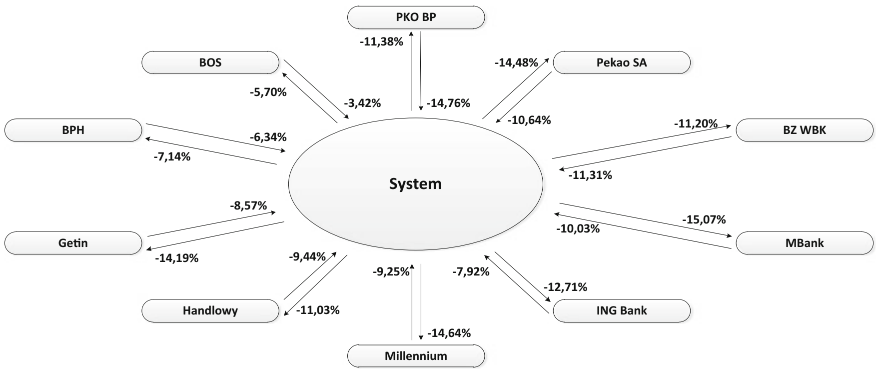

Fig. 3 The contribution of institutions to the risk of the system and the contribution of the system to the risk of the institutions

The results obtained allowed for identification of the institutions adding to systemic risk in Poland. Moreover, the modifications employed in the later part of the study allowed to identify also the weakest links in the banking chain of all institutions. Finally, the analysis of interconnections between the financial institutions and between each institution and the system, allowed us to shed some light on interconnectedness of the financial system in Poland and possibility of occurrence of the knock-on effects.

It seems important to state that the results point to similar group of risky institutions as estimated with different methods (e.g. S-Risk methodology). Further research encompasses modelling of differences in results between the traditional *CoVaR* method and our proposal (once the minimum necessary amount of observations is available), as well as using the proposed approach for other (small or emerging) economies, such as for instance other Central Europe group countries. Another possible direction of research is extending the index-based methodology of *CoVaR* calculation to include all SIFIs in the base line (synthetic index) to try to capture the systemic risk in total.

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The Quality of Financial Information and Stock Market Development: A Panel Data Study for the European Economies

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Abstract The main aim of the paper is to investigate whether the quality of financial information facilitates and promotes the stock market development. We test this hypothesis by using a sample of 36 European economies in the period 2006–2012 based on dynamic panel regression (system GMM) approach. The strength of auditing and reporting standards (SARS) is used as a measure of financial information quality, while the stock market capitalization relative to GDP measures the stock market development. The estimated results demonstrate positive and significant relationship between financial information quality and capital market development after controlling for the standard macroeconomic and financial specific stock market determinants, suggesting that financial reporting quality is one of the most important determinants of stock market development in European economies. The effects of financial reporting to stock market development are much more significant in the case of non-EU countries. Additionally, the results suggest that growth rate, foreign direct investment, banking sector and corporate governance quality are positively and significantly associated with stock market development, while inflation rate and stock price volatility as measures of macroeconomic and stock price instability have negative influence on stock market activity.

1 Introduction

The main purpose of the paper is to investigate the impact of financial information quality on stock market development. So, the underlying hypothesis of the empirical study is that the transparent and objective financial reporting can play an important role in promote the stock market investment activities. We test this

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_14

hypothesis of the sample of 36 European economies for the period 2006–2012 by applying dynamic panel data specifications to identify both within and cross-country effects.

Financial statements provide key insights for investment decisions of all stakeholders, so better information quality due to stronger financial auditing and reporting standards reduce information asymmetry and costs for price protections, strength the investors' confidence and trust on stock market, improve firms' valuations, make firms' access to capital easier, and potentially increase the number of firms listing their equity on the market. All these mechanisms should facilitate the stock market development.

The strength of auditing and reporting standards (SARS) is used as a measure of the quality of financial information. Many studies found that high quality of reporting standards, Daska et al. (2008); Jara et al. (2011) as well as their acceptability and enforceability influences the users' perception of quality of financial information, Wulandari and Rahman (2004); Ball (2006); Barth et al. (2008); Chen et al. (2002).

This measure is based on executive perceptions of their surroundings and it is derivated by Executive Opinion Survey of the World Economic Forum. The size of stock markets (stock market capitalization) and stock market trading activity (stock market total traded value) relative to GDP are the aggregate variables that we use as proxies variables for stock markets development. We use several macroeconomic and financial specific determinants of stock markets development as controlling variables.

The estimated results demonstrate positive and significant relationship between financial information quality and capital markets development after controlling for fundamental macroeconomic and institution stock market determinants such as growth of real GDP, inflation rate, bank credit, institutional capacity and corporate ethics. These results indicate that the quality of financial information facilitates stock market development and the public trust in politicians and the corporate board efficiency amplify the potential positive effects of financial information quality on stock markets development.

The rest of this paper is organized as follows. In Sect. 2, we present a selective literature review of the quality of financial information and stock market development, including papers concerned with various aspects of institutional and accounting demission. In Sect. 3 we present our data and describe the research methodology framework used in the empirical work. We discuss the common known statistical problems associated with panel estimation of stock markets determinants and then explain our preferred econometric method—System GMM. At the end of this Section, we present the estimated results and the main findings. Section 4 presents conclusions and we also suggest topics for future investigation.

2 Literature Review

The earlier stream of the empirical literature related to stock market development is focus on macroeconomic and institutional determinants. For example, Garcia and Liu (1999) found that set of macroeconomic factors are the more important factors of stock market development, while several other studies have shown that legal protections for investors are associated with capital market development, Djankov et al. (2007). Some studies in this stream of literature have suggested that accounting and disclosure quality is associated with capital market development, based on cross-sectional regression estimates, La Porta et al. (1997, 2008). Additionally, Friedman (2015) went further and used industry leaders' perceptions of standards' strength as persons who are incorporating the enforcement and the standards. In a panel of over 140 countries from 2002 to 2013, Friedman (2015) confirm, empirically, that stronger auditing and reporting standards are positively associated with subsequent levels of equity market development. Also, the research verifies the Executive Option Survey perceived strength of auditing and reporting standard (PSARS) is significantly correlated with the probability that firms use high-quality auditors, the probability that firms use high-quality reporting standards, so it has explanatory power for country differences in market development. Additionally, author showed the public trust in politics and managers have effects on straight of auditing and reporting standards.

The accounting literature related to financial markets is focus on the economic consequences of adoption of IFRS: improving the liquidity of the market, Christensen et al. (2013) as well as decreasing the investment risks, Daske et al. (2008), improving investor protection and maintenance of investor confidence, European Commission (2015).

The paper contributes to the literature by applying more appropriate panel technique (System Generalized Method of Moments) to investigate the stock markets development in the European economies focusing on the quality of financial information. Several studies have examined the influence of accounting and disclosure quality on stock markets development bases on cross-sectional estimation, La Porta et al. (1997, 2008). To date, only one paper, Friedman (2015) use the strength of auditing and reporting standards to measure the quality of financial information and addressed the possible endogeneity issue. However, we focus our research on European economies and we use several new macroeconomic and financial specific determinants (foreging direct investment, stock price volatility, and banking sector development) as controlling variables. The estimated results based on the models specification found more robust evidence that the quality of financial information (measured by the strength of auditing and reporting standards) is positively associated with stock markets development in the sample of 38 - European countries.

3 Empirical Work

3.1 Research Methodology Framework

The aim of the empirical work within this paper is to examine how the strength of financial auditing and reporting standards affects capital markets development for the sample of 36 European economies in the period 2006–2012. In order to fulfill this goal, dynamic panel data model (system GMM) is used because it accounts for the endogeneity of lagged dependent variable and for the potential endogeneity of some other explanatory variables, such as omitted variables and error measurement as well-known econometric problems that can produce potential bias in coefficients and standard errors estimations (Arrelano and Bond 1991).

The system GMM (system generalized method of moments) estimator introduced by Arrelano and Bover (1995) and further developed by Blundell and Bond (1998) is appropriate for panel data like the one used in this paper with relatively large N (number of countries) and small T (number of years).

The system GMM model is presented by the following equation:

$$SMD_{it} = \alpha SMD_{i,t-1} + \beta X_{it} + \gamma F_{it} + \phi FI + \omega CG + \lambda Y_i + \mu_i + u_i \tag{1}$$

where, SMD_{it} is the stock markets development in country i over time period t measured by the stock market capitalization relative to GDP; $SMD_{i,t\text{-}1}$ is a lagged value of stock market development, i.e. lagged dependent (endogenous) variable which allows for a dynamic structure of the model: vector, X_{it}, contains macroeconomic specific determinants which vary over i and t; vector, F_{it}, represents the financial specific determinants of stock market development, the vector, FI_{it}, is represented by the proxy variable that capture the financial information quality as a main interest variable in this empirical work and the symbol, CG_{it}, represents the quality of corporate governance measured by the efficacy of corporate boards.

The symbol, Y_i within the equation is related to interaction variable that measure whether the EU status of the countries is important in the relationship between the quality of financial information and stock market development or whether the EU status is important in the relationship between the corporate governance quality and stock market development. The other part of the equation contains individual (unobservable country-specific) effects μ_i, along with the independently identically distributed stochastic disturbance term u_{it}. According to the capital market and macroeconomic theory we defined growth rate, investment rate, stock price volatility, quality of financial information and corporate governance as endogenous variables, while inflation rate and foreign direct investment are identified as exogenous variables.

The data are first transformed using forward orthogonal deviations (Arrelano and Bover 1995). Like first differencing, this transformation eliminates the individual error components. Unlike first differencing, it is robust to gaps in panel data and keeps lagged variables orthogonal to contemporaneous error terms.

Some features of System GMM are important to be addressed. First, an identifying assumption is that the errors do not display second-order autocorrelation. Second, the "two-step" GMM estimator that allows for heteroscedasticity and cross-correlation can result in downward-biased standard errors, therefore we use the Windmeijer (2005) small-sample correction in the reported estimates.

3.2 Sample and Data Description

The broadest dataset used in the empirical research includes 28 EU countries (Austria, Belgium, Croatia, Czech Republic, Demark, Estonia, Hungary, Latvia, Lithuania, Finland, France, Iceland, Ireland, Italy, Germany, Greece, Netherlands, Norway, Portugal, Poland, Romania, Spain, Sweden, the Slovak Republic, Switzerland and Slovenia), 4 EU candidate countries (Macedonia, Serbia, Montenegro, and Turkey), and 4 non-EU European countries (Armenia, Kazakhstan, the Russian Federation and Ukraine) and covers annual data in the period 2006–2012. The choice of dataset is based on the availability of data for European countries.

The Stock Market Capitalization relative to GDP is used as a proxy variable for measuring stock market development. Actually, this variable measures the equity market's total capitalization as a percentage of GDP in year *t*, and is a standard variable for stock market development.

The quality of financial information as a main interest variable in the model is measure by the strength of auditing and reporting standards (SARS) as a proxy variable. This variable is derivate by the Executive Opinion Survey (EOS) and reported from the World Economic Forum (WEF). The numerical scores for this proxy variable that measure the quality of financial information is country-year average responses to prompts in the Executive Opinion Survey as reported in Global Competitiveness Reports. The data about the quality of corporate governance measured by the efficacy of corporate governance as firm's specific determinant of stock market development is also provided by the Executive Opinion Survey (EOS).

Variables representing macroeconomic determinants of stock market development include: annual growth rate of real GDP as a measure of economic performance; inflation rate as a measure of macroeconomic stability, and investment rate measured by the gross fixed capital formation relative to GDP. The data of these variables are taken from the World Bank's World Development Indicators data set.

Proxies for financial specific determinants are Bank Credit to private sector relative to GDP which represent the banking sectors development and Stock price volatility (the average of the 360-day volatility of the national stock market index) which measure the stock market (in) stability. The main source of these variables is the Global Financial Development Indicators database reported by World Bank.

The summary statistics for all variables are reported in the Table 1.

Table 1 The summitry statistics for the main variables in the models

Variable	Description	Mean	Stand. dev.	Skewness	Kurtosis	Obs.
Economic growth	Annual rate of economic growth rate, %	1.85	4.76	−0.593	4.423	266
Inflation rate	Percentage change of average annual price, %	4.14	3.59	1.764	8.519	259
Financial information quality	Strength of auditing and reporting standards perception	4.99	0.79	0.0284	1.922	264
Corporate governance	Efficacy of corporate governance	4.72	0.61	0.2088	1.964	264
Stock Market capitalization	The value of domestic shares traded on the stock market relative to GDP	47.46	41.98	1.969	8.160	265
Stock price volatility	Average of the 360-day volatility of the national stock market index	24.06	12.08	1.404	9.083	246
Bank private credit	Bank domestic credit to private sector, % of GDP	85.74	49.23	1.104	4.084	256
Investment rate	Gross domestic fixed investment, % of GDP	22.90	4.56	1.090	5.187	262
EU	Dummy variable for EU membership	1—Emerging European economies, 0—Non EU countries				

3.3 Estimated Results and Discussion

The estimated results of all dynamic panel specification models with two-step standard errors and the standard post-estimation tests are reported in the Table 2.

The analysis sample includes 36 European economies for the period 2006–2012.

The coefficient of the lagged stock markets development [stock market development (t-1)] as a right side variable (endogenous regressor) of the each dynamic panel model is expectedly positive and significant indicating that stock market capitalization in the previous year has positive impact on current stock market development.

According the results of all model specifications reported in the Table 2, growth rate of real GDP, investment rate and foreign direct investment are positively and significantly associated with stock markets development, while inflation rate and stock price volatility as measures of macroeconomic and stock price stability have negative influence on stock market activity. Moreover, the results found that banking sector and stock market are complementary, suggesting that the well-developed banking sector co-exist with big stock markets.

Most importantly, the estimated results demonstrate positive and significant relationship between financial information quality and stock markets development after controlling for fundamental macroeconomic and financial specific determinants. These results indicate that the quality of financial information facilitates the

Table 2 Estimated results by System Generalized Method of Moments (system GMM)

	Model 1	Model 2	Model 3
Dependent variable: Stock market development			
Independent variables:			
L1. Stock market development	0.384***	0.402***	0.361***
	(0.000)	(0.000)	(0.000)
Investment rate	0.672***	0.583***	0.596***
	(0.000)	(0.000)	(0.000)
Growth rate	0.891***	0.908***	0.899***
	(0.000)	(0.000)	(0.000)
Banking sector development	0.269***	0.260***	0.339***
	(0.000)	(0.000)	(0.000)
Inflation rate	−1.266***	−1.312***	−1.264***
	(0.003)	(0.000)	(0.001)
Stock price volatility	−0.447***	−0.457***	−0.457***
	(0.000)	(0.000)	(0.005)
Financial information quality	7.321***	10.872***	10.601***
	(0.008)	(0.000)	(0.000)
Corporate governance quality	9.054***	9.692***	14.870***
	(0.000)	(0.000)	(0.000)
Financial information quality*EU status		−3.634**	
		(0.025)	
Corporate governance quality*EU status			−6.139***
			(0.004)
Constant	−78.794	−84.776	−102.772
	(0.000)	(0.000)	(0.000)
Sargan test (p-value) (Ho: instruments are valid)	0.0889	0.0642	0.0811
Arellano-bond AR(2) test (p-value) (Ho: no second order serial correlation)	0.56	0.25	0.31
Observation	206	206	206
Number of countries	36	36	36

Source**:** Authors' calculation
Note: ***Statistical significance at the 1% level, ** at 5% level, * at the 10% level (in parenthesis are p-values). All models are estimated by using two-step standard errors

stock market development in European economies. In the same time, the results indicate that corporate governance quality as a country-specific determent has an important role in promoting stock market development. Finally, we include interception variables in the model to test the impact of EU countries status on the interactions between financial information and corporate governance quality with stock market development. However, we found that these relationships are not linear, suggesting that the benefits of stronger reporting and corporate governance standards to stock market development are much more significant for non-EU countries.

We have carried out several standard specification tests (Hansen test and Arellano-Bond test for AR(2)) in order to verify the reliability of our estimates. The result of the Hansen test supports the validity of the over-identifying restrictions (the p-value is under the critical value, so we failed to reject the null hypothesis that the instruments are valid), while the Arellano-Bond test AR(2) indicates the absence of second order serial correlation in all regressions (the p-value is not significant, so we failed to reject the null hypothesis for no second order serial correlation).

4 Conclusions

The estimated results based on dynamic panel regression analysis (system GMM) for 36 European countries in the period 2006–2012 demonstrate positive and significant relationship between financial information quality and capital markets development after controlling for macroeconomic and financial specific stock market determinants. These results indicate that the quality of financial information facilitates the stock market development in European economies taken in our sample. Additionally, the results suggest that growth rate and foreign direct investment are positively and significantly associated with stock markets development, while inflation rate and stock price volatility as measures of macroeconomic and stock price stability have negative influence on stock market activity. Moreover, the results found that banking sector and stock market are complementary, suggesting that the well-developed banking sector co-exist with big stock markets. Most importantly, the estimated results demonstrate positive and significant relationship between financial information quality and stock markets development after controlling for fundamental macroeconomic and financial specific determinants. These results indicate that the quality of financial information facilitates the stock market development in European economies, but the most significant impact is found in the case of non-EU countries.

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Impacts of Urban Environmental Attributes on Residential Housing Prices in Warsaw (Poland): Spatial Hedonic Analysis of City Districts

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Abstract The study aimed to investigate the home-buyers' preferences in relation to urban environmental attributes (two types of air pollution and five types of noise) for Warsaw, Poland and test the applicability of hedonic pricing method (HPM) in Poland. The econometric classical hedonic housing price models are developed and estimated for the city of Warsaw and hedonic models with spatial adjustments (spatial autoregressive model and spatial error model) are developed for separate city districts. The AMRON database of Polish Banks Association is used with 6318 observations between 2012 and 2014 years. The GIS technique and MATLAB tool are applied for implementation to the database location, environmental and spatial attributes. Most of structural and location attributes occurred to be statistically significant with expected signs of influence on prices. Models for separate districts differ, with environmental variables: rail, aircraft, tram, industrial noise, NO_2 and PM10 concentrations being significant in some districts.

1 Introduction

Housing is a multi-attribute commodity comprising diverse, heterogeneous characteristics. The relationship between house price and it's attributes is complicated. To understand this, many attempts had been made. Examples are (Ridker and Henning 1967)—offering theoretical and econometric literature on location theory (with special reference to air pollution). Dipasquale and Wheaton (1996) present a conceptual framework explaining how locational and neighborhood characteristics influence property values in urban areas.

Freeman (1979) listed the environmental attributes among other variables when conducting a statistical test to measure people's willingness to pay for housing with different attributes. There are many aspects that contribute to environmental attributes, for instance: noise and air quality (Hui et al. 2007).

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_15

However, the limitation in applicability of the method is developed private housing market requirement There are also methodological concerns on the best forms of hedonic price models, including models with spatial adjustments.

This paper focuses on environmental characteristics of a residential property on its market value in Warsaw districts. Four forms of models were applied to explore the relationship between housing price and housing attributes: linear, logarithmic, spatial error model (SEM) and spatial autoregressive model (SAR).

The study aimed to (1) investigate home-buyers' preferences in relation to outdoor environmental attributes, also structural, location and neighborhood characteristics of a residential property; (2) test different forms of hedonic models; (3) assess actual marginal monetary values attributed to separate characteristics by a hedonic pricing analysis of city districts, also using more sophisticated approach—hedonic analysis with spatial adjustments; and (4) test the applicability of the hedonic pricing method in Poland.

This section has provided an introduction. The following will deliver literature review. Section 3 will elaborate on the methodology and data used in this study. Section 4 will report the results. The discussion and concluding remarks will be given in Sect. 5.

2 Literature Review

Rosen (1974) is the first to present a theory of hedonic pricing (preceded by Lancaster's (1966) seminal paper presenting groundbreaking theory of hedonic utility). Rosen argues that an item can be valued as the sum of its utility generating characteristics; that is, an item's total price should be the sum of the individual prices of its characteristics. This implies that an item's price can be regressed on the characteristics to determine the way in which each characteristic uniquely contributes to the price. The method has been commonly applied to assess variations in housing prices in relation to the value of inherent and external attributes (Freeman 2003).

The hedonic pricing method has been widely applied in Europe and the USA to assess also environmental attributes of properties and the marginal value of associated factors.

As for air quality, its relationship with property price was first investigated by Ridker and Henning (1967) to estimate the effect of air pollution on property values in St. Louis. They found negative relationship between property values and sulfate measures. Diamond (1980) also found a significant negative effect in Chicago by using annual air particulate count. Repeating the study by Ridker and Henning (1967), Wieand (1973), however, found no significant relationship between property value and the level of suspended particulates, SO_2 and SO_3. A much larger number of cities were examined in further studies in the USA (Chau et al. 2011). In Asia a spatial-econometric hedonic housing analysis for Seoul metropolitan area was conducted by Kim et al. (2003) in order to measure the marginal value of improvements in sulfur dioxide (SO_2) and nitrogen oxides (NO_x) concentrations. They found that marginal WTP for a 4% improvement in mean SO_2 concentrations is about $2333 or 1.4% of mean housing price, while NO_x pollution levels occurred to be statistically insignificant.

It is believed that noise level is negatively related to property price. Palmquist (1992), Tayor et al. (1982) studied the externality of traffic noise. They found significant negative relationship between traffic noise and property prices. There are a lot of studies on airport noise, confirming negative significant impact of airport noise on property prices i.e. (Espey and Lopez 2000; Levesque 1994).

Unfortunately a little has been done to assess how different environmental externalities affect housing prices in Poland. The method is successfully used in developed countries since the limitation in applicability of the method is developed private housing market requirement. (Ligus and Peternek in press) tried to assess relationships between air quality, noise level and the accessibility to green areas for residential housing market in Cracow. In models for city districts some environmental variables occurred to be statistically significant (variables "rail noise" and "distance to park" being significant in some districts) but most of environmental attributes, especially concerning air quality were not significant. Similar analysis was conducted for Wroclaw, except "green areas" variable, (Ligus and Peternek 2016). The results were similar. The analysis for the capital and the largest city in Poland—Warsaw—is to bring something new into this findings or to confirm them.

3 Methodology and Data

3.1 Study Area and Data Collection

Warsaw is the capital and largest city in Poland. It stands on the Vistula River in east-central Poland. Warsaw is divided into 18 districts: Mokotow, Praga Poludnie, Ursynow, Wola, Bielany, Targowek, Srodmiescie, Bemowo, Bialoleka, Ochota, Wawer, Praga Polnoc, Ursus, Zoliborz, Wlochy, Wilanow, Rembertow, Wesola (see Fig. 1).

In this study, 6318 transaction records in Warsaw City between 2012 and 2014 years were selected from the Polish Banks Association property transaction database, containing data regarding mainly structural characteristics and transaction prices of properties. The database is currently considered the best for property information mining and analysis in Poland. Figure 1 presents the location of records together with the division into 18 city districts.

Spatial data, as registry of buildings with addresses, were obtained from the Department of Geodesy, Cartography and Cadastre in Warsaw, the flood area from the Regional Water Management Office in Warsaw and noise and pollution information from the Marshal Office of the Mazowieckie Voivodeship. Spatial analysis

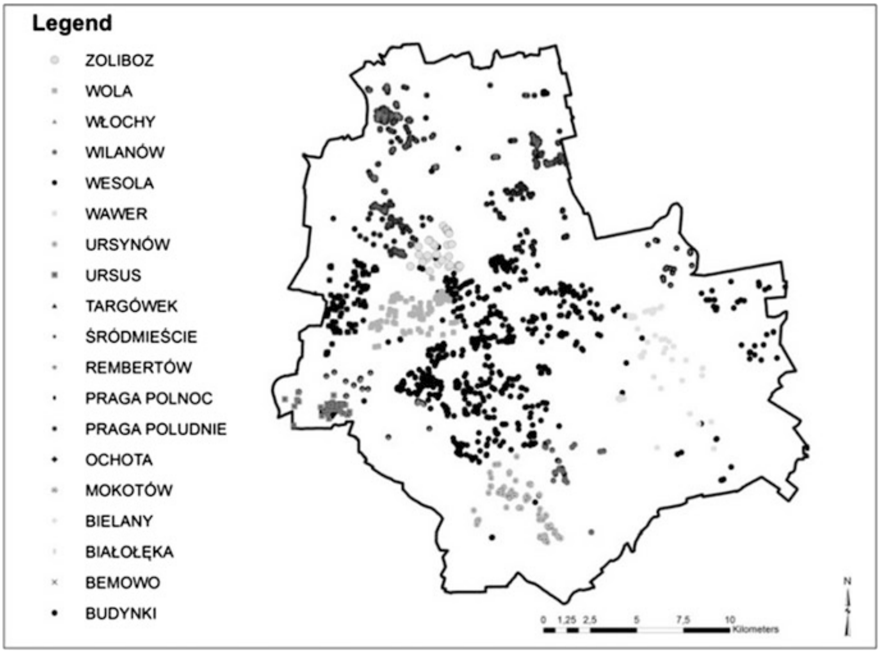

Fig. 1 Districts in Warsaw

of attributes were conducted with using ARC GIS 10.2.2. Distances from buildings to city center were calculated using distance matrix option with QGIS 2.6.

3.2 Hedonic Pricing Method and Regression Model

In general, the purchase price of a heterogeneous housing goods could be expressed by a hedonic pricing model which embraces a bundle of housing characteristics, including environmental ones. The partial derivatives of the price with respect to the constituent variables provide information on the marginal willingness to pay (WTP) for an additional unit of each characteristic (Garrod and Willis 1999). As a result, the implicit price of individual characteristics could be deduced. This hedonic equation is a reduced form in which it is implicit that the supply of each and all characteristics is perfectly elastic. In most real world situations, however, such an assumption is often untenable. Therefore, a second stage model to reveal the demand of each characteristic has been proposed (Freeman 2003) or it is possible in the first stage of analysis to derive only average (approximate) values.

There is not enough guidance from economic theory on the relationship between the price of the house and its attributes (Cropper et al. 1988). As a result, many forms can be used. In the literature (Habb and McConnell 2002) there are

Table 1 Variables and their definitions enlisted in the hedonic pricing study of residential properties in Warsaw

Variable	Definition	Unit or coding	Expected sign[a]
Housing price variable			
P	Transaction price of the apartment	PLN	n.a.
Housing structural attributes			
s_1	Total floor area of the apartment	m^2	+
s_2	Age of the building	Year of construction	+
Housing location and neighborhood attributes			
l_1	Distance to the city center	m	–
l_2	Flood area	1 if yes, 0 if no	–
Environmental attributes			
e_1	Rail noise	dB	–
e_2	Traffic noise	dB	–
e_3	Industrial noise	dB	–
e_4	Tram noise	dB	–
e_5	Aircraft noise	dB	–
e_6	NO_2 (nitrogen dioxide)	$\mu g/m^3$	–
e_7	Particulate matter PM10	$\mu g/m^3$	–

[a]"+" sign denotes augmenting; "–" suppressing effect on apartment price

considered linear, logarithmic, Box-Cox transformation and square forms. Logarithmic model is probably mostly used relationship in hedonic price technique (Bockstael 1996; Jim and Chen 2007). However, in practical applications attributes selection is strongly limited by data availability. In analysis for Warsaw we considered three kinds of functional relations: classical linear model, semi-log model and model with Box-Cox transformation (Ligus and Peternek in press).

Table 1 gives details for the attributes enlisted in the study for Warsaw.

Our analysis concentrates on environmental attributes but unfortunately the most important variables (NO_2 and PM10) are strongly dependent on each other. In addition there is correlation between distance to the city center and PM10 and between distance to the city center and tram noise. To avoid impact of variable distance to the city center and to find real influence of variables PM10 and tram noise on apartment price we decided to divide Warsaw into 18 districts and repeat analysis in districts. The districts will be treated as homogeneous class in relation to the distance to the city center. In this situation, the variable should not vary the price and therefore should not be significant.

In all districts we estimated linear and semi-log models, usually choosing the latter with higher multiple R-squared. It is established that hedonic prices in real estate research are varied vary often across space such as city areas, regions, and countries. So we decided to use also spatial models. Spatial dependence in a collection of sample data means that observations at location i depend on other observations at locations j ($i \neq j$). In literature usually there are considered two spatial models: spatial autoregressive model (SAR) and spatial error model (SEM)

(Hui et al. 2007; LeSage and Pace 2009). Table 2 presents forms of SAR and SEM model.

In SAR model spatial dependence is incorporated as an additional variable in the form of spatially lagged dependent variable. It should be used when the focus of interest is to determine the existence and strength of a spatial interaction. Therefore SAR model should be considered similarly as a time series model with lagged variables and the housing prices can be explained by their inherent attributes and also by "neighbors" characteristics, which are described in terms of the distances or contiguity.

SEM model considers the spatial dependence through the error term. It should be used when potentially biased from the spatial autocorrelation could appear. SEM model has non-spherical error term in which off-diagonal elements of the covariance matrix state the structure of spatial dependence. Therefore SEM model focuses on modeling of error terms to avoid a biased due to existence of spatial dependence.

In both models the central role plays the spatial weighting matrix. There are two general approaches to quantify location in weighting spatial matrix (LeSage and Pace 2009).

Table 2 The forms of SAR and SEM model

SAR model	SEM model
$\mathbf{P} = \rho\mathbf{WP} + \beta\mathbf{X} + \boldsymbol{\varepsilon}$	$\mathbf{P} = \beta\mathbf{X} + \boldsymbol{\varepsilon}$ $\boldsymbol{\varepsilon} = \lambda\mathbf{W}\boldsymbol{\varepsilon} + \mathbf{u}$

where: **P** is an $(n \text{ x } 1)$ vector of housing prices, **X** represents the usual $(n \text{ x } (m + k + r))$ data matrix containing explanatory variables, **W** is a known $(n \text{ x } n)$spatial weight matrix, ρ—is a coefficient on the spatially lagged dependent variable, β—is an $((m + k + r) \text{ x } 1)$ vector of parameters, $\boldsymbol{\varepsilon}$, $\mathbf{u}$ are an $(n \text{ x } 1)$ vectors of random error terms, λ—is a coefficient on the spatially correlated errors.

Estimation of both models and both tests was computed in MATLAB with the use of Econometric Toolbox by LeSage (www.spatial-econometrics.com).

4 Results

The results of estimation of the models with the highest R-squared for districts in Warsaw presents Table 3.

We were able to estimate significant models for all 18 districts. All models explain the volatility of prices quite well, with coefficient of determination higher than 75%. Unfortunately, in some districts both spatial models seem to be insignificant. But in districts where the coefficients of spatial dependency appear significant both models have higher value of coefficient of determination than classical models. Estimation of classical models in districts revealed that the log model is not always the best one—it was a surprise. Expected signs of dependency were confirmed in most districts. In four districts (two for particulate matter PM10 variable and two for nitrogen dioxide variable) we found the signs to be opposite

Table 3 Results of estimation of models with the highest R-squared for districts in Warsaw

District	District/R-squared	Variable	Coefficient	t-Statistic/asymtot t-stat	p-Value
Wola	*SAR model*	intercept	10.01	49.18	0.000
	R-squared:	ln floor area	0.94	38.27	0.000
	0.7260	ln dist_centr	−0.25	−13.83	0.000
		rho	0.10	20.40	0.000
Wlochy	*SAR model*	intercept	11.53	11.92	0.000
	R-squared:	ln floor area	0.96	24.30	0.000
	0.8238	ln dist_centr	−0.32	−2.84	0.004
		rho	0.02	1.97	0.048
Wilanow	*SEM model*	intercept	9.11	51.60	0.000
	R-squared:	ln floor area	0.96	24.37	0.000
	0.8161	lambda	0.44	2.95	0.003
Wesola	*Log model*	intercept	12.37	3.64	0.000
	R-squared:	ln floor area	1.01	18.80	0.000
	0.7085	ln age_build	−0.83	−2.16	0.032
		ln PM10	0.87	2.04	0.043
Wawer	*Log model*	intercept	7.82	10.27	0.000
	R-squared:	ln floor area	0.81	16.13	0.000
	0.7098	rail_noise	−0.001	−2.07	0.040
		ln PM10	0.51	2.22	0.028
Ursynow	*SEM model*	intercept	8.86	38.09	0.000
	R-squared:	ln floor area	0.90	33.32	0.000
	0.7829	dist_centr	−0.001	−0.42	0.067
		No2	0.00005	3.06	0.002
		lambda	0.54	5.63	0.000
Ursus	*SEM model*	intercept	8.72	60.63	0.000
	R-squared:	ln floor area	1.01	28.25	0.000
	0.8323	lambda	0.62	5.02	0.000
Targowek	*SEM model*	intercept	96,833.65	3.12	0.001
	R-squared:	floor area	5529.56	33.02	0.000
	0.8297	No2	−2925.88	−2.37	0.017
		lambda	0.57	5.10	0.000
Rembertow	*Log model*	intercept	9.53	43.44	0.000
	R-squared:	ln floor area	0.78	14.62	0.000
	0.7926	rail_noise	−0.001	−2.07	0.041
Bemowo	*SEM model*	intercept	76,531.13	2.01	0.044
	R-squared:	floor area	7218.97	36.57	0.000
	0.7839	No2	−2297.75	−1.64	0.049
		indust_noise	−1217.74	−3.75	0.000
		lambda	0.70	8.41	0.000
Praga Polnoc	*Log model*	intercept	9.01	69.18	0.000
	R-s: 0.8000	ln floor area	0.93	26.55	0.000

(continued)

Table 3 (continued)

District	District/R-squared	Variable	Coefficient	t-Statistic/asymtot t-stat	p-Value
Praga Poludnie	*SEM model*	intercept	10.20	663.94	0.000
	R-squared:	ln floor area	0.93	43.94	0.000
	0.7730	lambda	0.59	52.15	0.000
Ochota	*SAR model*	intercept	−97,236.94	−5.73	0.000
	R-squared:	floor area	8566.22	43.57	0.000
	0.8530	rho	0.15	3.05	0.002
Mokotow	*Log model*	intercept	10.03	23.29	0.000
	R-squared:	ln floor area	1.18	65.24	0.000
	0.8362	ln PM10	−0.24	−3.07	0.002
		ln dist_centr	−0.10	−3.47	0.000
		rail noise	0.001	2.40	0.016
		tram noise	0.001	8.10	0.000
Srodmiescie	*SEM model*	intercept	10.28	316.01	0.000
	R-squared:	ln floor area	1.11	47.76	0.000
	0.8004	ln No2	−0.34	−4.15	0.000
		ln dist_centr	−0.058	−1.74	0.081
		lambda	0.61	52.95	0.000
Zoliborz	*Log model*	intercept	12.64	7.85	0.000
	R-squared:	ln floor area	1.21	33.71	0.000
	0.8680	ln No2	0.38	2.08	0.039
		ln dist_centr	−0.65	−3.87	0.000
Bielany	*SAR model*	intercept	6.85	10.38	0.000
	R-squared:	ln floor area	0.93	35.16	0.000
	0.7892	dist_centr	−0.00002	−2.84	0.005
		tram noise	−0.0005	−2.11	0.035
		rho	0.20	3.66	0.003
Bialoleka	*SEM model*	intercept	62,992.17	3.86	0.000
	R-squared:	floor area	4311.43	44.13	0.000
	0.8705	No2	1433.42	1.93	0.053
		aircraft no	−114.72	−0.73	0.468
		lambda	0.46	5.84	0.000

to expected but deeper analysis showed that there is strong dependency between these two air pollution variables and between each variable and distance to the city center. It appears that the higher value of NO_2 could mean shorter distance from the property to the road and therefore shorter traveling time and ease of moving by car.

We also found opposite signs of coefficients for noise variables in model for Mokotow. We suppose it could be related to the availability of public transport.

Our analysis concentrates on selected models with significant environmental variables. For districts Targowek and Bemowo we estimated significant spatial models with linear variables. In both districts the higher multiple R-squared were achieved for SEM models. Major factor influencing on apartment price in both districts is floor area. But also some environmental variables were significant. Sale price would decrease in Targowek on average by 2925 PLN if the nitrogen dioxide concentration would be higher by 1 μg/m^3. In Bemowo district rise in nitrogen dioxide concentration and industry noise by one unit would decrease the price by 2298 PLN and 1218 PLN respectively.

In Srodmiescie district SEM model also has the highest explanatory power. In this model we analyzed variables after logistic transformation. On average 0.31% drop of apartment price would be observed if nitrogen dioxide concentration would increase by 1%.

5 Conclusions

This study focuses on environmental characteristics of a residential property on its market value in Warsaw districts. Our study uses a GIS technique as a more advanced computational tool.

Four forms of models were applied to explore the relationship between housing price and housing attributes: linear, logarithmic, spatial error model and spatial autoregressive model. Results of the hedonic regression analysis for all analyzed models give quite good explanatory power. They also confirm previous researches findings that there is no clear indication arising from economic theory which kind of model should be implemented. In most districts the best fitted models were models with spatial dependency variables—so this relationship cannot be ignored. A surprise was that linear models were better than semi-log models in some districts. Interpretation of the parameters of attributes in spatial models was close to parameters in classical models. This result is in accordance with the views presented in the literature on the use of spatial models.

To conclude, this research helps to improve our understanding on housing price determination in Poland. There are two rather obvious major factors influencing on apartment price: floor area and distance to the city center. Most of analyzed environmental attributes occurred to be statistically insignificant in models for city districts. But the models for separate districts do differ, with variables: rail, aircraft, tram, industrial noise, NO_2 and PM10 concentrations being significant in some districts. In general the results indicate insufficient degree of efficiency of the real estate market in Poland in order to value the environmental attributes.

Acknowledgements This paper was prepared as part of the research projects “Value based management of investments in renewable energy sources” [UMO-2011/01/D/HS4/05925] and “Evaluation of the environmental effects in a cost-benefit analysis of the investments in low-emission energy sources” [UMO-2011/01/B/HS4/02322], executed by the Wroclaw University of Economics and financed by the National Science Centre, Poland.

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Macro- and Microprudential Regulations and Their Effects on Procyclicality of Solvency and Liquidity Risk

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Abstract This paper aims to identify the effect of macroprudential policies and microprudential regulations and their interactions on the sensitivity of leverage and liquidity funding risk to the business cycle during both non-crisis and crisis period. In this paper we focus on major types of macroprudential instruments as designed by the International Monetary Fund, and on microprudential regulations' indices. Applying the two-step robust GMM estimator to 782 banks from over 60 countries covering the period of 2000–2011 we find that both macroprudential and microprudential instruments have insignificant impact on procyclicality of leverage in the non-crisis period. Macroprudential instruments decrease procyclicality of liquidity during non-crisis period and increase procyclicality of leverage during the crisis. Restrictions on the range of activities conducted by banks reduce procyclicality of liquidity risk during non-crisis period. Interaction between macroprudential instruments targeted at risk-taking by borrowers and restrictions on the range of activities taken by banks has been found to be effective in reducing procyclicality of leverage during the crisis period.

1 Introduction

Leverage and liquidity risk of the banking sector have become an area of a deepened research in the finance literature due to their dynamic changes across business cycle, and thus potential to amplify procyclicality of the financial sector (Bank of England 2009; CGFS 2012; European Systemic Risk Board ESRB 2014a, b).

Previous research on bank risk, and in particular on leverage and liquidity risk, shows that bank size is important driver of sensitivity of bank risk to its determinants. In this study we contribute to previous research in this area (see Adrian and Shin 2010a; Haq and Heaney 2012; Acharya and Viswanathan 2010; Acharya and Ryan 2016; Laux and Rauter 2016) by looking at the role of macroprudential policy

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_16

and microprudential regulations in the link between business cycle and bank leverage as well as bank liquidity risk across countries. We aim to answer several questions. First, do macroprudential policies reduce procyclicality of leverage and liquidity risk during non-crisis period. What is the role of microprudential regulations in this procyclicality? Second, do macroprudential policy instruments affect sensitivity of leverage and liquidity risk to business cycle during the crisis period? Third, is concurrent application of macroprudential policies and microprudential regulations effective in reducing procyclicality of leverage and liquidity risk. To find out answers to these questions we apply the two-step GMM Blundell and Bond (1998) approach to individual bank data from over 60 countries.

The rest of the paper is organized as follows. Section 2 presents literature review. Section 3 covers research design and data. Section 4 presents analysis of research results. Finally, Sect. 5 presents implications of our research.

2 Related Literature

Our study is related to three broad streams in the banking and financial literature. The first focuses on the factors which may be significant in explaining bank risk (Kane and Unal 1988; Flannery and James 1984; Haq and Heaney 2012). This literature, however, considers only the drivers of equity risk measures (i.e. systematic risk proxied by beta coefficient; idiosyncratic risk; total risk, i.e. bank equity return standard deviation; interest rate risk, i.e. interest rate beta; see Kane and Unal 1988; Flannery and James 1984; Haq and Heaney 2012) and credit risk (measured as loan loss provisions divided by total assets), and is not interested in analyzing the differences in the levels of leverage. In the same vein, Haq and Heaney (2012) find mixed evidence on the relation between bank specific factors and bank risk measures in 15 European countries. Their study, however, does not cover the macroeconomic factors affecting bank leverage.

The other stream in the literature focuses on procyclicality of leverage (Adrian and Shin 2010b; Acharya and Viswanathan 2010; Acharya and Ryan 2016; Laux and Rauter 2016; Kowalska and Olszak 2016) and on procyclicality of liquidity risk, proxied by loans to deposits ratio (LTD, see e.g. Kowalska and Olszak 2016). This procyclicality is, however, approximated in a very diversified way. Adrian and Shin (2010b) measure it as a positive association between leverage (i.e. total assets divided by total equity) and liquidity risk (i.e. proxied by total asset growth). This approach is used in several papers (see, for example, Damar et al. 2013; Beccalli et al. 2015), but seems to be quite controversial. It seems better to proxy this procyclicality by looking at the association between leverage and business cycle [as suggested in a stylized paper by BoE (2009)]. Therefore, Acharya and Ryan (2016) and Laux and Rauter (2016) recommend capturing this procyclicality by looking at the association between leverage growth and business cycle. Some papers on procyclicality of leverage show that leverage plays significant role in amplification of financial shocks through balance sheets (Adrian and Shin 2010b;

Acharya and Viswanathan 2010). These studies also find that there is some link between leverage and liquidity in investment banks (Adrian and Shin 2010b) and that market liquidity and funding liquidity are affected by the build-up of leverage in financial sector (Acharya and Viswanathan 2010). In a recent paper Laux and Rauter (2016) document strong procyclicality of leverage, and show that fair value accounting contributes to the positive relation between GDP growth and book leverage growth during expansionary periods. This procyclicality is stronger in the case of commercial than in the case of savings banks. In a recent paper Kowalska and Olszak (2016) show that during non-crisis periods, leverage is not necessarily procyclical. The procyclicality, is however, visible during crisis period, in particular in the sample of large banks. As for liquidity risk, it has been found to be procyclical during non-crisis period and countercyclical during the crisis (see Kowalska and Olszak 2016).

The third stream in the financial economics literature analyzes the factors explaining financial stability of banks (Barth et al. 2006; Lim et al. 2011; Cerutti et al. 2015; Claessens et al. 2014; Olszak et al. 2016a, b), and procyclicality of the banking sector as a macroprudential policy objective (Lim et al. 2011; Cerutti et al. 2015; Claessens et al. 2014). Barth et al. (2006) show that microprudential regulations and supervision (both official and private) may have some impact on the occurrence of banking crises. However, they do not necessarily reduce their frequency.

The contemporary literature on macroprudential policy shows that macroprudential policy instruments are important in affecting procyclicality of leverage. Lim et al. (2011) explore the links between macroprudential policy instruments and developments in leverage and credit, using aggregated annual data from 49 countries in years 2000–2010. They document evidence suggesting that the presence of policies such as loan to value ratio (LTV) and debt to income ratio (DTI) limits, ceilings on credit growth, reserve requirements and dynamic provisioning rules can mitigate the procyclicality of credit and leverage (i.e. they reduce the positive sensitivity of credit and leverage to the business cycle, proxied by real GDP growth). Claessens et al. (2013, 2014), find that borrower-targeted instruments are effective in reducing the growth in bank's leverage, asset and non-core liabilities. Countercyclical instruments also help mitigate increases in bank leverage, but they are of little effect thorough the cycle. Some of policies are counterproductive during downswing, serving to aggravate declines, which is consistent with ex ante nature of macroprudential tools. Cerutti et al. (2015) show that usage of macroprudential policies is generally associated with lower growth in aggregated credit, notably in household credit. Olszak et al. (2016b) show that macroprudential policy instruments may be effective in reducing the procyclical impact of capital ratio on lending during the last financial crisis. This effect is particularly strong in the sample of large banks.

In this study we contribute to previous research by testing the role of macroprudential policy and microprudential regulations in the link between business cycle and bank leverage as well as bank liquidity risk across countries. We aim to verify several hypotheses, focusing on the impact of regulations on sensitivity of leverage and liquidity risk to the business cycle during non-crisis period and in the last financial crisis period. The first set of hypotheses refers to the potential role of macroprudential policies and macroprudential regulations in the sensitivity of solvency and liquidity risk during non-crisis period. The other set of hypotheses conctrates on the role of macro- and microprudential regulations in the procyclicality of leverage and liquidity risk during the last financial crisis. And finally, the third group of hypotheses focuses on the interactions between macro- and microprudential regulations and on the effects of these interactions on procyclicality of leverage and liquidity risk during the non-crisis and the crisis period.

Macroprudential policies aim at reduction of risk taking by banks and by bank borrowers, in particular during non-crisis period, and therefore we predict that should reduce procyclicality of leverage and liquidity risk during non-crisis period (hypothesis H1a). As for the impact of microprudential regulation, previous evidence does not suggest its potential to affect the levels of bank risk and its procyclicality. We therefore, expect that microprudential regulations do not affect significantly the sensitivity of leverage and liquidity risk to business cycle (hypothesis H1b). Macroprudential policies protect banks from crisis period due to higher risk buffers (capital and reserves). We therefore, predict that banks' leverage and liquidity risk should be immune to GDP in the crisis period in countries in which more macroprudential policies were applied in the pre-crisis period (hypothesis H2a). Previous evidence on microprudential regulations only shows that they may be effective in affecting procyclicality of loan loss provisions (Olszak et al. 2016a). However, there is no guidance as to the potential effects of these regulations on procyclicality of leverage and liquidity risk during the crisis period. In lack of such evidence, we are going to test the potential role of such regulations in the sensitivity of leverage and of liquidity risk on to the business cycle during the crisis period. We expect that concurrent application of macroprudential policies and microprudential regulations may be effective in reducing procyclicality of leverage and liquidity risk (hypothesis H3).

3 Research Design and Data

To compute the sensitivity of individual banks' leverage and funding risk to bank specific and macroeconomic factors and to crisis period, we estimate two separate equations (one for leverage and the other for liquidity), denoted as:

$$
\begin{aligned}
y_{i,t} = {} & \alpha y_{i,t-1} + \sum\nolimits_{k=1}^{6} \gamma_k BSV_{i,t-1} + \sum\nolimits_{s=1}^{2} \varphi_s BC_{\,j,t} + \delta_1 \text{ Crisis} \\
& + \delta_2 \text{ Crisis} * GDP_{j,t} + \beta_1 MPI_j + \beta_2 MPI_j * GDP_{j,t} + \beta_3 MPI_j * \text{Crisis} \\
& + \beta_4 MPI_j * GDP_{j,t} * \text{Crisis} + \beta_5 \text{Regrestr}_j + \beta_6 \text{Regrestr}_j * GDP_{j,t} \\
& + \beta_7 \text{Regrestr}_j * \text{Crisis} + \beta_8 \text{Regrestr}_j * GDP_{j,t} * \text{Crisis} + \beta_9 MPI_j * \text{Regrestr}_j \\
& + \beta_{10} MPI_j * \text{Regrestr}_j * GDP_{j,t} + \beta_{11} MPI_j * \text{Regrestr}_j * \text{Crisis} \\
& + \beta_{12} MPI_j * \text{Regrestr}_j * GDP_{j,t} * \text{Crisis} + \vartheta_i + \varepsilon_{i,t}
\end{aligned}
$$

where:

i—the number of the bank; j—the number of country; t—the number of observation for the i-th bank or j-th country; $y_{i,t}$—dependent variable, i.e. leverage (in the case of leverage model; defined as total assets divided by equity capital) and liquidity (in the case of liquidity risk model; this variable equals loans of nonfinancial sector to deposits of nonfinancial sector; This ratio is a proxy for maturity mismatch of the bank's balance sheet; it measures funding liquidity risk), $y_{\,i,t\text{-}1}$—lagged dependent variable; BSV—bank specific variable which include: leverage; liquidity; Loans—loans to total assets; is our measure of credit risk; L growth—real annual loans growth rate. It measures sensitivity of solvency and liquidity risk to changes in bank lending activity; Deposits—deposits from nonfinancial customers divided by total assets (included only in the model of leverage); Dep banks—deposits from banks divided by total assets (included only in the model of liquidity risk); QLP—quality of the lending portfolio; it equals loan loss provisions divided by average loans; size—logarithm of assets; BC—business cycle measures proxied by GDP and Δ Unempl, i.e.: GDP—real GDP per capita growth. A positive coefficient suggests procyclicality of leverage or liquidity risk, respectively, during non-crisis period. A negative coefficient would imply economic insignificance of business cycle to levels of leverage and liquidity risk during non-crisis period; Δ Unempl—annual change in unemployment rate; Crisis—dummy variable equal to 1 in 2008, 2009, 2010 and 0 otherwise; Crisis*GDP—interaction term between Crisis and GDP, it informs about sensitivity of leverage or liquidity risk to GDP during crises; a positive coefficient in the leverage model, suggests procyclicality of leverage'; a negative coefficient on Crisis*GDPG in the model of liquidity risk 2, implies counter-cyclicality of liquidity risk; MPI denotes aggregated index of macroprudential policy instruments, i.e. borrower targeted instruments (denoted as Borrower) and financial institutions restrictions (denoted as Financial). The values of these indices were calculated following Olszak et al. (2016a) approach. Regrestr is defined as restrictions on activities conducted by banks (see Barth et al. 2006).

Our econometric model involves explanatory variables, in particular bank-specific variables, which may be endogenous and this may result in estimation bias. In order to limit this possible estimation bias we consider the system of generalized method of moments (GMM) developed by Blundell and Bond (1998) with Windmejer's (2005) finite sample correction. We control for the potential endogeneity of bank specific variables in the two step system GMM estimation procedure, by the inclusion of up to two lags of explanatory variables as instruments. The UNEMPL, as well as the country and the time dummy variables are the only variables considered exogenous.

We use pooled cross-section and time series data of individual banks' balance sheet items and profit and loss accounts from 67 countries and country-specific macroeconomic indicators for these countries, over a period from 2000 to 2011. The balance sheet and profit and loss account data are taken from consolidated financials available in the Bankscope database, whereas the macroeconomic data were accessed from the Worldbank and the IMF web pages. Due to the fact that a large number of banks included in the sample are located in Japan, USA and in Russia, we exclude these banks to make sure that our results are not affected by estimation bias, resulting from concentration of our research sample. The data on macroprudential indices, measuring the relative application of macroprudential instruments across countries were taken from the Cerutti et al. (2015) dataset. To measure microprudential regulations restrictiveness we use overall activities restrictions index (denoted as RESTRICTIONS) developed by Barth et al. (2006, 2013).

We follow a three stage procedure in the estimation of the model of leverage and model of liquidity risk. In the first stage we estimate regression in which we include only bank specific and macroeconomic variables, applying besides the two-step GMM approach, more traditional approaches, i.e. ordinary least squares and fixed effects regression. Next, we estimate models in which we also include interaction terms between macroprudential policy and business cycle during crisis as well as models including interaction terms between activities restriction index and business cycle during crisis. Such an approach would give us opportunity to assess the effect of policies on the procyclicality of leverage or liquidity risk. And finally, in the third stage we shall estimate regressions covering interactions between macroprudential policies and microprudential regulations, to find out whether such interactions add to procyclicality of leverage and liquidity risk.

4 Results

We present our results for the impact of macro- and microprudential policies in Table 1 (for leverage) and in Table 2 (for liquidity risk). These table refer to the first two stages in our research strategy, presented in previous section. In Table 3 we present result for the interaction between macroprudential policy and microprudential regulation restrictiveness, which is the third stage of our research procedure. This section is divided into three subsections. Section 4.1 covers results on the effects of regulatory instruments on procyclicality of leverage. Section 4.2 presents the effects of regulations on procyclicality of liquidity risk. And finally, Sect. 4.3 includes the analysis of effects of interacted macroprudential and microprudential regulations on the sensitivity of leverage to the business cycle during the last financial crisis.

Table 1 Sensitivity of leverage to business cycle and micro- and macroprudential instruments

	ols		fe		GMM		GMM		GMM Borrower		GMM Financial		GMM Regrestr	
Leverage	Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)	
Leverage(−1)	0.831 (108.2)	***	0.484 (37.04)	***	0.916 (48.00)	***	0.827 (31.28)	***	0.922 (42.37)	***	0.920 (44.12)	***	0.889 (36.60)	***
Liquidity(−1)	−0.025 (−2.91)	***	−0.037 (−2.58)	**	0.061 (2.68)	***	0.028 (1.68)	*	0.062 (2.60)	***	0.067 (2.79)	***	0.053 (2.43)	**
Loans(−1)	0.033 (3.19)	***	0.037 (2.00)	**	−0.047 (−1.88)	*	−0.019 (−1.06)		−0.048 (−1.81)	*	−0.055 (−2.09)	**	−0.038 (−1.59)	
ΔLoans(−1)	0.004 (2.63)	***	0.003 (1.42)		−0.002 (−0.71)		0.000 (0.07)		−0.002 (−0.72)		−0.001 (−0.48)		−0.002 (−0.59)	
Deposits(−1)	−0.012 (−2.71)	***	0.000 (0.02)		−0.002 (−0.18)		−0.018 (−2.03)	**	−0.009 (−0.92)		−0.009 (−0.92)		−0.004 (−0.47)	
QLP(−1)	−0.057 (−1.95)	*	0.022 (0.62)		−0.136 (−2.48)	**	−0.098 (−2.13)	**	−0.117 (−2.25)	**	−0.108 (−2.03)	**	−0.166 (−2.94)	***
Size(−1)	0.594 (8.10)	***	0.737 (2.49)	**	0.061 (0.45)		0.582 (3.27)	***	−0.010 (−0.06)		0.069 (0.47)		0.135 (0.81)	
GDP	−0.070 (−3.16)	***	−0.039 (−1.46)		−0.041 (−1.19)		−0.056 (−2.38)	**	−0.025 (−0.54)		−0.065 (−1.19)		−0.039 (−1.04)	
ΔUnempl	−0.111 (−2.05)	**	−0.080 (−1.42)		−0.339 (−2.47)	**	−0.125 (−1.64)		−0.299 (−2.08)	**	−0.412 (−2.57)	**	−0.345 (−2.65)	***
Crisis	−0.557 (−3.83)	***	−0.391 (−2.19)	**	−0.054 (−0.26)		−0.465 (−2.94)	***	0.170 (0.50)		0.066 (0.12)		−0.485 (−1.70)	*
Crisis * GDP	0.051 (1.66)	*	0.003 (0.10)		0.048 (0.79)		0.044 (1.13)		−0.006 (−0.07)		−0.089 (−0.84)		0.105 (1.65)	
Regulation									0.277 (0.67)		−0.117 (−0.68)		0.241 (1.22)	
Regulation * GDP									−0.017 (−0.21)		0.011 (0.32)		0.009 (0.25)	

(continued)

Table 1 (continued)

Leverage	ols		fe		GMM		GMM		GMM Borrower		GMM Financial		GMM Regrestr	
	Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)	
Regulation * crisis									−0.935 (−1.17)		−0.208 (−0.48)		−1.273 (−2.92)	***
Regulation * GDP * crisis									0.185 (1.21)		0.149 (1.99)	**	0.024 (0.31)	
Cons	−0.563 (−0.85)		3.055 (1.40)		−0.392 (−0.30)		−0.558 (−0.45)		0.470 (0.33)		0.282 (0.19)		−0.165 (−0.12)	
Year dummies	No		No		Yes		Yes		Yes		Yes		Yes	
Country dummies	No		No		Yes		Yes		Yes		Yes		Yes	
Year and country dummies	No		No		No		Yes		No		No		No	
AR1					−5.52	***	−5.54	***	−5.77	***	−5.77	***	−5.3	***
AR2					2.56	**	2.63	***	2.24	**	2.25	**	2.36	**
Sargan test					827.08	***	1725.7	***	788.86	***	764.46	***	740.16	***
Hansen test					398.96	***	755.67		360.83	***	358.93	***	360.13	***
No of observ.	6017		6017		6017		6017		5341		5341		5378	
No of banks	771		771		771		771		689		689		687	

Notes: ols denotes ordinary least squares regression; fe denotes fixed effects model; GMM denotes the two-step system GMM Blundell and Bond (1998) approach with Windmeijer's finite sample correction; Coef is the regression coefficient; Regulation, covers macroprudential policy and microprudential regulation, i.e., Borrower, Financial and Regrestr, respectively; T-statistics are given in parentheses

***, ** or * next to coefficients indicate that coefficients are significantly different from zero at the 1%, 5%, or 10% levels, respectively

Table 2 Sensitivity of liquidity risk to business cycle and micro- and macroprudential instruments

	ols		fe		GMM		GMM		GMM Borrower		GMM Financial		GMM Regrestr	
Liquidity	Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)		Coef (t-stat)	
Liquidity(−1)	0.760 (41.43)	***	0.627 (22.32)	***	0.477 (3.85)	***	0.531 (6.76)	***	0.624 (4.26)	***	0.652 (5.16)	***	0.693 (5.14)	***
Leverage(−1)	−0.045 (−2.93)	***	−0.024 (−0.93)		−0.033 (−0.74)		−0.076 (−2.48)	**	−0.019 (−0.36)		−0.002 (−0.03)		−0.012 (−0.26)	
Loans(−1)	0.201 (9.32)	***	0.007 (0.20)		0.425 (3.09)	***	0.354 (4.02)	***	0.210 (1.24)		0.185 (1.28)		0.169 (1.10)	
ΔLoans(−1)	0.009 (2.60)	***	0.011 (3.13)	***	0.011 (1.59)		0.020 (3.50)	***	0.007 (1.03)		0.016 (2.25)	**	0.010 (1.68)	*
Dep banks(−1)	−0.005 (−0.60)		0.043 (2.65)	***	0.042 (1.36)		0.040 (1.85)	*	0.055 (1.48)		0.051 (1.71)	*	0.075 (2.43)	**
QLP(−1)	−0.160 (−2.71)	***	−0.361 (−5.15)	***	−0.216 (−1.78)	*	−0.293 (−2.78)	***	−0.258 (−1.83)	*	−0.201 (−1.52)		−0.186 (−1.37)	
Size(−1)	0.165 (1.12)		3.746 (6.38)	***	0.640 (1.34)		0.942 (2.46)	**	1.670 (2.72)	***	0.780 (1.47)		1.411 (2.81)	***
GDP	0.237 (5.31)	***	0.137 (2.56)	**	0.310 (2.72)	***	0.162 (2.44)	**	0.897 (5.26)	***	0.569 (3.26)	***	0.372 (3.08)	***
ΔUnempl	−0.326 (−2.99)	***	−0.226 (−2.02)	**	−1.660 (−4.49)	***	−0.349 (−2.95)	***	−1.497 (−3.74)	***	−1.686 (−4.41)	***	−1.460 (−3.98)	***
Crisis	0.305 (1.04)		0.281 (0.79)		2.039 (3.21)	***	0.156 (0.46)		1.126 (1.06)		5.844 (3.65)	***	2.424 (2.63)	***
Crisis * GDP	−0.124 (−1.97)	**	0.016 (0.24)		−0.499 (−3.01)	***	−0.092 (−1.29)		−1.423 (−6.03)	***	−0.759 (−2.72)	***	−0.650 (−3.13)	***
Regulation									5.110 (3.15)	***	1.251 (1.75)	*	0.061 (0.12)	
Regulation * GDP									−2.122 (−6.62)	***	−0.285 (−2.22)	**	−0.154 (−1.33)	

(continued)

Table 2 (continued)

Liquidity	ols Coef (t-stat)		fe Coef (t-stat)		GMM Coef (t-stat)		GMM Coef (t-stat)		GMM Borrower Coef (t-stat)		GMM Financial Coef (t-stat)		GMM Regrestr Coef (t-stat)	
Regulation * Crisis									−1.937 (−0.61)		−3.085 (−2.21)	**	0.943 (0.94)	
Regulation * GDP * Crisis									3.503 (6.13)	***	0.293 (1.20)		0.096 (0.46)	
Cons	4.531 (3.42)	***	−4.017 (−0.92)		3.363 (0.73)		3.110 (0.87)		−3.500 (−0.62)		1.509 (0.33)		−4.967 (−1.06)	
Year dummies	No		No		Yes		Yes		Yes		Yes		Yes	
Country dummies	No		No		Yes		Yes		Yes		Yes		Yes	
Year and country dummies	No		No		No		Yes		No		No		No	
AR1					−11.32	***	−11.93	***	−10.71	***	−10.93	***	−10.7	***
AR2					−0.35		−0.15		1.15		0.25		−0.81	
Sargan test					5216.61	***	5747.68	***	4059.93	***	4627.07	***	4658.28	***
Hansen test					483.69	***	727.35		419.24	***	434.7	***	431.16	***
No of observ.	5861		5861		5861		5861		5191		5191		5231	
No of banks	733		733		733		733		652		652		649	

Notes: ols denotes ordinary least squares regression; fe denotes fixed effects model; GMM denotes the two-step system GMM Blundell and Bond (1998) approach with Windmeijer's finite sample correction; Coef is the regression coefficient; Regulation, covers macroprudential policy and microprudential regulation, i.e., Borrower, Financial and Regrestr, respectively; T-statistics are given in parentheses

***, ** or * next to coefficients indicate that coefficients are significantly different from zero at the 1%, 5%, or 10% levels, respectively

Table 3 The effect of interactions between macroprudential policy and mircroprudential regulations on the sensitivity of leverage and liquidity risk to business cycle during crisis and non-crisis period

Leverage	Borrower Coef (t-stat)		Financial Coef (t-stat)		Liquidity	Borrower Coef (t-stat)		Financial Coef (t-stat)	
Leverage (−1)	0.904 (35.41)	***	0.884 (33.26)	***	Liquidity (−1)	0.642 (4.20)	***	0.714 (4.97)	***
Liquidity (−1)	0.041 (1.85)	*	0.049 (2.30)	**	Leverage (−1)	0.000 (0.00)		0.004 (0.07)	
Loans(−1)	−0.021 (−0.84)		−0.035 (−1.45)		Loans(−1)	0.170 (0.94)		0.104 (0.61)	
ΔLoans (−1)	−0.003 (−1.03)		−0.002 (−0.62)		ΔLoans (−1)	0.011 (1.43)		0.019 (2.52)	**
Deposits (−1)	−0.016 (−1.65)	*	−0.017 (−1.77)	*	Dep banks (−1)	0.088 (2.26)	**	0.080 (2.31)	**
QLP(−1)	−0.159 (−2.72)	***	−0.167 (−2.92)	***	QLP(−1)	−0.248 (−1.56)		−0.166 (−1.08)	
Size(−1)	−0.121 (−0.65)		0.079 (0.45)		Size(−1)	2.203 (2.96)	***	1.687 (2.53)	**
GDP	−0.007 (−0.15)		−0.019 (−0.36)		GDP	0.746 (4.17)	***	0.292 (1.37)	
ΔUnempl	−0.296 (−2.32)	**	−0.342 (−2.32)	**	ΔUnempl	−1.332 (−3.18)	***	−1.285 (−2.97)	***
MPI	0.393 (0.44)		−0.039 (−0.22)		MPI	6.612 (2.26)	**	0.902 (1.05)	
MPI * GDP	−0.317 (−1.89)	*	−0.017 (−0.46)		MPI * GDP	−2.442 (−3.57)	***	0.049 (0.32)	
Regrestr	0.227 (1.14)		0.436 (1.55)		Regrestr	−0.507 (−0.7)		−0.077 (−0.09)	
Regrestr * GDP	0.024 (0.51)		0.007 (0.11)		Regrestr * GDP	0.169 (0.91)		−0.067 (−0.29)	
MPI * Regrestr	−0.792 (−1.39)		−0.266 (−1.16)		MPI * Regrestr	1.540 (0.98)		0.887 (1.43)	
MPI * Regrestr * GDP	0.222 (1.72)	*	0.026 (0.55)		MPI * Regrestr * GDP	−0.122 (−0.32)		−0.293 (−1.73)	*
Crisis	−0.865 (−1.73)	*	−0.654 (−0.82)		Crisis	2.544 (1.44)		7.298 (2.70)	***
Crisis* GDP	0.016 (0.20)		0.038 (0.33)		Crisis* GDP	−1.557 (−4.26)	***	−0.721 (−1.70)	*
MPI * crisis	1.158 (0.44)		−0.228 (−0.46)		MPI * crisis	−5.187 (−0.81)		−4.384 (−2.38)	**
MPI * GDP * crisis	0.784 (2.14)	**	0.048 (0.63)		MPI * GDP * crisis	4.979 (3.84)	***	0.040 (0.14)	
Regrestr * crisis	−1.382 (−3.15)	***	−2.286 (−2.76)	***	Regrestr * crisis	2.097 (1.62)		1.741 (1.01)	

(continued)

Table 3 (continued)

Leverage	Borrower Coef (t-stat)		Financial Coef (t-stat)		Liquidity	Borrower Coef (t-stat)		Financial Coef (t-stat)	
Regrestr * GDP* crisis	−0.020 (−0.21)		−0.054 (−0.43)		Regrestr * GDP* crisis	−0.318 (−1.00)		−0.234 (−0.67)	
MPI * Regrestr * crisis	1.066 (0.63)		1.024 (1.65)		MPI * Regrestr * crisis	−5.035 (−1.40)		−0.863 (−0.71)	
MPI * Regrestr * GDP * crisis	−0.490 (−1.74)	*	0.007 (0.07)		MPI * Regrestr * GDP * crisis	−0.019 (−0.03)		0.625 (2.32)	**
Cons	2.171 (1.41)		1.457 (1.01)		Cons	−8.832 (−1.35)		−6.236 (−1.09)	
Year dummies	yes		yes		Year dummies	yes		yes	
Country dummies	yes		yes		Country dummies	yes		yes	
Year and country dummies	no		no		Year and country dummies	no		no	
AR1	−5.68	***	−5.57	***	AR1	−9.00	***	−10.17	***
AR2	2.11	**	1.88	*	AR2	0.53		−0.53	
Sargan test	677.23	***	675.91	***	Sargan test	3599.51	***	4031.16	***
Hansen test	326.46	***	316.48	***	Hansen test	375.84	***	375.37	***
No of observ.	4772		4772		No of observ.	4638		4638	
No of banks	614		614		No of banks	579		579	

Notes: GMM denotes the two-step system GMM Blundell and Bond (1998) approach with Windmeijer's finite sample correction; Coef is the regression coefficient; T-statistics are given in parentheses

***, ** or * next to coefficients indicate that coefficients are significantly different from zero at the 1%, 5%, or 10% levels, respectively

4.1 *Macroprudential Policy and Microprudential Regulations and Their Effect on Procyclicality of Leverage*

In the first four columns in Table 1 we present the effect of bank specific variables and business cycle on the levels of leverage of individual banks. Consistent with previous evidence (Kowalska and Olszak 2016) we find that business cycle does not affect bank leverage in an economically significant way during non-crisis period, because the regression coefficient are negative. However, during crisis period, the association between leverage and business cycle is positive (and statistically significant in the OLS regression), which implies procyclicality of leverage. As can be seen from Table 1 macroprudential policy does not exert an empirically significant impact on the sensitivity of leverage to business cycle during non-crisis period, because all coefficients on double interaction *Regulation*GDP* are statistically insignificant. However, in countries in which more macroprudential instruments (in particular those reducing the risks-taking by banks) were applied in the pre-crisis period, leverage during crisis turned out to be more procyclical, because the coefficient of triple interaction term (*Regulation*GDP*Crisis*) is positive and statistically significant.

As for the impact of microprudential regulations we find that during non-crisis period activities restrictions (Regrestr) do not have a statistically significant effect on sensitivity of leverage to business cycle, because the regression coefficients on double interaction of *Regulation*GDP* is statistically insignificant. Restrictions on the range of activities which banks can conduct do not also reduce procyclicality of leverage during crisis period, because the coefficient on *Regulation*GDP*Crisis* is statistically insignificant (see the last column in Table 1).

4.2 Macroprudential Policy and Microprudential Regulations and Their Effect on Procyclicality of Liquidity Risk

In Table 2 we present results for the sensitivity of liquidity risk, proxied with LTD ratio, to bank specific variables and to the business cycle and the role of macro- and microprudential instruments in procyclicality of this liquidity. Consistently with previous evidence (see Kowalska and Olszak 2016), we find that liquidity risk is strongly procyclical during non-crisis period (see the positive and statistically significant coefficients on GDP in all estimations in Table 2) and statistically countercyclical during the last financial crisis (see the negative association between liquidity and double interaction term of Crisis*GDP). Macroprudential policy does seem to affect procyclicality of liquidity during the non-crisis period, because the regression coefficients on Regulation*GDP (see columns denoted as GMM Borrower and GMM Financial) are negative and statistically significant and definitely stronger than positive coefficients on GDP. In particular, if we look at the role of borrower targeted instruments, we find that in countries in which more such instruments were applied, bank procyclicality of liquidity risk was reduced from 0.897 to -1.126 (this is the result of $-2.122 + 0.897$). What's more, borrower targeted instruments seem to increase procyclicality of LTD during crisis period, because the coefficient on Regulation*GDP*Crisis (see column GMM Borrower) is positive and significant (at 1%). As for the impact of microprudential regulations we find that during non-crisis period activities restrictions (Regrestr) do not have a statistically significant effect on sensitivity of liquidity risk to business cycle, because the regression coefficients on double interaction of Regulation*GDP is statistically insignificant. The same effect is found for the crisis period.

4.3 Interactions Between Macroprudential Policy and Microprudential Regulations and Their Effect on Procyclicality of Leverage and Liquidity Risk

Concurrent application of restrictive microprudential regulations and macroprudential policy instruments targeted at risk-taking by borrowers seems to influence significantly the sensitivity of leverage to business cycle during non-crisis period, because the coefficient on *MPI*Regrestr*GDP* is positive and statistically significant in the first regression in Table 3 (see column denoted Borrower). Such an effect implies that interaction between these regulation results in an increased procyclicality of leverage during non-crisis period. However, interacting these instruments during crisis period does seem to have an economically significant impact on procyclicality of leverage and reduces this procyclicality. In particular, the coefficient on *MPI*Regrestr*GDP*Crisis* is negative (equal to −0.490) and statistically significant at 10% (in estimation included in the column denoted as Borrower), implying that application of both these tools seems to reduce the procyclical impact found individually for macroprudential instruments. Thus interaction of macro- and microprudential instruments may be effective in reducing procyclicality of leverage.

Concurrent application of restrictive microprudential regulations (restrictions on bank activities) and macroprudential instruments (i.e. instruments targeted at risk-taking by banks) does affect significantly the sensitivity of liquidity risk to business cycle during non-crisis period, because the coefficient on Macropr index*Microprud*GDPG per capita is negative and statistically significant in regression presented in the last column in Table 3.

Additionally, interacting these instruments during crisis period does also seem to have an economically significant impact on procyclicality of liquidity risk. In particular, the coefficient on MPI*Regrestr*GDP*Crisis is positive and statistically significant (see the last column in Table 3), implying that application of both these tools seems to decrease the counter-cyclical impact found individually for microprudential regulations and macroprudential policies (see the negative and coefficients on Regulation*GDP*Crisis in the last three columns in Table 2). Thus interaction of macro- and microprudential instruments does not seem to be effective in reducing procyclicality of liquidity risk during crisis period.

5 Conclusions

This paper aimed to test the role of macroprudential policies and microprudential regulations and their interactions on the sensitivity of leverage and liquidity funding risk to the business cycle during both non-crisis and crisis period. With this study we have identified several economically significant phenomena. First, we have found that both macroprudential and microprudential instruments have insignificant impact on procyclicality of leverage in the non-crisis period. In contrast, for liquidity risk this impact in the non-crisis period has been shown to be countercyclical and statistically significant. Second, macroprudential instruments increase procyclicality of leverage and liquidity risk during the crisis period. Microprudential regulations have not been able to reduce procyclicality of both leverage and liquidity risk during the last crisis. Third, interaction between macroprudential instruments targeted at risk-taking by borrowers and restrictions on the range of activities taken by banks has been found to be effective in reducing procyclicality of leverage during the crisis period. With reference to liquidity risk, we've shown that interaction between macroprudential instruments targeted at risk-taking behavior of bank and activities restrictiveness index reduces countercyclicality of liquidity risk.

Our results have implications for the regulatory and supervisory policy. We show that microprudential regulations, in particular those which limit the range of activities conducted by banks, may be effective in reducing the procyclicality of liquidity risk during non-crisis. Therefore limiting the range of bank operations could be considered as a step in policy-decisions. Macroprudential instruments do not necessarily work to limit procyclicality of leverage. However, they seem to be an important driver of increased countercyclicality of liquidity risk, in particular during the non-crisis period. Consequently, they should be implemented to decrease procyclicality of liquidity risk.

Acknowledgement The authors gratefully acknowledge that this study has been financed by the Faculty of Management of University of Warsaw (statutory research) from funds delivered by the Ministry of Science and Higher Education.

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Part IV
Banks and Other Financial Institutions

Balance Sheet Shaping Through Decision Model and the Role of the Funds Transfer Pricing Process

Beata Lubinska

Abstract The banking industry is currently facing a number of challenges driven by the regulatory requirements, low or even negative interest rates and margin compression. As a result active and conscious balance sheet management has increased in importance and banks are required to optimize and allocate resources very precisely to their businesses. This article lunches the hypotheses that the application of the optimization technique improves the management of the banking book in terms of quantifiable impact on a bank's P&L and that the Funds Transfer Pricing process could be used as a mean to achieve the target position of a bank. It proposes two steps approach to prove the above hypotheses, i.e. the application of the decision model and the FTP process. In addition, the article provides the reader with the main concepts of the FTP framework and details regarding the Balance Sheet shaping.

1 Introduction

This article proposes the two steps approach for the optimization of the financial outcome of a bank: the application of the decision model to establish the target structure of the Banking Book and the Funds Transfer Pricing (FTP) process as a tool once target structure is determined. The decision model is intended to achieve the following results: the maximization of the assets income and minimization of the funding costs. It takes into account the regulatory requirements and risk tolerance of the financial institution.

Funds Transfer Pricing (FTP) is a term used to describe the sum of polices and methodologies a bank applies in its internal steering systems to charge for the use (and credit for the generation of) funding and liquidity (Widowitz et al. 2014).

Asset–liability management is one of the most important issues in bank strategic planning (Kosmidou and Zopounidis 2002). The application of the optimization tool for determination of the optimal balance among profitability, risk, liquidity and

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_17

other uncertainties has been already studied prior to the financial crisis in 2007–2009. After the financial crisis significant regulatory pressures have additionally forced banks to improve their risk management and capital allocation practices. The Basel Committee on Banking Supervision 2016, the European Commission 2014 and the Prudential Regulation Authority 2015 require banks to revamp their approach towards the financial risk management and practice. The recent Basel III regulation highlights the necessity of the maintenance of the balance funding structure and minimum liquidity cushions and therefore forces banks towards new business model in order to create the right incentives and to maintain regulatory limits.

There is also another important risk financial institutions are struggling with at the global level. This risk is driven by extremely low interest rates in the prolonged term horizon. Consequently, the floating rate assets are earning less interest income meanwhile the demand and saving deposits, which are the main source of funding for the commercial and retail banks, are floored at the certain level in order to maintain competitiveness and market share of a bank. Obviously it leads to the margin compression and the urgent review of its whole business model.

This article states that banks could tackle the aforementioned challenges through the definition of the most appropriate (target) structure of the banking book and implement the Funds Transfer Pricing model to achieve the "right" composition of assets and funding base.

The article is organized as follows. In the first section it explains what is meant by the decision model, what are its building blocks and the resulting economic benefit. The magnitude of this benefit has been calculated for a sample of commercial banks across Europe and UK. However, this article provides only the illustrative example for a small, in terms of assets volume, European bank. The subsequent section is expected to provide the reader with the main concepts of the FTP process, its landscape and details regarding the shaping of the balance sheet. It concludes with three take away messages.

2 Decision Model: Maximization of the Assets Income and Minimization of the Funding Costs

The real challenge of senior management of a bank is to understand the trade off between profitability of the asset base and willingness to take certain amount of risk resulting from its activity. The main risks arising from extending loans to clients are credit, liquidity, interest rate and currency risk. The first attempt to implement the integrated management of interest rate risk and liquidity risk has been proposed by Baldan, Zen and Rebonato in 2012. In their research authors conclude that there is a need to arrive at integrated risk management in which the control of each of these risks is placed in relation to the bank's different functions and influence its strategic decisions (Baldan et al. 2012). The proposed in this article decision model

(Lubinska 2016) focuses on risks which could potentially cause significant losses as banks have different risk appetite towards different risk categories. For example, some banks, especially in Europe, are currently very much focused on the client rating and are willing to grant loans only to the precise client segments in order to limit the exposure to credit risk.

Another important financial risk which is included in the decision model is interest rate risk. The Net Interest Income sensitivity (NII sensitivity) is arising mainly from different re-pricing tenors of assets, imperfect correlation between administered rate mortgages and market rates (especially in UK) and early redemption optionality embedded in the client loans (prepayments). Fixed rate assets have impact on the structural exposure to the interest rate risk and overall duration of the Banking Book.

Finally, without any doubt, the liquidity risk is probably one of the most scrutinized risks by the regulator so its inclusion into the decision model is an imperative. This is due to the recent Basel III standards which aim to achieve two separate but complementary objectives. The first objective is to promote short term resilience of a bank's liquidity risk profile but insuring that it has sufficient high quality liquid assets (HQLA) to survive a significant stress scenario lasting for 30 days. The second objective is to reduce funding risk over a longer time horizon by requiring banks to fund their activities with sufficiently stable sources of funding in order to mitigate the risk of future funding stress. To achieve this objective, the Committee introduced the Net Stable Funding Ratio which requires banks to maintain a stable funding profile in relation to the composition of their balance sheet. As a consequence it limits overreliance on the short term wholesale funding and promotes funding stability (BSBC, The Liquidity Coverage Ratio and liquidity risk monitoring tools 2013).

The target composition of the assets base, which results from the application of the decision model, allows maximizing the asset income and, in the same time, respecting the regulatory and internal limits set up by regulator and senior management.

The article is meant to provide the reader with the illustrative example of the application of the decision model for assets. For this purpose the initial assets base of the European bank has been analysed.

The Risk Sensitive Asset base amounts to 5 bln Euro and is composed as following:

- Floating rate assets—78.37%
- Fixed rate assets—20.31%
- Liquidity buffer—1.3%

In this example the resulting income based on the initial assets composition amounts to 74.86 mln Euro over 6 months period as of December 2014.

The internal Risk Tolerance towards credit risk, liquidity risk and interest rate risk form the constraints for the objective function which maximizes the assets income.

After implementation of the decision model the composition of this assets base is changing as follows:

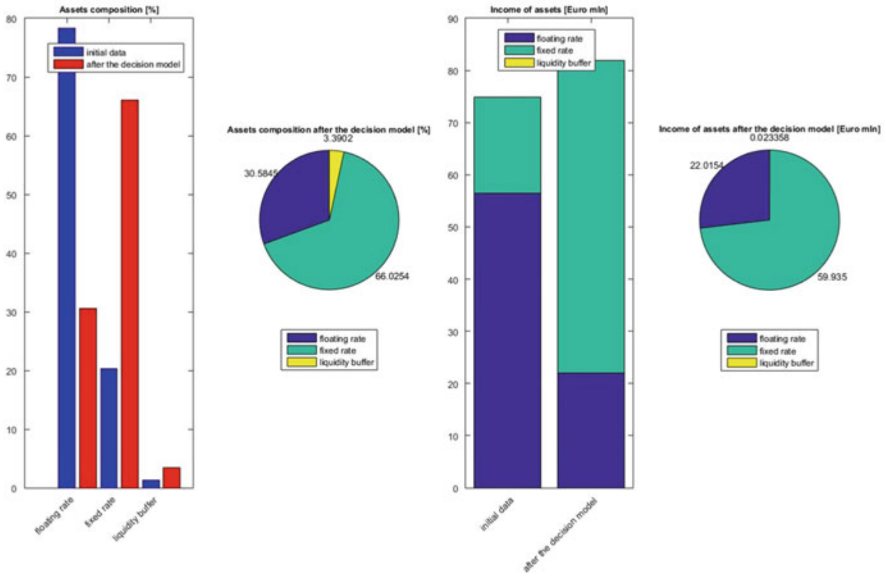

Fig. 1 The new composition of assets in the European bank and the resulting increased income after the implementation of the decision model

– Floating rate assets—30.58%
– Fixed rate assets—66 %
– Liquidity buffer—3.4%

The resulting interest income under base scenario (no stress assumption) is equal to 81.96 mln Euro over 6 month time period. The economic benefit from the implementation of the decision model is equal to 14.2 mln Euro on annual basis (Fig. 1).

Another important application of the decision model is related to the minimization of the overall funding cost of a bank. Such an exercise consists, in this case, in seeking the funding composition which helps to reduce the funding cost and to remain within the internal limits determined by the Board of Directors and regulatory requirements. The funding composition is mostly decided by the Treasury department therefore the decision model represents a supportive tool for a bank's Treasurer. It is within Treasurer's responsibility to minimize the funding cost and to keep the NII sensitivity created by the interest rate and liquidity exposure of the Banking Book within the predefined level. Again the real challenge here consists in understanding the trade-off between profitability coming from the achievable cheapest funding base (target position) and risks which Treasury has to run in order to ensure its profitability. In his role Treasurer has to assess the directional gap the bank should take on from the interest rate risk perspective and to put in place funding strategies that the liquidity of the bank is managed in a proper manner.

An understanding of the trade off between the degree of the maturity transformation of a bank and potential impact on the P&L resulting from the difference between interest and liquidity spreads of assets and liabilities is the first thing to be assessed and built into the decision model.

Finally, the importance of the appropriate size of the liquid assets portfolio has to be underlined as holding those assets represents the negative cost of carry, especially when the yield of the liquid assets (mainly government bonds) is low meanwhile the funding costs of the financial institutions significantly increased over the past years. Consequently, it is extremely important, from the profitability perspective, that the Treasury correctly estimates the optimal size of the liquidity buffer to be held.

The amount of liquidity buffer is assessed through stress testing which has become a key component of the supervisory assessment process of bank's capital and liquidity adequacy (Hauschild and Buschmann 2014).

The below example shows the application of the decision model applied to the funding base of the examined European bank with 3.7 bln Euro of Risk Sensitive Liabilities and the resulting economic benefit.

The initial funding base of the bank is composed of:

- Corporate current accounts—7.4%
- Corporate time deposits—1.5%
- Wholesale funding—70%
- Bonds issued—21%

The resulting cost of funds under base scenario is equal to 35.79 mln Euro over 6 month time period (Fig. 2).

The limits in terms of exposure to the interest rate risk, liquidity risk and funding concentration form the constraints for the objective function which minimize the overall cost of funds.

After the decision model is put in place the composition of funding base is changing as follows:

- Corporate current accounts—2.53%
- Corporate time deposits—7.65%
- Wholesale funding—79.99%
- Bonds issued—9.8%

The resulting cost of funds under base scenario (no stress assumption) is equal to 35.54 mln Euro over 6 month time period.

The economical benefit from the implementation of the decision model amounts to 0.56 mln Euro on annual basis.

It has to be noted that the economic benefit arising as a result of the application of the decision model is strictly related to the size of the balance sheet. The presented above example represents small sized bank (5 bln Euro RSA) based in Europe. For medium and big sized financial institutions the magnitude of the economic benefit is proportional to the size of the balance sheet. Another factor to be taken into consideration is the model sensitivity as different external or

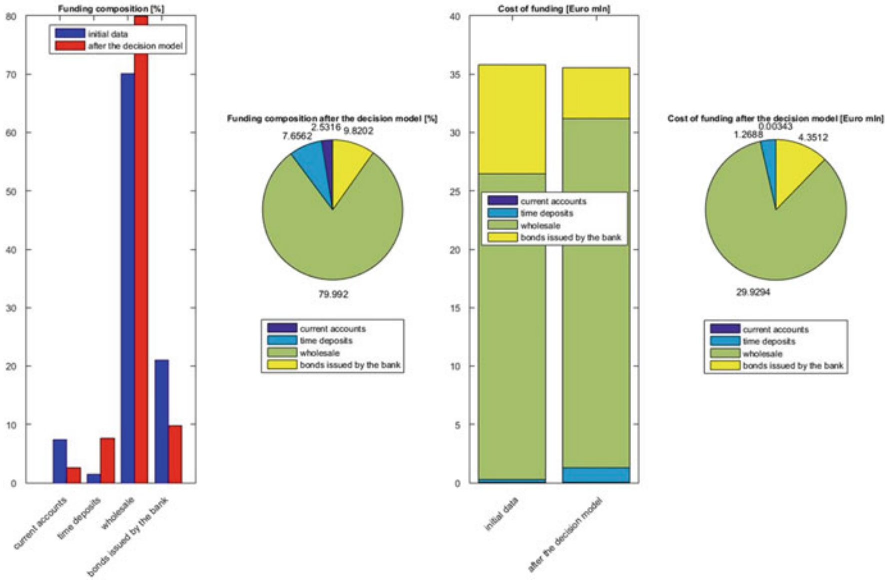

Fig. 2 The new composition of funding base in the European bank and the resulting economic benefit after the implementation of the decision model

internal factors impact economic benefit achieved by the model in the different way. For example, it has been turned out in performed analysis that the change in the behavioural assumptions for current and savings accounts and the change in the assets structure are factors the decision model for the target funding position appears to be most sensitive to.

The decision model applies the numerical optimization techniques which are not discussed in this article.

Once the target position both for assets and/or liabilities is determined the next step consists in using the FTP scheme as a tool towards achievement of the target structure estimated by the decision model. In particular, having the direction provided by the model upon the appropriate composition of assets and/or funding the next step is the navigation in the FTP landscape.

3 Funds Transfer Pricing Process (FTP): General Concepts

As already mentioned at the beginning of this article the FTP process is extremely powerful tool, which is deeply rooted in any divisional P&L or profit centre calculation. In fact, FTP is the means by which a bank's overall Net Interest Income can be split into originating units and subunits, thus enabling the bank's

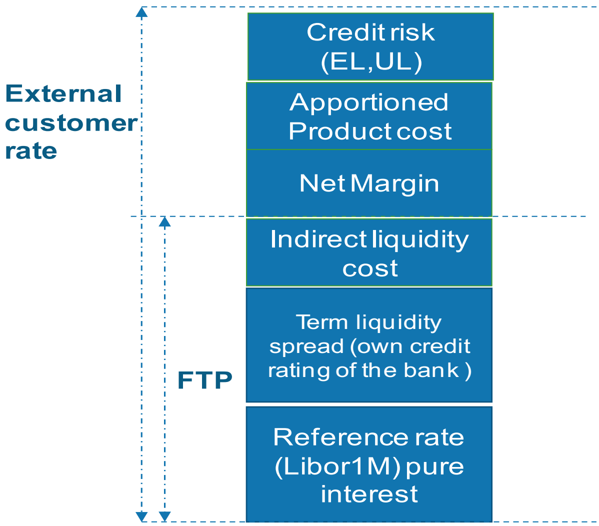

Fig. 3 The FTP building blocks

management to perform an effective planning, monitoring and control cycle (Widowitz et al. 2014). The FTP rate is composed of several components which basically represent the transference of the interest rate and liquidity risk from the Business Units to the Treasury in order to be managed centrally and keep the Business Units immune to financial risks (Fig. 3).

The FTP process separates the Net Interest Income components arising from client business margins, interest rate and liquidity maturity transformation.

There are at least four elements that need to be included in the holistic FTP framework. The first element consists in the definition of the framework for all products which represents sources of liquidity cost, both based on the deterministic cash flows (known as term liquidity) and for contingent liquidity arising from the stochastic cash flows (Widowitz et al. 2014). The second one is the FTP curve set up. This is driven by the underlying principle that assets get charged their cost of funds which is credited to the bank's funding units and the base of this calculation is the FTP curve. Neu et al. (2012) show that the most common approach in the past years and still very often implemented in the European banks consist in the curve construct based on the gross marginal cost of funds which answers the question: what is the opportunity cost to fund one unit of new asset volume in the wholesale market? However, it has to be noted that the aforementioned approach was developed and implemented at the time when balance sheets were growing and the growth was funded by additional capital market issuances very easily (Widowitz et al. 2014). In some cases, in order to further incentivise the growth of the balance sheet the FTP curve is dampened, i.e. the medium long term curve set up is lowered by the factor which reflects the target maturity transformation run by the bank. As a result only a certain portion of the bank's funding spread paid in the wholesale market is charged to assets. After the 2007–2009 crises, things are different as banks shrink their balance sheets and try to reduce their dependence on wholesale funding. In addition treasurers are more restricted in issuing specific tenures on capital markets (Widowitz et al. 2014). It leads to the necessity of more sophisticated and tailored FTP curve set up. For example, having stable and cheap deposit base is an imperative to maintain competitiveness. This fact has to be reflected in the FTP curve construct. The challenge in the FTP curve set up is to answer the question: what is the opportunity benefit of investing one unit of new deposit? (Widowitz et al. 2014). At this point it is worth to underline the importance of this element in the FTP framework as the curve construct has to be aligned with the strategic objectives decided by the senior management and to support the business model of an institution. The first rule, in order to achieve this goal, is transparency in the curve setting and deep understanding of the specifics of the balance sheet (target funding base and extent of the maturity transformation run by the bank).

Another important element in the FTP process is to define the correct FTP methodology. In this article the intention is to focus only on several products categories. Consequently, it gives a short overview of how FTP works for fixed and floating rate loans, amortizing and revolving loans. The FTP rate for loans is largely implemented by almost all banks. It is standard within the market to calculate and include the liquidity spread in the product pricing. Liquidity spread is usually derived from the difference between the bank's funding curve (swap curve shifted by the bank's term funding spread) and the swap curve for the tenor which corresponds the behavioural or contractual life of the product. In case of the amortizing loans the common market practice is to calculate the Internal Rate of Return (IRR) on the bank's term funding curve for both interest rate and mismatch liquidity risk meanwhile the transfer price for the revolving credit facility is calculated according to two approaches. The first one, the simplified approach, consists in the allocating the FTP rate to the drawn part of the product in line with its drawn amount and the tenor of the drawdown. For the undrawn portion of the product the contingency liquidity costs are allocated. Although simple, this approach represents some limitations such as the necessity of the generating a large number of funding tickets that have to be adjusted upon each change of the drawn amount. Furthermore, the Treasury would neglect the fact that many short term draws will be rolled over and will be actually drawn until the final maturity of the facility. In order to overcome those limitations, the alternative approach consists in behavioural analysis of the portfolios of the revolving facility and identification of the core and volatile part of the product. The core part which is supposed to be drawn until the final maturity will be charged the term liquidity cost until equal to the final maturity of the facility. Meanwhile the volatile part will be short term with usage which fluctuates in the short term. For the uncertainty of the volatile part the contingent liquidity needs to be held for which the costs should be allocated to the product (Widowitz et al. 2014). The behavioural analysis is performed for other items such as current or savings accounts. Behavioural assessment begins with segmentation based on key factors preferably using a single customer view (Soulellis 2014). Segmentation models should enhance customer understanding and be based on historical data, market information and expert judgement. Distinctive segments will enable an institution to model the lifetime value of the customer segment in terms of their expected behavioural life and stressed outflow for FTP calculations. Finally, it is extremely important to keep in mind the challenge which Treasury faces given the recent Basel III requirements for liquidity. The recognition of the additional costs resulting from the implementation of the new regulatory requirements is an imperative for the more sophisticated FTP framework. For many banks the question how to integrate the cost to comply with these ratios into the FTP still remains an open problem. The fourth element in the FTP framework is to ensure the transparency through the construct of the robust target operating model.

Both transparency and simplicity in the FTP framework should be unquestionable driver in the definition of the target operating model as only the clear methodology rules which are shared by every single participant in the FTP process can lead to the achievement of the strategic objectives of the bank and the correct shaping of the Balance Sheet (Grant 2011). Another important aspect in the FTP governance and framework is the oversight of the incentive premium scheme and of the management overlays (Cadamagnani 2015).

A Prudential Regulation Authority (PRA) cross–firm review of FTP practices at major UK banks revealed important issues in bank's internal transfer pricing policies and framework. One of the major issues underlined in the study performed in the PRA review was that banks were not separating the management overlays from their funding curve. Some banks were found to be applying different cost of funding curves to new loans and deposit in order to incentivize loan origination and deposit—gathering simultaneously. PRA view is that this is the vulnerability in the FTP framework of the bank as dampening practice skews business incentives and makes it less clear what performance is for individual products before and after any management overlay. The important point has been made that strategic decisions need to be made acknowledging the true economics of business and not unwittingly as a result of the inappropriate internal pricing methodologies (Cadamagnani 2015).

The section below focuses on the implementation of the incentive premium scheme and the management overlay as important tools in steering the Balance Sheet and to reach the designed target state. The incentive premium scheme and management overlays are powerful tools in the desired balance sheet shaping. The underlying logic behind those tools is to incentivize the growth of the certain product categories or the certain tenors through the additional "mark up" of the funding curve. In case of the incentive premium scheme it is usually a temporary tool which recognizes the additional premium to business units in order to incentivize the growth of the certain asset or liability class. For example, if the current accounts represent the strategically important product and the senior management would like to grow its base, Treasury will recognize additional mark up in the FTP rate to the business unit responsible for this product.

Instead, the management overlays consist in the shift of the whole segments of the funding curve up or down in order to recognize the higher structure funding costs the bank is running in the certain markets (for example in the Euro or USD market) or to subsidize growth of certain products, for example assets by charging them lower cost of funds that the bank is actually paying in the external market. As already mentioned those tools are powerful and for this reason their implementation and inclusion within the FTP framework have to be well governed, documented and transparent.

4 Conclusions

Active and conscious balance sheet management has increased in importance due to the scarcity of resources after the financial crises 2007–2009 such as capital and funding. As a result of regulatory landscape, historically low interest rates environment and significant margin compression banks are required to optimize and allocate resources very precisely to their businesses. New regulatory requirements set minimum levels for funding structure and liquidity buffers. Maturity transformation which is important revenue source is also under regulatory scrutiny. There is increasing pressure on unsecured funding driven by the widening liquidity spreads. All these factors force banks to redesign their target funding mixes and asset portfolios composition. There is a clear need for the maximization of the asset income and minimization of funding costs in situations where the bank as a whole has to obey to different limits (both internal and regulatory). Therefore, this article proposes the application of the decision model in order to define the target balance sheet structure and the FTP process as a tool for shaping.

Finally, the article leaves the reader with three take away messages:

- Application of the optimization technique improves the management of the Banking Book under interest rate risk and liquidity risk in terms of quantifiable **economic** impact on the P&L of a bank deriving from the optimization process. Decision model, discussed in this article, is the concrete example of the application of the optimization techniques.
- Mathematical models can provide useful information to understand the optimal structure for the Banking Book in terms of its composition of assets and liabilities. In this paper I am stating that the optimization of the target profile of the Banking Book of a bank is valid and useful strategic exercise as it increases the profitability of the asset side and reduces the overall cost of funding.
- The FTP process is a powerful tool in the balance sheet management which supports the achievement of the desired target structure of a bank defined by the decision model. As a tool to assist strategic balance sheet management the incentives and subsidies need to be made transparent and come on the top of a true and fair view of the bank's liquidity cost.

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Testing *VaR* Under Basel III with Application to No-Failure Setting

Marta Małecka

Abstract We investigated practical aspects of *VaR* model testing in case of no-failure series, with the special focus on significance levels recommended under Basel III. We considered alternative approaches to the standard likelihood ratio (*LR*) statistics, which are Wald and Lagrange Multiplier (*LM*) tests. The aim of the paper was to propose a *VaR* test available directly for no-failure setting and to compare *VaR* tests based on various rules—*LR*, Wald and Lagrange Multiplier. The comparative analysis involved both practical applicability aspects and formal evaluation of statistical properties of the tests. We showed that the *LM* rule applied to *Va*R test construction offers a practical advantage of direct applicability to all kinds of observed failure sequences, independent on the number of *VaR* breaches. We also presented possible power gains, resulting from the alternative approach, which result in more effective detection of misspecified risk models.

1 Introduction

The standard approach to risk model testing is based on the Value-at-Risk (VaR) framework and uses failure-based methods. Since scarcity of observations is inherent to extreme events, a small number of failures is problematic. The paper investigates the problem of testing VaR on low levels of tolerance, when standard market conditions imply no failures. The study was motivated by the current Basel III framework which suggests VaR testing on significance levels 97.5% and 99%.

VaR measure was firstly proposed as practical risk management tool of the investment bank in 1990s of the twentieth century and then sanctioned by the Basel Committee on Banking Supervision. The international system of risk measurement recommendations was based on VaR in 1990s (Basel 1996), shortly after its original inception by JP Morgan (Morgan 1994). Since 2012 the Basel Committee on Banking Supervision has worked on a major reform of its global standards, which resulted in a partial shift from VaR to ES (expected shortfall) risk measure in the Basel III Accord (Basel 2012–2016). This shift however did not include the fundamentals of testing rules.

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_18

Though widely recognized as means to capture risk in extremal situations, *ES* still lacks commonly accepted backtesting procedures (Carver 2013, 2014; Hull and White 2014; Emmer et al. 2015). The main challenge is unavailability of the distribution of the tail average. Compared with these difficulties, straightforward manner of *VaR* backtesting is appealing and results in *VaR*-based Basel framework of risk model validation. According to Basel III rules it is recommended to verify risk model based on *VaR* on two levels. Consequently, in the context of model backtesting, *VaR* still attracts attention of both market practitioners and regulators.

The underlying step in *VaR* backtesting procedure involves checking the unconditional coverage property. It refers to the *VaR* failure rate and means that number of *VaR* exceedances in the sample should math the assumed tollerance level. A standard approach to check the unconditional coverage property is the Kupiec (1995) test, formulated in the likelihood ratio framework.

This paper proposes two tests of *VaR* unconditional coverage property. Using the Lagrange Multiplier (*LM*) and Wald rules of test construction, we form alternative statistics to the Kupiec *LR* test. Through the *LM* approach we obtained the procedure which has a practical advantage of direct applicability in all market situations. Specifically it outperforms other procedures as being well defined in case of no failure series, which is very likely to occur in practice under low tollerance levels suggested by Basel rules. Through simulations we showed that the proposed *LM* statistic exhibits larger power than other tests in detecting risk underestimation. It is thus recommended for risk management to prevent unexpectedly large losses.

2 Testing *VaR* Failure Rate

Let R be the random return form a portfolio over the holding period, where the distribution function F_R of R is continuous. *VaR* at p tolerance level, $p \in (0, 1)$, is the maximum potential loss realized by R over the holding horizon with probability $1-p$, formally defined as the distribution $p-$quantile (e.g. Christoffersen 2012; Skoglund and Chen 2015):

$$VaR_p(R) = -F_R^{-1}(p). \tag{1}$$

Let $(R_1, R_2, \ldots, R_T)$ denote the series of observations of R. Defined as the random variable quantile, the true *VaR* is unobservable, therefore model evaluation is based on comparing *VaR* forecasts $VaR_p(R_t)$ for time t with realized values of random return[1] R_t, $t = 1, \ldots, T$. Standard testing procedures are built on the zero-one *VaR*

[1]For the sake of brevity, throughout the paper, we adopted the notation, which favours convenience over precision, where we do not distinguish random variables from their realized values. The meaning will be clear from the context.

failure process, which informs, whether the value of R_t falls below the forecasted risk level $VaR_p(R_t)$:

$$I_t = 1_{\{-R_t > VaR_p(R_t)\}}, \quad t = 1, \ldots, T. \tag{2}$$

The basic statistical verification of a *VaR* model relies on the unconditional distribution of I_t and involves checking whether the probability of *VaR* exceedance matches the *VaR* tollerance level, i.e. $P(I_t = 1) = p$. This unconditional coverage property is tested in the long term through the overall proportion of *VaR* failures to the number of observations in the zero-one hit sequence Eq. (2).

Using the Bernoulli model

$$I_t \sim Z - J(\pi), \tag{3}$$

$t = 1, \ldots, T$, where $Z - J(\pi)$ denotes Bernoulli distribution with parameter π, the unconditional coverage criterion may be written as

$$\pi = p. \tag{4}$$

The Kupiec test (1995), designed to assess the unconditional coverage property, verifies the parameter restriction in the above Bernoulli model through the likelihood ratio (*LR*) framework. The null hypothesis $H_0 : \pi = p$ is tested against the alternative $H_1 : \pi \neq p$ by the following statistic

$$LR_{uc} = -2\log\frac{p^{T_1}(1-p)^{T_0}}{\hat{\pi}^{T_1}(1-\hat{\pi})^{T_0}} \tag{5}$$

where T_1 is the number of *VaR* exceedances, $T_0 = T - T_1$ and parameter π is estimated through $\hat{\pi} = \frac{T_1}{T}$. Using asymptotic properties of the likelihood ratio, we have that under the null LR_{uc} is $\chi^2_{(1)}$ distributed.

Alternatively to the *LR* approach the unconditional coverage property may be verified, within the maximum likelihood framework, by statistics built on Wald or Lagrange Multiplier (*LM*) rules.[2] The log likelihood for the series $(I_t)_{t=1}^T$ has the form

$$\log L(\pi, I_1, I_2 \ldots, I_T) = T_1 \log\pi + (T - T_1)\log(1-\pi), \tag{6}$$

and its first and second derivatives are respectively

[2]The overview of *LR*, Wald and *LM* test can be found in many positions of econometric literature (e.g. Engle 1984; Maddala and Lahiri 2009).

$$\frac{\partial \log L(\pi, I_1, I_2 \ldots, I_T)}{\partial \pi} = \frac{T_1}{\pi} - \frac{T - T_1}{1 - \pi} \tag{7}$$

and

$$\frac{\partial^2 \log L(\pi, I_1, I_2 \ldots, I_T)}{\partial \pi^2} = -\frac{T_1}{\pi^2} - \frac{T - T_1}{(1 - \pi)^2}. \tag{8}$$

Comparing Eq. (7) with zero yields the result $\pi = \frac{T_1}{T}$ and substituting to Eq. (8) gives negative value, which prove that the ML estimate of π is $\widehat{\pi} = \frac{T_1}{T}$.

The general formulation of the Wald test for the hypothesis $H_0 : \theta = \theta^0$, $\theta \in \mathbf{R}^k$ is based on comparing the hypothesized value θ^0 with its $\widehat{\theta}$ estimate through the statistic

$$W = \left(\widehat{\theta} - \theta^0\right)' I\left(\widehat{\theta}\right)\left(\widehat{\theta} - \theta^0\right), \tag{9}$$

where variance estimate $I\left(\widehat{\theta}\right)$ at point $\widehat{\theta}$ is given by the Fisher information i.e. $I(\theta) = -E\left(\frac{\partial^2 L(\theta)}{\partial \theta \theta'}\right)$. If $\widehat{\theta}$ has the limiting normal distribution and $I(\theta)$ is consistently estimated by $I\left(\widehat{\theta}\right)$, the Wald statistic has the limiting χ^2 distribution.

Under the Bernoulli model Eq. (3) the Fisher information is given by

$$\begin{aligned} I(\pi_1) &= -E\left(\frac{\partial^2 \log L(\pi_1, I_1, I_2 \ldots, I_T)}{\partial \pi_1^2}\right) = \\ &= -E\left(\frac{-T\pi_1(1 - \pi_1) - (T_1 - T\pi_1)(1 - 2\pi_1)}{\pi_1^2(1 - \pi_1)^2}\right) \end{aligned} \tag{10}$$

Because $E(T_1 - T\pi_1) = 0$, then

$$I(\pi_1) = \frac{T}{\pi_1(1 - \pi_1)}.$$

Thus VaR test of the unconditional property, based on the Wald rule, with the null $H_0 : \pi = p$, has the following form:

$$W_{uc} = \frac{T(p - \widehat{\pi})^2}{\widehat{\pi}(1 - \widehat{\pi})} = \frac{(Tp - T_1)^2}{T\frac{T_1}{T}\left(1 - \frac{T_1}{T}\right)} = \frac{T(Tp - T_1)^2}{T_1(T - T_1)}. \tag{11}$$

Under the null the statistic W_{uc} has the asymptotic $\chi^2_{(1)}$ distribution.

The Lagrange Multiplier testing framework relies on the score function, whose asymptotic distribution is obtained by applying the central limit theorem. The Lagrange Multiplier test of the general hypothesis $H_0: \theta = \theta^0$, $\theta \in \mathbf{R}^k$, based on the sample $\mathbf{X}$, is formulated as

$$LM = s'\left(\theta^0, \mathbf{X}\right)' I^{-1}\left(\theta^0\right) s\left(\theta^0, \mathbf{X}\right). \tag{12}$$

Using the result Eq. (7), the score function for the series $(I_t)_{t=1}^{T}$ is

$$s(\pi) = \frac{\partial \log L(\pi, I_1, I_2 \ldots, I_T)}{\partial \pi} = \frac{T_1 - T\pi}{\pi(1-\pi)}.$$

The score function related to the Fisher information Eq. (10), gives the *LM*-based unconditional coverage *VaR* test:

$$LM_{uc} = \frac{s^2(p, I_1, I_2 \ldots, I_T)}{I(p)} = \frac{(Tp - T_1)^2}{p^2(1-p)^2} \cdot \frac{p(1-p)}{T} = \frac{(Tp - T_1)^2}{Tp(1-p)}. \tag{13}$$

Under the null the statistic LM_{uc} has the asymptotic $\chi^2_{(1)}$ distribution and is equivalent to the standard normal test statistic. A practical advantage of the LM_{uc} statistic, compared to the standard *LR*-based Kupiec LR_{uc} test is that LM_{uc} is well defined in the case of no failure setting.

3 Simulation Study of Test Properties

The simulation study of unconditional coverage *VaR* test properties was based on Bernoulli process in the form Eq. (3). By manipulating the parameter value, the Bernoulli model allowed for generating zero-one hit sequence $\{I_t\}_{t=1}^{T}$, both under the null and under the alternative. We considered series lengths $T = 250, 500, 750, 1000$. In order to compute the size of the tests, we simulated 10,000 hit sequence samples under the assumption that the hit variables are Bernoulli distributed with parameter p. According to Basel III recommendations, p was set to levels $p = 1\%$ and $p = 2.5\%$, which matched the assumed *VaR* tollerance levels. The empirical size was computed as the proportion of rejections of the true null hypothesis. The test significance was set to 5%.

The size results for both *VaR* levels—1% *VaR* and 2.5% *VaR* (Tables 1 and 2)—showed that LM_{uc} test was the most accurate of the three maximum-likelihood-based statistics. In most cases the LR_{uc} and W_{uc} tests tended to be oversized, which showed the possibility to overreject the null hypothesis when it is true, when using these statistics. The overrejection tendency of LR_{uc} and W_{uc} was observed for both *VaR* levels, however the size distortion was lower for 2.5% *VaR*. The size estimates

Table 1 Empirical size of the unconditional 1% *VaR* tests

Test	Series length			
	250	500	750	1000
LR_{uc}	0.097	0.066	0.043	0.053
W_{uc}	0.087	0.120	0.062	0.080
LM_{uc}	0.041	0.035	0.062	0.040

Table 2 Empirical size of the unconditional 2.5% *VaR* tests

Test	Series length			
	250	500	750	1000
LR_{uc}	0.076	0.060	0.066	0.039
W_{uc}	0.053	0.068	0.072	0.048
LM_{uc}	0.040	0.036	0.043	0.050

for LM_{uc} statistics hoovered around the nominal test size of 5% and most often fit within the limits 4–6%.

In the power exercise we generated zero-one hit sequences under the alternative and computed relevant rejection frequencies. The experiments were based on Bernoulli trials with incorrect parameter $\pi \neq p$. We considered the alternative hypothesis only in the direction of risk underestimation. For 1% *VaR*, we chose alternative hypothesis with parameter π on levels 2% and 3% and for 2.5% *VaR* on levels 4% and 5%. The power estimates were calculated as rejection frequencies over 10,000 simulations. As in the size experiments, test significance was set to 5%.

With the aim of achieving comparability, the power results were size-corrected. To this end the power comparison was conducted with the use of the Monte Carlo test technique, which is based on the assumption that the finite sample distribution of the test statistic can be simulated (Dufour 2006).

Comparative analysis of test results showed that the LM_{uc} test exhibited highest power against risk underestimation (Tables 3, 4, 5 and 6). The largest difference in favour of LM_{uc} test was observed for the shortest considered series length—250. In this case, in 1% *VaR* experiments, the LM_{uc} rejection frequencies were over 10 p.p. higher than for other statistics and in 5% *VaR* experiments—over 5 p.p. With lengthening series lengths the power results were systematically increasing for all tests and the differences between tests were declining. This confirmed differences in finite sample performance and at the same time asymptotic equivalence of the tests.

4 Summary and Conclusions

The study examined risk model validation under Basel III recommendations. With reference to the Basel rules we considered *VaR* model verification through testing unconditional coverage property. We proposed two test statistics built within maximum likelihood framework—based on Wald and Lagrange multiplier rules.

Table 3 Empirical power of unconditional 1% *VaR* tests against Bernoulli alternative with $p = 2\%$

Test	Series length			
	250	500	750	1000
LR_{uc}	0.28	0.42	0.64	0.75
W_{uc}	0.13	0.20	0.33	0.53
LM_{uc}	0.39	0.56	0.70	0.79

Table 4 Empirical power of unconditional 1% *VaR* tests against Bernoulli alternative with $p = 3\%$

Test	Series length			
	250	500	750	1000
LR_{uc}	0.65	0.89	0.98	1.00
W_{uc}	0.63	0.74	0.80	0.98
LM_{uc}	0.78	0.95	0.99	1.00

Table 5 Empirical power of unconditional 2.5% *VaR* tests against Bernoulli alternative with $p = 4\%$

Test	Series length			
	250	500	750	1000
LR_{uc}	0.30	0.43	0.68	0.76
W_{uc}	0.06	0.27	0.52	0.71
LM_{uc}	0.36	0.56	0.70	0.81

Table 6 Empirical power of unconditional 2.5% *VaR* tests against Bernoulli alternative with $p = 5\%$

Test	Series length			
	250	500	750	1000
LR_{uc}	0.60	0.82	0.95	0.99
W_{uc}	0.23	0.69	0.91	0.98
LM_{uc}	0.65	0.89	0.96	0.99

Using the Lagrange multiplier rule we obtained a test statistic, whose practical advantage over popular Kupiec likelihood ratio test is its definiteness in no-failure hit sequences. Through the simulation study we showed that the proposed *VaR* Lagrange multiplier test outperformed other procedures both in terms of test size and power. It was more accurate and effective in detecting risk underestimation. The above findings indicate the test potential as a model verification tool in portfolio analysis, where risk is regarded a key determinant of a capital structure.

Acknowledgements The research was supported by the Polish National Science Centre grant DEC-2013/11/N/HS4/03354.

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Factors of Influence on Relationship Banking of Polish Firms

Helmut Pernsteiner and Jerzy Węcławski

Abstract In the field of business research, the relationships of firms to banks are not normally in a central focus, but for the survival of enterprises this issue may be important. Especially during a crisis, when cash from banks is extremely important to realize a plan of restructuring, the relationships to banks(s) becomes a crucial factor. One factor in the field of relationships to banks is the so called relationship banking, which is a well-known practice in the bank oriented economies in Europe. Relationship banking means a long run relationship between one or a small number of banks to firms, especially in lending, so the terminus is in this field relationship lending. Banks receive intensive information about the firm over a long period of time, so that the banks are able to estimate at a high level the economic situation of the firms. On the other hand the enterprises are looking for a higher level of understanding and help in critical situations. Relationship banking leads to lower competition among the banks, so that there is a fear of firms paying too much for banking products. On the basis of a huge telephone-questionnaire in Poland concerning financial management we have tried to answer some research questions in the field of relationship banking in detail in order to bring light into this somewhat dark area of relationships between banks and firms. The main aspect of relationship banking is the duration of this relationship. Using empirical methodology, we analyse this relationship on the basis of the length of time as well as aspects such as the age of the firm, the number of bank relationships, the industry, the influence of strategies and the access to credits.

1 Introduction

In the field of business research, the relationships of firms to banks are not normally in a central focus.

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_19

From the point of view of the enterprise are two cases important: On the one hand the firm will choose from some offers of the bank products (e. g. loans) and will find the best and that means very often the cheapest offer. In this area the enterprise likes to have contacts to many banks so it is sure to get some interesting and attractive offers. The relationships to the banks are very professional with low personal contact levels; there is no longer binding between the two institutions. This is typical for the Anglo-Saxon world, where public capital markets are well developed.

On the other hand—mainly in the countries in Continental Europe, the so called "bank economies"—there are strong relationships between one, two or even more banks to a firm. The terminus for this long run relationships is relationship banking (Iturralde et al. 2010). If you compare this system e.g. in the case of lending (Berger and Udell 2002) with the above mentioned so you will find a lower level of competition, because it is very clear that the competition is mainly between two or even three banks. If there is a strong relationship banking—that means the contacts are only to one bank—there is even no competition (Pernsteiner and Węcławski 2016). So the firm maybe has the fear to pay too much for example for a credit (Degryse and Van Cayseele 2000) or hope for a cheaper loan (Carletti 2004). But the enterprise see this long relationship as a partnership and therefore as a kind of "insurance" in the time of a crisis (Iturralde et al. 2010; Sauter 2015). In such a dark period for the firm it will need additional money to realize the restructuring plan to come in a better future. In this time it is very difficult to earn money for such a plan: The (old) shareholders are mainly not able to give additional money, new shareholders cannot be found because of the bad economic situation, new banks will see their engagement as too risky, so the (old) bank is the only one which is maybe willing to make a further engagement. Now the relationship banking-process will work: As result of the long-time relationship the so called "house bank" has gathered huge information about the enterprise and can decide very precisely. The former engagement of the bank was very high, so the loss in the case of default of the firm is very high; as a consequence there is a high interest of the bank to bring the firm out of the crisis, maybe with fresh money.

This article deals with relationship banking of Polish firms. Poland as one of the largest Eastern-European countries achieved many years of high growth rates after the transformation to a market economy since the early 1990s. The financial system is a bank oriented one—as a typical Continental European country—and banks are strongly engaged in corporate finance. The banks have a high level of competitiveness, but they are in favour of relationship banking.

We will bring light into this somewhat dark area of relationship banking of Polish firms based on a huge telephone-questionnaire of 758 Polish firms, which are not SMEs. In concrete our basis point is the duration of the relationship between bank and firm.

Using empirical methodology, we analyse this relationship on the basis of the length of time (Berger and Udell 1995; Iturralde et al. 2010), that means we would like to find out to which kind of firms relationship banking is more important. The analysis is oriented to two groups of factors: Variables characterizing the firm like the age of the firm, the industry and the influence of corporate strategies, and variables characterizing the relationship between banks and firms like the number of bank relationships and the access to credits.

There are nearly no research results available for these aspects for European firms, and even for Polish firms (Tymoczko 2012). The presentation with its outcomes shall set some stones for this research mosaic in the field of finance and banking.

The authors are very grateful to the financial aid given from the Polish National Science Centre (NCN Project No. 2012/07/B/HS4/00455, "Corporate governance ownership structure and other financial issues of family business in Poland and Austria—a comparative analysis").

2 Literature Review

Relationship banking as mentioned dominant relationship structure between banks and firms in Poland is primarily focused to relationship lending which means to realize the need of the enterprises for liquidity from banks for some years.

From the point of view of the bank the orientation is clear: They want the money back with the interests along the fixed timeline, or in other words they want to reduce their risks to zero. The main problem in this case is the information asymmetry between the CFOs of the firms and the loan specialists in the banks (Berger and Udell 1995). Since many of centuries banks are able to deal with these problems and they are experts in using collaterals and covenants to earn more information about the enterprise. That means that beside the collaterals the gathering and analysing of information must be in the focus of banks. Relationship lending is a main column of gathering this information (Elyasiani and Goldberg 2004), especially of the long time line of information and the established personal contacts over years, which lead to a better estimation about the risks of the firm (von Rheinbaben and Ruckes 2004).

Relationship lending has further pros for the banks: The long contacts may reduce the probability that other banks will enter in this relationship with aggressive conditions and therefore improve the ability for the bank to come to signing the credit contract with good conditions for the bank. Important engagement as lender and personal contacts to the firm will both give the chance for more "influence" in important decisions of the enterprise (Elsas 2005): on the one hand with conditions in the contracts like covenants and on the other hand with an advisory position because of the personal contacts; the latter will be more important for small firms. Another positive aspect for the bank is to sell a future loan (Bharath et al. 2007) and the so called "cross selling", that means the better ability to sell other non-credit products and services such as asset management, deposits, insurances, etc. In a family firm the contact to the owners may be important for the bank to offer personal loans, personal insurances and private banking products.

As above mentioned relationship banking and especially relationship lending lead to an "insurance against critical liquidity problems in a crisis or near-crisis; the firm is looking for an additional loan. Another advantage for the firm lies in the hope to achieve better price conditions for all bank products because that bank will see the firm as an important client . . ." (Pernsteiner and Węcławski 2016).

There is nearly no research for Poland in this field, especially for non-listed firms. It is even not possible to get some data from public information or data banks. Therefore we use the methodology of a questionnaire.

3 Hypotheses

The main aspect of relationship banking is the duration of this relationship (Iturralde et al. 2010). Therefore we will analyse some relations on the basis of the duration of relationship banking. We argue that some characteristics have large influence to specifications of the firm like the age of the firm, the industry and the strategies and goals of the enterprise. The length of the relationship banking is influenced by the number of banks and the number of contacts between the two partners, the access to loans and the level of contentment with the loans in general.

So we are able to define our hypotheses:

H1: The length of relationship banking is higher with older firms (Iturralde et al. 2010).
H2: The length of relationship banking depends on the number of banks and the amount of contacts between banks and firms.
H3: Relationship banking is more important in the sector of trade/service as in manufacturing firms.
H4: The length of relationship banking depends on the strategies and goals of the firm.
H5: The length of relationship banking is higher by a good access to loans.
H6: The length of relationship banking is higher when the contentment with loans is higher.

4 Data and Descriptive Analysis

The data for this project was collected by the authors' research. The research was carried out in the second and third quarter of 2014 on a random sample of 758 enterprises which employ more than 49 persons. The questionnaire—based interviews were carried out using CATI and CAWI techniques.

Most of the enterprises are in the manufacturing sector (57.1%), the rest are firms acting in the trade and service sector.

45% of the firms earn the majority of their turnover in whole Poland, 35% in their own Polish district and only 20% with foreign activities.

The average age of the firms in the data set is 21 years. Only 8% of the firms are younger than 10 years, 42% are active between 10 and 20 years and 50% are older than 20 years.

The firms in our data set show us a clear hierarchy of goals. For 94% of the enterprises an important goal is to realize the long run going concern of the firm, for 77% is important to minimize the enterprise risk; 75% of the enterprises say that independence is very important and they like to be independent in their activities in the future too. For nearly 72% of the firms is important to realize a high growth rate and for 69% it is important to improve long term value and—interesting—only 41% are short term oriented in maximizing profits.

Collaboration with banks is another field. 18% inform that they are working constantly with only one bank, 40% with two banks, 25% with three banks and the rest with more banks. Most of the enterprises are dealing a long time with their most important bank, in detail nearly 16% more than 20 years, 40% between 11 and 20 years and the rest are acting in a shorter period. We asked further about the number of contacts to the most important bank; 10% say, that their personal contacts with the bank are very often, 71% quite often and 19% as often. Interesting is that there is no firm which tell us that the personal contacts are rare. We have to say that this answer is an answer of feeling or behaviour, it can be interpreted that it is from the point of view of the firms too often or they are happy that they are in close contacts.

For the external financing activities of the firms the bank loans are really important. 73% of the firms are using short term-loans, 47% long term loans. 46% of the "short term-users" are very satisfied and the same percentage of the firms using long term-loans are very satisfied with this instrument too. An interesting question in the past crises-period is the access to bank credits. 22% of the firms say that the access to loans is very easy and 47% say that the access is easy. Only for 5% of the firms the impression is "difficult" and nearly 2% say "very difficult".

5 Econometric Model

For verifying the hypotheses we use a linear regression model. The dependent variable is the duration of relationship banking, the explaining variables are characterising the firms and the relationship to banks. We use some control variables too. As control variables we define turnover 2013, assets 2013 and number of employees 2013 (X1–X3).

The 14 explaining variables (X4–17) are:

X4: Age of the firm in years
X5: Number of banks collaborating with the firm
X6: Intensity of contacts with the most important bank
X7: Number of banks collaborating with the firm over a long time
X8: Manufacturing firms (1), others (0)

X 9: Importance of the goal long term growth of value
X10: Importance of the goal short term maximizing of profits
X11: Importance of the goal independence of the firm
X12: Importance of the goal of a high growth rate
X13: Importance of the goal of long run going concern
X14: Importance of the goal of minimizing the enterprise risk
X15: Access to bank credits
X16: Contentment with short term bank credits
X17: Contentment with long term bank credits.

The analysis was realized by SPSS. The estimation for model (1) with combined variables and for the other three models with combined variables (2, 3, 4) show similar results (Table 1). All models contain no strong correlated ones what is typical for that data.

6 Empirical Results, Conclusions and Limitations

The estimation for the model with combined variables (Table 1) show similar results.

Our first hypothesis is, that the length of relationship banking is higher with older firms. We see a positive relation between the two aspects (length of relationship banking and age of the firm [X4]; Pearson = 0.367, p = 0.01). The hypothesis will be accepted. This situation describes the reality well: Older firms have a well—established and organised financial management and the relevant persons in the bank(s) and the firm know each other over a long time. The bank know the specifications of the firm well and their financial policy so she offers tailored products. The CFO save time and is satisfied. They are learning over the years and strengthen their relationship.

Therefore for the banks it is important to look for good personal contacts and they shall not change their employees too often.

Hypothesis 2 deals with the number of banks and the contacts between banks and firms. Only the aspect of number of banks collaborating with the firm [X5] is significant; that means that the length of relationship banking is increasing with the number of banks (Pearson = 0.114, p = 0.05). Hypothesis 2 can be only confirmed with this aspect. In general we can say that Polish firms are collaborating with a low number of banks (1.6) and this amount is lower than in other European countries (Gajewski et al. 2012).

We think there are some reasons possible to explain this result. One point has the focus on the firm: In the last decades Poland has high growth rates and the firms expand their activities and need therefore more banks, maybe they start with a more regional oriented bank and need additional a bank with more international experience. A high value of independence may be the reason to look for another bank. A

Table 1 Results of estimations of model and significance level

	Model 1				Model 2				Model 3				Model 4			
Variable	B	Std. error	t	Sig.	B	Std. error	t	Sig.	B	Std. error	t	Sig.	B	Std. error	t	Sig.
Constant	3.549	6.267	.566	.572	4.434	5.658	.784	.434	5.792	5.675	1.021	.308	5.397	5.074	1.063	.288
X1	1.077	1.248	.863	.389	.064	.822	.077	.938								
X2	−1.538	1.217	−1.264	.208					−.460	.821	−.561	.576				
X3	1.134	2.016	.562	.574									.258	1.531	.169	.866
X4	.193	.038	5.086	.000	.194	.037	5.269	.000	.196	.037	5.248	.000	.200	.035	5.672	.000
X5	.993	.408	2.433	.016	.900	.380	2.366	.019	1.019	.401	2.540	.012	.856	.369	2.322	.021
X6	−.297	.368	−.806	.421	−.380	.340	−1.118	.265	−.307	.365	−.840	.402	−.470	.319	−1.475	.141
X7	−.389	.523	−.744	.457	−.197	.501	−.393	.694	−.412	.509	−.808	.420	−.230	.478	−.482	.630
X8	−1.479	.886	−1.670	.096	−1.568	.824	−1.902	.058	−1.498	.870	−1.721	.087	−1.616	.786	−2.055	.041
X9	−.580	.485	−1.195	.233	−.479	.461	−1.038	.300	−.552	.480	−1.152	.251	−.423	.440	−.961	.337
X10	−.036	.364	−.098	.922	.001	.340	.004	.997	−.069	.358	−.193	.847	−.010	.326	−.031	.976
X11	.211	.466	.453	.651	.325	.423	.769	.442	.142	.459	.308	.758	.171	.397	.432	.666
X12	−.220	.561	−.393	.695	−.378	.521	−.725	.469	−.171	.549	−.312	.755	−.439	.501	−.876	.382
X13	.068	.911	.074	.941	−.018	.878	−.020	.984	.123	.897	.137	.891	−.116	.802	−.145	.885
X14	1.334	.568	2.349	.020	1.345	.533	2.522	.012	1.316	.562	2.340	.020	1.385	.516	2.684	.008
X15	.954	.300	3.185	.002	.790	.279	2.833	.005	.963	.296	3.247	.001	.742	.261	2.846	.005
X16	−.421	.211	−1.995	.047	−.323	.197	−1.645	.100	−.391	.207	−1.890	.060	−.235	.187	−1.259	.209
X17	.076	.213	.359	.720	−.080	.197	−.406	.685	.036	.208	.174	.862	−.073	.186	−.391	.696

Source: Own calculations

second focus lay on the banks: The competition in the Polish bank market got more intensive, so it is natural that the number of banks for the firms increased.

The third hypothesis is dealing with the industry (trade/service vs. manufacturing). We use the variable 1 for a manufacturing firm and 0 for firms in the trade and service sector [X8]. The significant negative number shows that relationship banking is more intensive if the firm is in the trade and service sector (Pearson $= -0.110$, $p = 0.05$). The trade service sector in a large country like Poland is more national oriented and therefore they do not need more banks for complicated problems, they use their long bank structure with good experience.

"The length of relationship banking depends on the strategies and goals of the firm." (Hypothesis 4) We looked for six goals and strategies [X9–X14]. We are only able to accept variable X14 ("minimizing enterprise risk"—Pearson not significant). Firms which are more oriented to reduce the risk of the firm are more focused to relationship banking—this is a clear picture. We can only accept the hypothesis partially.

In hypothesis 5 we test the influence of a good access to bank loans [X15]. And it is reality, that when the firms say that they have a good access to loans (in 2013) the length of relationship banking is higher (Pearson $= 0.131$, $p = 0.05$). We think this shows the value of relationship banking: The information level of the firm in the bank is high, they know each other and so the "feeling" in the firm is that they have a good access to loans.

Our last hypothesis deals with the contentment with short and long term bank loans [X16, X17]. Only the contentment with short term bank loans is in a negative relation significant (Pearson not significant), that means that a high contentment with short term credits leads to stop relationship banking, maybe the impression is that the conditions are for the firm better under full competition.

We summarize that the length of relationship banking is higher with older firms, with firms which want to reduce their risks, depends on the number of banks and is higher by good access to loans. Relationship banking is more important in the sector of trade and service. With this information the banks are able to plan their strategies in the field of corporate lending better.

There are some limitations of this contribution to research. We have data from a relatively high number of Polish firms, but they cannot be a whole picture of the real world in size, industry, etc. It would be interesting to compare the results with other countries to explain if there are some cultural influences.

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Bootstrap Mean Squared Error of Prediction in Loss Reserving

Alicja Wolny-Dominiak

Abstract The prediction of total loss reserve in non-life insurance company is considered. One of the methods currently used in practice applies the generalized linear model (GLM). In the literature one can find the justified extension of the GLM to the hierarchical generalized linear model (HGLM) for loss reserving. A limitation in the use of the HGLM is the fact that the mean squared error of prediction (MSEP) is expressed by a complex analytical formula. An alternative to the analytical formula is to use the bootstrap procedure approximating the sampling distribution of the MSEP. This paper study two ways of bootstrap. The first one is the parametric bootstrap in which one simulates from fitted values of the HGLM. This approach is sensitive to incorrect fit of the model. Therefore the alternative is the simulation by resampling residuals and adding them back to the fitted values. The paper contains the comparison of this two approaches applying the loss triangle investigated by several authors. Bootstrap procedures are implemented in **R** software and the code is available to download (see http://web.ue.katowice.pl/woali/).

1 Introduction

The largest item on an insurer's balance sheet are technical reserves. Any variations in their values have a great impact on the insurer's financial strength. A large part of the provisions is the reserve for incurred but not reported (IBNR) claims or simply—the loss reserve, which is crucial to the insurer's solvency. A reserving analysis involves the determination of the random present value of an unknown amount of future claims. For a property/casualty insurance company this uncertain amount is usually the most important number on its financial statement. The care and expertise with which that number is developed are crucial to the company and to its policyholders. To company management the reserve prediction should provide reliable information in order to maximize the company's viability and probability.

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_20

The total loss reserve is generally determined by statistical methods based on both deterministic techniques and stochastic models and is a sum of outstanding claims liabilities obtained for homogenous group. A wide variety of the total loss reserve prediction tools are presented in literature in the group of stochastic methods. The most popular method is the chain-ladder method (CLM) e.g. (Mack 1994; Verrall 2000), (England and Verrall 2002). Parallel methods based on the regression model have been developed e.g. (Kremer 1982; Mack 1991; Pobłocka 2011; Wolny-Dominiak 2014). In (Renshaw and Verrall 1998) it is shown that the CLM is equivalent to the well-known generalized linear model (GLM) with fixed effects assuming over-dispersed Poisson (ODP) distribution for incremental claims. In the paper (Gigante et al. 2013a, b) authors shows an extension of the GLM for loss reserving containing both fixed effects as well as random effects. Model's parameters are estimated in the frequentist approach using hierarchical likelihood approach (Lee and Nelder 1996).

A key problem in the predicted of loss reserve is to measure the prediction accuracy. Usually the MSEP used. In (England and Verrall 1999) authors proposes the bootstrap estimator of the MSEP for GLM loss reserve as the alternative to the analytical formula. The motivation is the simplicity of this method of error estimation in loss reserving. Similar situation is in case of the hierarchical GLM (HGLM). The computations of this error estimate is a complicated process due to the complex structure of the analytic formula. Therefore this paper propose the bootstrap RMSEP on the use the parametric bootstrap as well as the residual as in (Efron and Tibshirani 1994). It gives the possibility to easy application in practice.

2 The Model and the Predicted Total Loss Reserve

Consider the data in loss triangle in which the random variable Y_{ij} with y_{ij} realizations $i, j = 0, \ldots, n$ is the incremental claim that occurred in year i (origin year) and was reported to the insurer after j years (development year). The realizations y_{ij} for $i + j \leq n$ are observed data (upper triangle) while y_{ij} for $i + j > n$ represent the future unobserved data (lower triangle). The Fig. 1 provides observed upper triangle.

The goal in loss reserving is to predict the random variable R being the total loss reserve defined as the sum of unknown future incremental claims

$$R = \sum_{i,j;i+j>n} Y_{ij} \tag{1}$$

assuming that $Y_{00}, \ldots, Y_{nn}$ are independent. The specific form of the predictor of total loss reserve $\widehat{R} = \sum_{i,j;i+j>n} \widehat{Y}_{ij}$ depends on the model used to obtain $\widehat{Y}_{ij}$, $i + j > n$.

This paper investigates the HGLM, cf. (Lee and Nelder 1996), in which it is assumed classically that random variable $Y_{ij}|u_i$ follows over-dispersed Poisson

Fig. 1 The incremental loss triangle

i	0	…	*n-1*	*n*
0	y_{00}	…	y_{0n-1}	y_{10n}
1	y_{10}	…	y_{1n-1}	
⋮		⋰		
n	y_{n0}			

(ODP) with the mean μ_{ij} and unknown dispersion parameter ϕ, cf. e.g. (Gigante et al. 2013a, b). The conditional expected value is of the form

$$E\left[Y_{ij}|u_i\right] = \exp\left(\mathbf{x}'_{ij}\boldsymbol{\beta} + \mathbf{z}'_{ij}\log(\mathbf{u})\right) \tag{2}$$

where $\boldsymbol{\beta} = (c, \beta_0, \ldots, \beta_n)'$ are fixed effects and $\mathbf{u} = (u_0, \ldots, u_n)'$ are independent realizations of random variable $\mathbf{U}$ following Tweedie distribution with unknown dispersion parameter ϕ_u, $\mathbf{x}'_{ij}$ is the row of the design matrix $\mathbf{X}$ and $\mathbf{z}'_{ij}$—the row of the dummy matrix $\mathbf{Z}$. In the model Eq. (2) the origin years are treated as random effects u_i and development years as fixed effects β_j. This representation implies the same development pattern for all accident years, where that pattern is described by parameters $(c, \beta_1, \ldots, \beta_n)$ (see Fig. 2).

The estimation of fixed and random effects in the HGLM is carried out using the hierarchical likelihood. The idea is to treat the vector of random effects $\mathbf{u} = (u_0, \ldots, u_n)'$ as the vector of fixed effects and transform the HGLM into an augmented GLM. Details concerning the h-likelihood estimation are presented in two fundamental works (Lee and Nelder 1996, 2001). The numerical example coming after uses the **R** implementation of the algorithm taken from the {hglm} package. After estimators $\widehat{\boldsymbol{\beta}}$ and $\widehat{\mathbf{u}}$ are found, the predictor of total loss reserve is of the form:

$$\widehat{R} = \sum_{\mathrm{i,j;i+j>n}} \exp\left(\mathbf{x}'_{ij}\widehat{\boldsymbol{\beta}} + \mathbf{z}'_{ij}\log(\widehat{\mathbf{u}})\right) \tag{3}$$

A similar mixed model-based approach is described in (Antonio 2006), but only for a lognormal distribution. The authors adopted the generalized linear mixed model (GLMM) and the REML as the method of estimation of the model parameters.

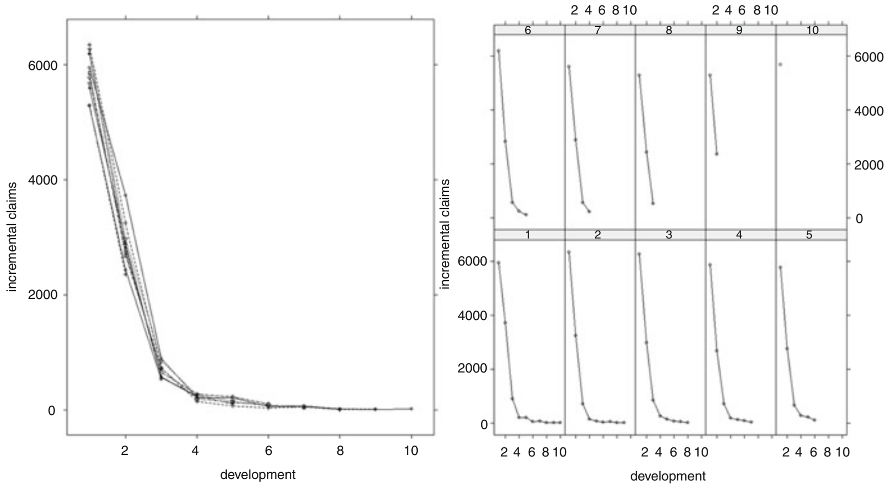

Fig. 2 Loss development pattern in the triangle

3 The Bootstrap MSEP

In order to assess the uncertainty of predictor $\widehat{R}$, usually the commonly used the root MSEP

$$\mathrm{RMSEP}\left(\widehat{R}\right) = \sqrt{E\left[\left(\widehat{R} - R\right)^2\right.} \tag{4}$$

is adopted. In (Gigante et al. 2013a) the analytic formula of this error is derived. The computation in practice is a complicated process. The alternative proposed here is the bootstrap procedure to estimate RMSEP($\widehat{R}$). This paper studies two ways of bootstrap. The first one is the parametric bootstrap in which one simulates from fitted values of the HGLM. The whole procedure starts with the estimation of parameters of the HGLM Eq. (2) based on the data from upper triangle obtaining $\left(\widehat{\boldsymbol{\beta}}, \widehat{\mathbf{u}}, \widehat{\phi}, \widehat{\phi}_u\right)'$. Next following steps are repeated *b=1,...,500* times:

1. generate independently random effects $\widehat{\mathbf{u}}^{\mathbf{b}} = \left(\widehat{u}_0^b, \ldots, \widehat{u}_n^b\right)'$ from Tweedie distribution with parameters $\left(\widehat{\mathbf{u}}, \widehat{\phi}_u\right)'$ and next direct estimators $\widehat{y}_{ij}^b$ for upper triangle and predictors $\widetilde{y}_{ij}^b$ lower triangle from Tweedie distribution with parameters $\left(\widehat{\boldsymbol{\beta}}, \widehat{\mathbf{u}}^{\mathrm{b}}, \widehat{\phi}\right)'$
2. estimate parameters of the HGLM Eq. (2) obtaining $\left(\widehat{\boldsymbol{\beta}}^{\mathrm{b}}, \widehat{\mathbf{u}}^{\mathrm{b}}\right)'$ based on $\widehat{y}_{ij}^b$ from upper triangle

3. calculate predictors $\widetilde{\widetilde{y}}_{ij}^{b}$ for lower triangle under the HGLM Eq. (2) plugging $\left(\widehat{\boldsymbol{\beta}}^{\mathrm{b}}, \widehat{\mathbf{u}}^{\mathrm{b}}\right)'$

   Finally the formula

$$\mathrm{RMSEP}\left(\widehat{R}\right) = \sqrt{\frac{1}{500}\left(\sum_{i,j;i+j>n} \widetilde{\widetilde{y}}_{ij}^{b} - \sum_{i,j;i+j>n} \widetilde{y}_{ij}^{b}\right)^2} \tag{5}$$

gives the parametric bootstrap estimator of RMSEP($\widehat{R}$).

This approach is sensitive to incorrect fit of the HGLM. Therefore the alternative is the simulation by resampling residuals and adding them back to the fitted values. In this procedure *b*th step is as follows:

1. resample r_{ij}^{b} with replacement from Pearson residuals $r_{ij} = \frac{y_{ij}-\widehat{y}_{ij}}{\sqrt{\widehat{y}_{ij}}}$ based on y_{ij} and estimated values $\widehat{y}_{ij}$ from upper triangle
2. calculate new values $y_{ij}^{b} = r_{ij}^{b}\sqrt{\widehat{y}_{ij}} + \widehat{y}_{ij}$ for upper triangle
3. estimate parameters of the HGLM Eq. (2) obtaining $\left(\widehat{\boldsymbol{\beta}}^{\mathrm{b}}, \widehat{\mathbf{u}}^{\mathrm{b}}, \widehat{\phi}^{b}\right)'$ based on y_{ij}^{b}
4. calculate predictors $\widetilde{y}_{ij}^{b}$ for lower triangle under the HGLM Eq. (2) plugging $\left(\widehat{\boldsymbol{\beta}}^{\mathrm{b}}, \widehat{\mathbf{u}}^{\mathrm{b}}\right)'$
5. generate independently random effects $\widehat{\mathbf{u}}^{\mathrm{b}} = \left(\widehat{u}_0^{b}, \ldots, \widehat{u}_n^{b}\right)'$ from Tweedie distribution with parameters $\left(\widehat{\mathbf{u}}^{\mathrm{b}}, \widehat{\phi}_u^{b}\right)'$ and next predictors $\widetilde{\widetilde{y}}_{ij}^{b}$ for lower triangle from Tweedie distribution with parameters $\left(\widehat{\boldsymbol{\beta}}^{\mathrm{b}}, \widehat{\mathbf{u}}^{\mathrm{b}}, \widehat{\phi}^{b}\right)'$

   Again the formula Eq. (5) gives the residual bootstrap estimator of RMSEP($\widehat{R}$).

4 Numerical Example

The subject of this analysis is the single loss triangle taken from (Wüthrich and Merz 2008). The Fig. 2 provides two plots of incremental claims separately for origin years $i = 0, \ldots, 8$. The left panel shows clearly the same development pattern for all origin years.

To demonstrate how the HGLM Eq. (2) operates in total loss reserve prediction, it is assumed that incremental claims conditionally follow Tweedie distribution $Y_{ij}|u_i \sim T(\mu_{ij}, \phi)$with the power $p = 1$ and random effects $u_0, \ldots, u_n$ follow Tweedie distribution with dispersion ϕ_u and the power $p = 2$. This model is equivalent to the ODP-Gamma HGLM. The vector of parameters $(\boldsymbol{\beta}, \mathbf{u}, \phi, \phi_u)'$ is estimated using the

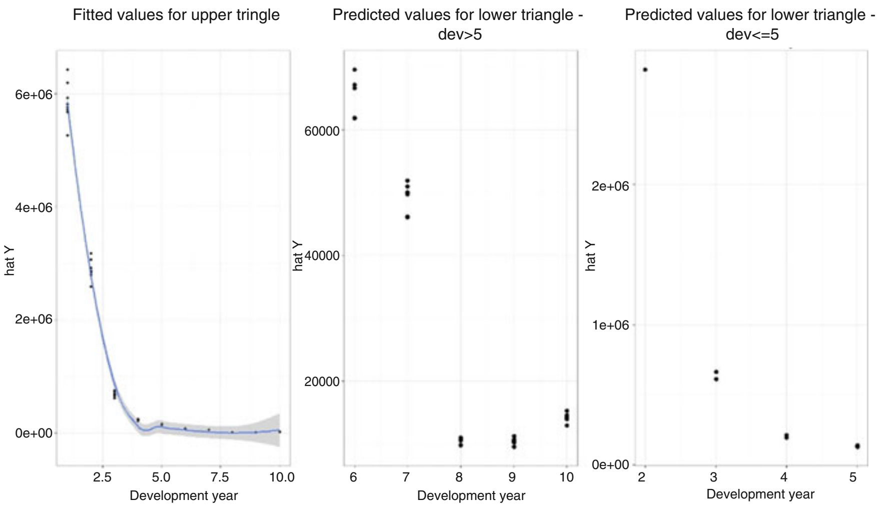

Fig. 3 Fitted and predicted values in the triangle

Table 1 Predicted loss reserves and bootstrap errors of prediction

Origin year	R	RMSEP resid	RMSEP param	% resid	% param
2	15,239.48	13,314.36	20,813.03	87.37	136.57
3	26,414.56	16,033.21	25,811.47	60.70	97.72
4	35,263.68	17,515.95	28,588.66	49.67	81.07
5	86,572.04	30,430.78	43,425.91	35.15	50.16
6	157,839.94	45,023.74	55,484.42	28.52	35.15
7	290,990.60	56,037.45	72,517.40	19.26	24.92
8	465,024.23	77,927.11	96,106.84	16.76	20.67
9	1,078,769.03	135,963.62	144,054.66	12.60	13.35
10	3,988,970.95	376,203.23	322,482.57	9.43	8.08
Total reserve	6,145,084	407,976	425,360	6.64	6.92

h-likelihood function, cf. (Lee and Nelder 1996). The **R** package {hglm} is used, cf. (R Core Team 2012; Ronnegard et al. 2010). Plugging received estimates $\left(\widehat{\boldsymbol{\beta}}, \widehat{\mathbf{u}}, \widehat{\phi}, \widehat{\phi}_u\right)'$ into the formula Eq. (3), the predictor of total loss reserve is obtained. The Fig. 3 shows, from the left side to the right side, fitted values $\widehat{Y}_{ij}$ for the upper triangle and predicted values $\widehat{Y}_{ij}$ for the lower triangle.

In order to find the estimate of the RMSEP($\widehat{R}$), parametric and residual bootstrap procedures were implemented. The number of simulations was $n = 500$. Table 1 presents the estimated RMSEPs given by Eq. (4), with the approximations using residual and parametric bootstrap. It shows the usual pattern: considerable uncertainty in the reserve estimates in the earlier origin years and then the relative prediction errors decrease. The RMSEP for the whole reserve as a percentage of the claims reserve is 6.64% for residual bootstrap. It is 6.92% for the parametric bootstrap what is slightly higher.

Comparing two bootstrap errors in single origin year the differences are much higher against parametric bootstrap. The reason is probably lower goodness of HGLM fit.

5 Conclusions

GLMs are popular statistical techniques in loss reserving. However, the independence assumption needed in GLMs is generally violated in many cases. There is a basic advantage of the mixed HGLM application. By imposing certain constraints on random effects, it is possible to take account of external information which does not come from the sample directly and which has an impact on the total loss reserve value. The downside, however, is the complex form of the error prediction. Therefore, it is proposed herein that the error should be determined by means of the bootstrap technique. Although this solution is not perfect, its important advantage is that full information on the absolute error distribution can be obtained easily using quantiles. It is well known that the parametric bootstrap works best when the model is correctly fitted and the uncertainty regards only the exact parameter values. Therefore in loss reserving safer residual bootstrap is rather recommended.

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Mixture Cure Models in Prediction of Time to Default: Comparison with Logit and Cox Models

Ewa Wycinka and Tomasz Jurkiewicz

Abstract Mixture cure models are an extension of the standard survival models used for predicting survivors in the case of two distinct subpopulations [Sy and Taylor (Biometrics 56: 227–236, 2000)]. The models assume that the studied population is a mixture of susceptible individuals, who may experience the event of interest, and non-susceptible individuals, who will never experience it [Corbière and Joly (Comput Methods Prog Biomed 85(2): 173–180, 2007)]. Mixture cure models were used for the first time in medical statistics to model long-term survival of cancer patients. Tong et al. (Eur J Oper Res 218(1): 132–139, 2012) introduced mixture cure models to the area of credit scoring, where a large proportion of the accounts do not experience default during the loan term. In this paper, we investigate the use of a mixture cure model for a sample of 5000 consumer credit accounts from a 60-month personal loans portfolio of a Polish financial institution. All loans have been observed for 24 months. Default is the event of interest, whereas earlier repayment is considered to be censoring. We develop and compare default prediction models using the logistic regression, Cox model and mixture cure approaches. Similarities with and differences to the study results obtained by Tong et al. (Eur J Oper Res 218(1): 132–139, 2012) are scrutinised. The final discussion focuses on the usefulness of mixture cure models in predicting the probability of default, and the limitations of these models.

1 Introduction

Nowadays, one of the most important tasks for banks and financial institutions is to assess the risk of default. Under regulations introduced by the Basel II Accord, banks are allowed to use the estimates from their own internal risk rating systems in the formula which determines the minimum capital they have to set aside to cover the credit risk in their lending (see: Thomas 2010). Crook et al. (2007) argues that the effect of the Basel II Accord on the competitive advantage of financial

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_21

institutions is so significant that researching the adequacy, applicability and validity of the adopted models seems to be a crucial scientific challenge. The Accord also concentrates on the long-run probability of default which opens the doors to the risk assessment methods that incorporate the evaluation of the distribution of probability in time. The attention given by financial institutions to credit risk prediction and assessment has grown significantly since the last worldwide financial crisis.

The risk assessment tools used to manage a borrower's account during its life and possible write-off include: statistical models (discriminant analysis, linear and logistics regression, multivariate adaptive regression splines, classification and regression trees, non-parametric smoothing, survival analysis); operational research models (linear programming, quadratic programming, integer programming, multiple criteria programming, dynamic programming); and data mining methods (Marques et al. 2013). None of these methods has been proven to be particularly superior to the others. This paper analyses some of the statistical models in order to contribute to this topic.

Many authors have recently studied and compared the performance of logit and survival models in the management of risk in retail credits. One of the advantages of survival analysis is its ability to model the probability of default over time. Survival models were introduced to credit scoring by Narain (1992). Many studies have proven the slight prevalence of Cox models over logit models (Banasik et al. 1999; Stepanova and Thomas 2002; Andreeva 2006). Another feature of survival analysis is the ability to deal with censored observations. Such observations arise when follow-up is shorter than time to event of default. Termination of the loan term, due to the early repayment of credit, causes the end of follow-up and, as a result, is the source of censored observations.

In the Cox model, one assumes that each unit will eventually experience the event. In credit risk, this is an elusive assumption as most of the accounts do not default till the end of the loan term. The solution to this problem can be mixture cure models which assume that the population of study is not homogeneous and consists of two subpopulations:

1. A subpopulation with units that are not susceptible to the event (they will never experience the event)—long survivors.
2. A subpopulation with units that are susceptible to the event (they experience the event during follow-up or they will experience the event in time).

The presence of long survivors in the dataset results in heavy censoring at the end of the follow-up period. Censored observations can represent each of the two subpopulations. The model incorporates two components:

1. An incidence model for predicting which individuals are susceptible (logit model).
2. A latency model for predicting the survival times of individuals, conditional upon their being susceptible (Cox model).

The expectation maximisation algorithm (EM algorithm) is used to find maximum likelihood estimates of the parameters for combined likelihood functions.

Mixture cure models allow distinctions to be made between those covariates that affect whether an account is susceptible to default and those that may affect the timing of default (Tong et al. 2012).

Mixture cure models were used for the first time in medical statistics to model long-term survival of cancer patients. Tong et al. (2012) proposed an application of mixture cure models for credit risk assessment. In this paper we analyse the features of the mixture cure model, as well as the logit and Cox models that are applied for prediction of default in Polish consumer loans. We find a lack of prevalence of the mixture cure model over the logit and Cox models in the specific structure of analysed data, especially in the presence of early censoring due to early repayments and the presence of tied observations.

2 The Formula of Mixture Cure Models

Let Y be the binary random variable such that $Y = 1$ for an individual that will eventually experience the event, and $Y = 0$ for one that will never experience the event, with the probability $p = P(Y = 1)$. Let T denote the time to the occurrence of the event, defined only when Y = 1, with density function $f(t|Y = 1)$ and survival function $S(t|Y = 1)$.

Let δ be the censoring indicator, where $\delta = 1$ indicates the non-censored unit and $\delta = 0$ the censored one. If $\delta = 1$, then $Y = 1$ and if $\delta = 0$, Y is not observed. Note that Y could equal either one (if the unit is susceptible and would eventually experience the event) or zero (if the unit is non-susceptible and will never experience the event) (Sy and Taylor 2000).

The survival function of T is given by:

$$S(t|x, z) = (1 - p(z)) + p(z)S(t|Y = 1, x) \tag{1}$$

The proportion of susceptible units $p(z) = P(Y = 1|z)$ can be modelled by logit model:

$$\ln\left(\frac{p(z)}{1 - p(z)}\right) = z^T\beta \tag{2}$$

where β is the vector of regression parameters and z is a vector of covariates.

Conditional distribution of T can be evaluated by Cox model:

$$S(t|Y = 1, x) = S_0(t|Y = 1)^{\exp(x^T b)}, \tag{3}$$

where $S_0(t|Y = 1)$ is the conditional baseline survival function, x is a vector of covariates and b is the vector of regression parameters. Vectors x and z of covariates may or may not comprise the same covariates.

Denote the data for individual i by $(t_i, \delta_i, x_i, z_i, y_i)$, $i = 1, \ldots, n$, which include observed data and unobserved $y_i{}'s$.

Taking into account the relation $h(\cdot) \cdot S(\cdot) = f(\cdot)$, the complete likelihood function can be written as:

$$L = \prod_{i=1}^{n} [1 - p(z_i)]^{1-y_i} p(z_i)^{y_i} h(t_i|Y = 1, x_i)^{\delta_i y_i} S(t_i|\, Y = 1, x_i)^{y_i} \tag{4}$$

The logarithm of the likelihood function is the sum of two components:

$$lnL = L^I + L^{II} \tag{5}$$

$$L^I = \sum_{i=1}^{n} y_i \ln [p(z_i)] + (1 - y_i) \ln [1 - p(z_i)] \tag{6}$$

$$L^{II} = \sum_{i=1}^{n} y_i \delta_i \ln [h(t_i|Y = 1, x_i)] + y_i \ln [S(t_i|\, Y = 1, x_i)] \tag{7}$$

Estimators of parameters $(\beta, b, S_0(t))$ are evaluated in iterative maximisation algorithm (EM algorithm).

The E-step computes the conditional expectation of the complete log-likelihood given by Eqs. (4) or (6) and (7) with respect to $y_i{}'s$ given the observed data and current estimates of parameters $(\beta, b, S_0(t))$. Formulas (6) and (7) are linear functions of Y.

The conditional expectation of Y *is*:

$$E(Y|b, \beta, S_0(t)) = \begin{cases} 1 & if \quad \delta_i = 1 \\ \dfrac{p(z_i)S(t_i|\, Y = 1, x_i)}{1 - p(z_i) + p(z_i)S(t_i|\, Y = 1, x_i)} & if \quad \delta_i = 0 \end{cases} \tag{8}$$

For $\delta = 0$, the expectation value is equal to the proportion of susceptible units.

Because $\delta_i lnE(Y|b, \beta, S_0(t)) = 0$ and $\delta_i E(Y|b, \beta, S_0(t)) = \delta_i$, the expectations of Eqs. (6) and (7) can be written as (Cai 2013):

$$E\left(L^I\right) = \sum_{i=1}^{n} E(y_i|\cdot) \ln [p(z_i)] + (1 - E(y_i|\cdot)) \ln [1 - p(z_i)] \tag{9}$$

$$E\left(L^{II}\right) = \sum_{i=1}^{n} \delta_i \ln \left[E(y_i|\cdot) h\left(t_i|Y = 1, x_i\right)\right] + E(y_i|\cdot) \ln [S(t_i|\, Y = 1, x_i)] \tag{10}$$

The M-step of the EM algorithm consists of maximising Eqs. (9) and (10) with respect to $(\beta, b, S_0(t))$. Maximum likelihood estimates of the failure time distribution of units that experienced the event can be obtained separately because Eq. (9)

depends only on β, and Eq. (10) depends only on the failure time distribution of units that experienced the event (Peng and Dear 2000). Equation (9) can be maximised by the Newton-Raphson optimisation method. Equation (10) can be written as

$$\ln \prod_{i=1}^{n} [h_0(t_i)\exp(bx_i + lnE(y_i|\cdot))]^{\delta_i} S_0(t_i)^{\exp(bx_i + lnE(y_i|\cdot))} \tag{11}$$

which is the log-likelihood function of the standard Cox model with the additional offset variable $\ln(E(y_i|\cdot)$ (Cai 2013). To maximise Eq. (10), Peng and Dear (2000) proposed a partial likelihood type method to estimate b without specifying the baseline hazard function. The sample data can contain tied event times[1] but the partial likelihood for the Cox model is developed under the assumption of continuous data. Four variants of the computing algorithm are commonly used to address this problem: Breslow approximation, Efron approximation, exact partial likelihood and averaged likelihood. If there are no ties, the four approaches are fully equivalent (Thernau and Grambsch 2000). To check if the chosen methods influence the results of estimation in the empirical analysis, we decided to consider two of them: the Breslow approximation and exact partial likelihood. The Breslow approximation is the simplest formula and the easiest for programming. However, this method is the least appropriate in the presence of ties. The exact partial likelihood approach is equivalent to that for matched logistic regression. It is technically appropriate when the timescale is discrete and has only a few unique values. The calculation of the exact partial likelihood is numerically intense.

Thereafter, in the E-step, Eq. (8) is updated with the evaluated values of b and β. However, to complete this step, an evaluation of $S_0(t|1)$ is required.

The E and M steps are repeated by replacing estimated parameters and iterating until the convergence on parameters $(\beta, b, S_0(t))$ (Tong et al. 2012). The standard errors of estimated parameters are not directly available due to the complexity of the used algorithm. Random bootstrap samples can be employed to obtain the approximations of the standard errors.

When $t \to \infty$ then $S(t|Y=1, x) \to 0$ and consequently $S(t|Y=1, x, z) \to 1 - p(z)$. Therefore, the mixture cure model is reduced to the logit model. Where there is non-susceptible fraction or the fraction is rare $1 - p(z) \to 0$ then the mixture cure model converges to the Cox PH model.

The logit model is one of the models used for the dichotomous dependent variable (Hosmer and Lemeshow 2000). Parameters of the logit model can be interpreted in terms of the odds ratio. The odds of the outcome being present among individuals with $z=1$ are defined as $p(1)/(1-p(1))$. The odds ratio (OR) is defined as the ratio of the odds for $z=1$ to the odds for $z=0$ (Hosmer and Lemeshow 2000).

[1]Ties—in survival analysis the situation when two or more individuals with $\delta = 1$ have the same observed lifetime (Lawless 2003, p.343).

The Cox model is one of the most popular regression models for estimating the distribution of time to event. It is a robust model in the sense that the results from using the Cox model will closely approximate the results for the correct parametric model. The Cox model is preferred over the logistic model when survival time information is available and censoring appears: that is, the Cox model uses more information (the survival times), than the logistic model which considers a (0, 1) outcome and ignores survival times and censoring. Parameters of the model can be interpreted in terms of hazard ratios. Hazard ratio: $HR = \exp(b)$ is defined as the hazard for one individual divided by the hazard for a different individual and indicates that the hazard for unit with the x covariate ($x = 1$) is $\exp(b)$ times the hazard for the unit without x covariate ($x = 0$) (Kleinbaum and Klein 2012).

3 Data

In this paper, we apply a mixture cure model to the analysis of time to default on a sample of 5000 consumer credit accounts from a 60-month retail loans portfolio of one of the Polish financial institutions. All loans have been observed for 24 months since loan origination. Default is defined as the first 90 days overdue. Defaults can occur from the third month until the end of the loan term. However, market research shows that after a certain time lapse the number of new defaults dramatically decreases. Biuro Informacji Kredytowej (BIK), in their report (2012), point out that for Polish retail credits, the final level of defaults is revealed after about 30 months from loan origination. When observing loans for 24 months, we can assume that most of the loans susceptible to default will have been revealed by this time, whilst credits that are still active will be long survivors. A scheme of payment can be aborted by early repayment of credit. In our dataset, there are 2274 creditors (45.5%) who repaid all 24 installments (or had a delay in payment that was shorter than 90 days), 297 creditors (5.9%) who defaulted during the first 24 months and 2429 creditors (48.58%) who repaid the credit.

In the analysis, default is the event of interest whereas earlier repayment is considered to be censoring. The dataset contains typical application characteristics such as: amount of credit, amount of the installments, the purpose of the loan, age of the applicant, property and educational level. Wycinka (2015) used this dataset and its characteristics in an earlier study and on the basis of the results obtained, we chose 19 dummy variables representing 12 covariates. In both studies, names of the covariates have been anonymised at the requirement of the financial institution making the data available. Variables are denoted by the letter X and numbers. The same labels have been used in both studies. Numbers preceded by an underscore denote the number of the variable's attributes. In all of the estimated models, the variable selection is performed using backward elimination selection (Hosmer et al. 2008). All the calculations are made with R (packages: Survival, smcure, HMeasure).

Table 1 Parameter estimates in the mixture cure models

<table>
<tr><th rowspan="2">Components</th><th colspan="8">Models</th></tr>
<tr><th colspan="4">Mixture cure model (Breslow formula)</th><th colspan="4">Mixture cure model (Exact formula)</th></tr>
<tr><td rowspan="2">Incidence (logit model)</td><td rowspan="2">OR</td><td colspan="2">95% CI</td><td rowspan="2">p-Value</td><td rowspan="2">OR</td><td colspan="2">95% CI</td><td rowspan="2">p-Value</td></tr>
<tr><td>Lower</td><td>Upper</td><td>Lower</td><td>Upper</td></tr>
<tr><td>Intercept</td><td>0.30</td><td>0.15</td><td>0.55</td><td>0.0004</td><td>0.16</td><td>0.11</td><td>0.24</td><td>0.0000</td></tr>
<tr><td>X12</td><td>1.58</td><td>1.16</td><td>2.05</td><td>0.0013</td><td>1.57</td><td>1.20</td><td>2.06</td><td>0.0010</td></tr>
<tr><td>X13</td><td>1.76</td><td>1.37</td><td>2.30</td><td>0.0000</td><td>1.81</td><td>1.43</td><td>2.37</td><td>0.0000</td></tr>
<tr><td>X1_3</td><td>0.43</td><td>0.22</td><td>0.87</td><td>0.0169</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>X2_2</td><td>0.52</td><td>0.29</td><td>1.03</td><td>0.0453</td><td>–</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>X4_2</td><td>2.65</td><td>1.83</td><td>3.88</td><td>0.0000</td><td>2.65</td><td>1.89</td><td>3.86</td><td>0.0000</td></tr>
<tr><td>X4_6</td><td>0.37</td><td>0.28</td><td>0.50</td><td>0.0000</td><td>0.38</td><td>0.29</td><td>0.49</td><td>0.0000</td></tr>
<tr><td>X5_3</td><td>0.67</td><td>0.50</td><td>0.90</td><td>0.0072</td><td>0.66</td><td>0.51</td><td>0.89</td><td>0.0034</td></tr>
<tr><td>X6_2</td><td>2.17</td><td>1.55</td><td>3.08</td><td>0.0000</td><td>2.18</td><td>1.56</td><td>3.07</td><td>0.0000</td></tr>
<tr><td>X6_3</td><td>1.54</td><td>1.09</td><td>2.08</td><td>0.0064</td><td>1.59</td><td>1.19</td><td>2.08</td><td>0.0013</td></tr>
<tr><td>X10_2</td><td>0.58</td><td>0.42</td><td>0.86</td><td>0.0034</td><td>0.53</td><td>0.38</td><td>0.74</td><td>0.0003</td></tr>
<tr><td>X10_3</td><td>0.51</td><td>0.34</td><td>0.74</td><td>0.0007</td><td>0.45</td><td>0.32</td><td>0.65</td><td>0.0000</td></tr>
<tr><td rowspan="2">Latency (Cox model)</td><td rowspan="2">HR</td><td colspan="2">95% CI</td><td rowspan="2">p-Value</td><td rowspan="2">HR</td><td colspan="2">95% CI</td><td rowspan="2">p-Value</td></tr>
<tr><td>Lower</td><td>Upper</td><td>Lower</td><td>Upper</td></tr>
<tr><td>X9</td><td>0.60</td><td>0.44</td><td>0.80</td><td>0.0010</td><td>0.60</td><td>0.44</td><td>0.80</td><td>0.0008</td></tr>
<tr><td>X5_3</td><td>0.78</td><td>0.61</td><td>0.98</td><td>0.0398</td><td>0.77</td><td>0.61</td><td>0.97</td><td>0.0310</td></tr>
<tr><td colspan="5">H = 0.197; AUC = 0.746</td><td colspan="4">H = 0.193; AUC = 0.736</td></tr>
</table>

'–' denotes variables not included in the model

4 Results

The mixture cure, Cox PH and logit models are evaluated. The mixture cure and Cox model are estimated twice: firstly, using the Breslow algorithm, and secondly using the exact formula. Parameter estimates for all of the models are presented in Tables 1, 2 and 3.

In the mixture cure model the incidence component is much more complex than the latency component (Table 1). Most of the covariates used are able to predict the account default and only two of these are used in the prediction of time to default. One of the variables (*X*5_3) is applied in both components of the model.

Sy and Taylor (2000) note that the relative importance of two components of the mixture cure model may differ between applications. Usually the incidence part of the model is most important and, as a result, a minimal number or even no covariates in the latency part is acceptable. Our results are consistent with these remarks. Sy and Taylor (2000) emphasise also that although the variables incorporated in two components of the mixture model have two parameters, one describing how the covariate affects long-term incidence and one describing how it affects latency, this still leads to the possibility of over-parameterisation (Sy and Taylor

Table 2 Parameter estimates in the Cox models

	Model							
	Cox model (Breslow formula)				Cox model (Exact formula)			
		95% CI[a]				95% CI[a]		
Covariates	HR	Lower	Upper	p-Value	HR	Lower	Upper	p-Value
X9	0.65	0.47	0.91	0.0066	0.64	0.47	0.90	0.0065
X12	1.51	1.17	1.92	0.0015	1.52	1.18	1.94	0.0014
X13	1.60	1.27	2.05	0.0001	1.61	1.27	2.06	0.0001
X2_2	0.54	0.34	0.97	0.0172	0.54	0.34	0.98	0.0168
X2_3	0.46	0.27	0.87	0.0089	0.46	0.26	0.86	0.0086
X4_2	2.28	1.66	3.08	0.0000	2.30	1.69	3.11	0.0000
X4_6	0.40	0.31	0.52	0.0000	0.40	0.30	0.51	0.0000
X5_3	0.64	0.50	0.83	0.0007	0.64	0.49	0.83	0.0007
X6_2	1.97	1.43	2.68	0.0000	1.98	1.44	2.72	0.0000
X6_3	1.41	1.05	1.87	0.0180	1.41	1.04	1.89	0.0178
X10_2	0.63	0.47	0.87	0.0035	0.63	0.46	0.87	0.0034
X10_3	0.55	0.39	0.78	0.0008	0.55	0.39	0.77	0.0008
H = 0.201; AUC = 0.742						H = 0.202; AUC = 0.743		

[a]Confidence intervals calculated as percentiles from 10,000 bootstrapped samples

Table 3 Parameter estimates in the logit model

		95% CI[a]		
Covariates	OR	Lower	Upper	p-Value
Intercept	0.27	0.16	0.44	0.0000
X9	0.56	0.40	0.79	0.0005
X12	1.56	1.19	2.02	0.0013
X13	1.75	1.36	2.26	0.0000
X14	1.64	1.03	2.44	0.0187
X4_2	2.21	1.58	3.09	0.0000
X4_6	0.39	0.29	0.51	0.0000
X5_2	0.57	0.38	0.83	0.0042
X5_3	0.46	0.33	0.64	0.0000
X6_2	1.68	1.21	2.31	0.0013
X10_2	0.58	0.42	0.81	0.0007
X10_3	0.50	0.35	0.71	0.0001
H = 0.206; AUC = 0.746				

[a]Confidence intervals calculated as percentiles from 10,000 bootstrapped samples

2000). Only one variable chosen by both parts of the model seems to minimise this risk.

Breslow's and the exact formulas give comparable evaluations. However, the exact formula proves to be more rigorous in the data selection process. In the final model in the incidence component of the exact formula, there are two variables fewer than in the model using the Breslow formula. We also observe the differences in the sequence of variable selection between the two formulas.

Sy and Taylor (2000) point out that the standard Cox model is a special case of the cure model, with an infinitely large intercept in the logistic part. For our data, the estimate intercept is $\ln(0, 30) = -1.201$, $p = 0.0004$ for the Breslow formula, and $\ln(0, 16) = -1.805$, $p < 0.0001$ for the exact formula. These are not infinitely large numbers; however, they are statistically significant, which can advocate the use of the standard Cox model instead of the mixture cure model.

The Cox models were evaluated twice: first by using the Breslow formula and then by using the exact formulas. Both models consisted of the same set of covariates and almost identical parameter estimates. The differences in using the Breslow and exact formulas were much lower than those observed in the mixture cure models. Both formulas led to the selection of the same set of covariates and comparable estimates of parameters and standard errors (Table 2). There were no differences in the variable selection process. The Cox models comprise both covariates used in the latency component of the mixture cure models and most of the covariates from the incidence part (Table 2). Additionally, they contain two covariates not included in the mixture cure models (X9, X2_3).

The logit model consists of 11 covariates (Table 3). Three of these were not used by mixture cure model in the incidence component. One should note that the dependent variable in the logit model is binary. In our study, the occurrence of default was the first attribute of the dependent variable, whereas all other loans were the second attribute. Therefore, long survivals and early repayments were both considered to be non-defaults. This assumption is different to the one for the mixture cure model, where for the censored observations the probabilities of default have been calculated.

Annesi et al. (1989) emphasise that notwithstanding the fact that the Cox model is superior to the logistic model in analysing longitudinal data, when the follow-up period is sufficiently short or the survival rate is high, the choice of the model is not so obvious and must depend on expertise and convenience. In our dataset, we analysed 24 time points to sufficiently support long-run time. The specificity of risk credit is that after applying the scoring process, one observes a very small share of defaults in the credit portfolio. As a result, we deal with high survival rates.

To sum up, each of the applied regression formulas (mixture cure model, logit model, Cox model) allowed us to identify the covariates influencing the risk of default.

5 Conclusions and Further Research

Sy and Taylor (2000) underline that mixture cure models require: long-term follow-up, large samples, without excessive censoring from loss to follow-up during the period when events can occur. Otherwise, identifiability problems between the incidence and latency parameters can occur. In our study, 24 months of follow-up and 297 complete observations[2] seem to fulfill the two first conditions. However, the presence of a high percentage of early repayments can create a problem due to the risk of disrupting the estimation of parameters in the time to default model. It would be interesting to verify the performance of the mixture cure models in credit portfolios where early repayments are prevented by the agreement's conditions and, as a result, where censoring during the loan term is rare.

The results of our study can be compared with some of the findings of Tong et al. (2012). The datasets have comparable sizes (297 observed defaults in our study and between 274 and 473 defaults in various loan terms in the study by Tong et al. (2012)) and both have been influenced by heavy censoring. The mixture cure model presented by Tong et al. (2012) also had a complex incidence part and a latency part that was reduced to two variables. In both studies the mixture cure, Cox PH and logistic models performed well and were competitive with one another. However, there were insufficient arguments for recommending a more computationally intensive mixture model instead of logit or Cox PH models.

Although we based our analysis on the idea developed in the paper by Tong et al. (2012), we focused on the features of the mixture cure models that were not analysed in their study.

Undoubtedly, the biggest advantage of the mixture cure model is its ability to predict which accounts are not susceptible to default, which overcomes the deficiency of standard survival models. Additionally, the latency part of the model allows the information from censored observations to be used. The ability to influence particular covariates on the risk of default and the time of default is another important benefit of the mixture cure model. As mentioned earlier, this model can be suitable for portfolios with no or rare early repayments and with long loan terms.

In the presence of early repayments, attention should be paid to the problem of censoring during follow-up, and modifications to mixture cure models that allow this to be handled should be studied. One possible solution is to treat defaults and early repayments as competing risks and to use mixture cure models extended to these competing risks. These problems will be analysed in the author's further research.

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[2]In survival analysis, the number of complete observations is crucial and not necessarily the total sample size (Hosmer et al. 2008).

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Part V
Public Finance

A New Business Model in Health Care Between Public and Private: Low Cost High Value Healthcare

Elena Querci and Patrizia Gazzola

Abstract The aim of the paper is analyzing the phenomenon of low cost high value in healthcare, understanding its organizational paradigm, the motivations, the services offered and placement. Over the past years, we have questioned the possibility of creating new models of health care organization, able to respond to the demand for health care with new management tools to develop, implement and spread both the public and private healthcare system. The model focused on public control of health over the years has always been more trouble in responding to the demand for health care in increasingly complex social contexts. There is a need to innovate with new management tools to be disseminated both the public health and the private sector. The ways to contain health care expenditure, normally involve a decrease in the quality of services. Some of the measures are commonly adopted patient co-pay schemes, or practicing de-facto rationing, either by limiting the number of actual treatments provided in combination with long waiting lists, or carrying out consumer health campaigns focused on prevention, all with the aim of limiting the demand for public health services. The low cost high value in health care can be an answer at this stage of welfare change. In the research the case study method is used and it's focused on two low cost high value medical centers: Centro Medico Santagostino and OdontoSalute, located in Northern Italy. The "cross-case analysis" is used to identify the specific features of the low cost high value business model and the contribution to the health system. This study demonstrated that the low cost high value business model in health care system is a solution to the welfare change. The need of more systematic studies in this area is highlighted.

1 Introduction

The Italian National Health System applies the principle of universal coverage. Due to the ongoing financial crisis the state increased the share of health costs for citizens (Ferré et al. 2014). Cost sharing is implemented for diagnostic procedures,

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_22

medications, specialist visits and for the unjustified interventions provided in hospital emergency departments. On top of that, patients pay directly for dental services, over-the-counter drugs, diagnostic services and a majority of specialist visits. People are often encouraged to opt for paid services privately in order to ensure faster access at the cares (Fattore and Ferré 2012). Containing health care expenditure can be done in many ways, however they all involve a decrease in the quality of services. Some of the measures commonly adopted are patient co-pay schemes, or practicing de-facto rationing, either by limiting the number of actual treatments provided in combination with long waiting lists, or carrying out consumer health campaigns focused on prevention, all with the aim of limiting the demand for public health services (Querci 2014a). Resources are limited and the Italian National Health Service is struggling to deal with many problems like inadequate treatments due to insufficient staff and long waiting lists, mainly caused by lack of hospitals, bureaucracy that is inefficient, poor management and general disorganization which all contribute to cost increases. Low Cost High Value companies are new entries in those areas of the competitive system left vacant by the welfare state and they meet the consumer/patient's new needs to safeguard health with out of pocket payment (Kachaner et al. 2010). Low cost health care providers, encouraged by the opening up of new market areas, particularly those in the lightweight care areas, are privileged correspondents of voluntary health care funds, while accredited private providers and the National Health Service itself often find it difficult to conform to the operating systems of company health funds which take into consideration things like on-line appointments, short waiting lists and even pleasant environments.

2 Organization and Research Method

According to Porter and Lee (2013), the value is defined as "health outcomes achieved that matter to patients relative to the cost of achieving those outcomes". In the research an analysis of changing economic and political choices in health care will be highlighted. Following Hibbard et al. (2012) we consider that achieving better health outcomes at lower cost is a major objective of many initiatives in health care. Major efforts are underway to shift provider payment from pay-for-volume towards pay-for-value, to create more transparency about the quality and cost of health care, and to shift to a greater focus on value. Companies that work on health care services have a new real space of action. The specific objective and the ultimate goal of the research is to find a benchmarking, through the study of cases (Hartley 1994), which may act as a guide for companies that want to follow this road or want to improve their corporate policies in view of low cost high value in order to maintain the virtuous cycle of economic growth and health. The adoption of a descriptive research design, fieldwork and qualitative method is the default choice in the structuring of research and considered appropriate to achieving the objectives of the work, to define the business model for Low Cost High Value in health care providers (Selltiz et al. 1976). Case studies are considered the most effective course to come up with answers to "how" and "why" questions when researchers have only limited control over events, but at the same time want to explore con-current trends with the aim of explaining certain phenomena and casual relationships. According with Yin (2003) this is the reason why case studies and real stories are the research strategies that are most suitable to this kind of study suggested applying the logic of "literal e theoretical replication", which is based either on the identification of cases that will give similar results (literal replication) or which will give different results, but for predictable reasons (theoretical replication). The importance of this logic is that it allows for the extension or replication of the emerging theory. In our case we have chosen the "literal replication" analyzing two kinds of companies active in the low cost/high value sector to find their similarities. They are Italian companies working in northern Italy: the Centro Medico Santagostino with the headquarter in Milan, Lombardy and OdontoSalute with the headquarter in Gemona, Friuli—Venezia Giulia. They are companies that have adopted the low cost/high quality philosophy by focusing on improving their organization and creating economies of scale to cut costs, thus making health services available to a wider range of consumers. Both companies adhere to the ethical code (Gazzola and Mella 2015) drawn up by the AssoLowcost and so, while adopting different business strategies, they must follow similar parameters. The study is supported by the Organisation for Economic Co-operation and Development (OECD) data and by the Centro Studi Investimenti Sociali (CENSIS) data.

Many researchers have analyzed the low cost high value in different sectors. Little has been said about the low cost high value in health care system. The main contribution of this line of research is to explain the importance of this new business model that it's between the public and private healthcare system. It can be the answer, at this stage, to welfare change. The study demonstrated the increasing need of more systematic studies in this area.

3 Financing Health Care System: The Cut

European health systems are looking for new models of health care organization, capable of meeting the demand for health care in increasingly complex social contexts, identifying new management tools to develop, implement and spread both in public and in private health sector (Mintzberg 2012; Mintzberg and Azevedo 2012). The traditional model focused on public control has not been able to guarantee levels of efficiency in a sustainable way. The application of the corporatization model solution, tied to a logic by market forces, and intervention private business, it has not been an alternative to guarantee accessible and quality health services. The causes are due to cuts in funding for healthcare (Fattore 2012). In the 3 years 2017–2019, health spending is expected to grow at an average annual rate of 1.5%, but in the same time frame the nominal GDP grows by an average of 2.8%. Then the weight of healthcare will less respect GDP. In detail: in 2016

Table 1 Planned expenditures in Italy 2016–2019

	2016	2017	2018	2019
Health spending (billion)	113.378	114.789	116.170	118.506
% GDP	6.8%	6.7%	6.6%	6.5%
Rate of change in	0.9%	1.2%	1.2%	2.0%

Source: Ministero Economia e Finanza (2016)

spending was expected to reach around 113.3 billion, in 2017 will reach 114.7 billion, in 2018 will reach 116.1 billion and 2019 will reach 118.5 billion. In the same period the incidence of GDP will increase from 6.8% in 2016 to 6.5% in 2019. In document of economics and finance 2016 expenditure planning for the health in Italy is summarized in Table 1.

The citizens no longer depend only on the Public Health System but turn to a wide and diverse range of providers from which to choose. In reality the shift from Public Health to the private sector is mainly due to the world-wide process of privatization, with European governments planning to cede assets for 35 billion euros by 2013 (KPMG 2010). There is an attempt to overcome the economic stagnation by privatizing goods and services which used to be protected by creating new markets and also expanding existing ones, increasing their profitability.

This is particularly true in the realms of local public services and in social health services where their profitability is guaranteed over time due to unvarying demand. The reasons why, in times of crisis, budgets allocated to social services are reduced and the rate of privatizations is increased at the very time when patients turn to the public sector looking for more sustainable costs, are mainly two. Firstly the conviction that implementing different forms of privatization will lead not only to financial savings, but also to increases in quality, efficiency and even to equality of health services. The second reason is that, even while recognizing that these policies are prejudicial to the fundamental right to health care, they are considered unavoidable in times of serious financial crisis (Querci 2014b).

The OECD reports (2015) a general decline in health expenditure and the adoption of containment measures in Italy as a result of the economic crisis. Such containment measures exhort citizens to use the out of pocket private health care. The spending out of pocket in Italy (3.2%) is higher than the OECD average (2.8%) (Aceti and Squillace 2016) (Fig. 1).

Therefore at "less public health, most private health" is added the phenomenon of health denied: "No health without money." It concerns, in particular, 2.4 million elderly and 2.2 million millennial. If in 2012 were 9 million Italians who have had to postpone or give up health services. In 2016 they became 11 million individuals who fail to pay out of pocket the performance (CENSIS 2015).

Who pays out-of-pocket health care often does so for the long waiting lists. It is important to define the difference in meaning between waiting lists and the lapse of time that occurs before a service is provided; the first refers to the number of patients in line while the second refers to the time patients must wait from the

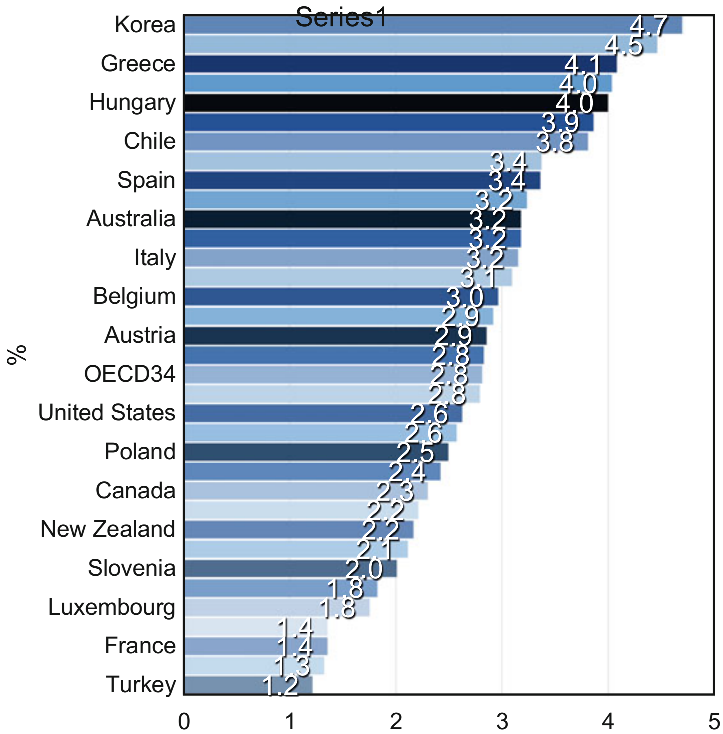

Fig. 1 Out of pocket medical spending as a share of final households consumption, 2013 (or nearest year). Source: OECD (2015)

moment they join the line to the moment when they actually receive treatment (Sanmartin 2003).

Striving to reach a point of balance between waiting lists and waiting time is rather complex since there is no direct benefit to be gained by increasing productivity; while this might lead to shorter waiting time it does not automatically shorten waiting lists which, on the contrary, might lengthen.

This is due to the phenomena known as supply-induced demand where an increase in supply can lead to an increase in demand, generated by the perception that reduced waiting time means better quality. Therefore, it is waiting time that is an indicator of an excess of demand in relation to supply (Boutsioli 2010).

The private opportunity cost increases for as long as the waiting time increases, since it is impossible to carry out normal daily activities like work, housework and free time activities. Equally important is the time involved in obtaining treatment like waiting time, travel time and last, but not least, the anxiety and uncertainty involved in not knowing when treatment will be provided (Rebba 2009).

It is necessary to specify that the waiting time between public, private or the low cost high value healthcare is different. The comparison of the data CENSIS (2015) with the retail prices offered by the Low Cost High Value showed the cost of each

Table 2 Comparing costs between public health, private and low cost high value

Cost in euro (2015)	Public ticket[a]	Intramoenia[a]	Private[a]	Centro medico Santagostino low cost high value[b]	OdontoSalute low cost high value[c]
Specialist visits					
Before cardiological examination with Ecg	41.70	113.50	108.10	80.00	
Gynecological examination	30.70	99.80	103.30	60.00	
Orthopaedic examination	31.70	101.90	103.60	60.00	
First eye examination	42.50	105.10	102.40	60.00	
Diagnostic examinations					
Full abdomen ultrasound	56.30	102.20	110.00	60.00	
Psa prostate specific antigen	13.80	19.30	18.80	13.80	
Laboratory analysis					
Total cholesterol	4.90	7.60	7.30	1.70	
Complete blood count	6.80	11.40	10.00	4.05	
Dental visits					
Simple tooth extraction with anaesthesia	24.90	76.10	88.00		45.00
Two-channel root canal treatment	48.10	182.10	179.00		100.00
Tartar removal	16.40	55.10	88.00		40.00

Source: [a]censis.it, [b]http://www.cmsantagostino.it, [c]http://www.odontosalute.it

day of waiting time for a medical examination. Every single day of waiting spared by purchasing private facilities rather than public ones will cost from 4.2–28 euros, depending on the service. Cost and waiting time have inverse trends in the transition from public to private. In fact the increase of the cost in the private services corresponds to a decrease in waiting time and vice versa. Table 2 shows that a gynaecological examination costs 30.7 euros in the public sector, while 103.3 euros in the private, but with different waiting times. The waiting time is 5.4 days in private and 38.3 days in public sectors, and, compared to a cost of 60 euros, the waiting time of high to low-cost value is 7 days. So the waiting time is the hidden cost that affects the choice of citizens to use the private sector, profit or non profit (CENSIS 2015) (Table 2).

4 Low Cost High Value Health Care

The variety of companies that are involved in the health services system are the accredited private provider, the so-called" private to private" health care provider, among which there are those that adhere to the low-cost philosophy, and the foreign health care provider that caters to the medical tourism industry. There are also providers of many additional kinds of health insurance that can be complementary to, supplementary to, or duplicative of that of the National Health System, (Querci 2014b). Therefore the opening up of the market to a third kind of "lightweight" private health care, positioned between the public and the private sectors, as well as the inclusion in some national trade union agreements of voluntary health care funds, is one of the paths chosen to provide an alternative to national health systems. They have entered the market just at the moment when a new field is opening up and they offer advanced technology, good organization, pleasant accommodation and the ability to fulfil the demands of that new field. Their company mission is to provide low cost quality health care while at the same time meeting the commitment of company health funds to provide the required services to their members, (Carbone et al. 2010). Health care companies in the low cost high value field share goals of long term economic viability, as well as that of total independence from the National Health Service. Out of pocket they choose to pursue different operating models and have different approaches to developing and adapting the low cost formula, while offering services comparable to others available in the same field, as evidenced in Table 3.

The business model that AssoLowcost recommends for its members is based on the following success factors: c*lear and transparent information regarding the prices charged for different services, careful attention to contact and reservation procedures, with several options for remote access to services, concentrate on certain services to achieve those economies of scale necessary to contain costs, adopting quality control standards in order to guarantee high levels of quality, implementing purchasing procedures and underwriting supply contracts with partner companies, information about the kind of work offered by low cost/high value health care companies relies mainly on word of mouth from clients, who pass on to others their positive impressions regarding services rendered.*

Table 3 Services low cost high value comparable to others available in the same field

Professional services	Price	Technical level of service	Ease of access to the service	Level of customer service	Shopping experience
Small professional firms	Medium	Intermediate	Intermediate	Intermediate/ high	Intermediate
Low cost high value	Low	Intermediate/ high	Intermediate/ high	Intermediate	High
Large firms	High	Intermediate/ high	Intermediate	Intermediate/ high	High

Source: AssoLowcost report (2011)

Prices of services are on average 30% lower than the price of private traditional health and sometimes inferior to the public ticket (Cinosi and Rizzo 2013).

5 Case Study

The two cases studied, Centro Medico Sant'Agostino and OdontoSalute, though offering different types of goods and services, shared certain common elements like business strategies, the organization of their supply chains and customer satisfaction and orientation. The two companies are characterized by profit margins based on industrial production; dental prosthesis and specialties for the Centro Medico Sant'Agostino and dental care and prosthesis for OdontoSalute. Table 4 compares their strong points.

Table 4 Commercial strong points of the Centro Medico Santagostino, and the OdontaSalute

	Centro Medico SantAgostino	OdontaSalute
Born	2009	2008 (born like Progetto Dentale Apollonia (in June 2013 changed its name to OdontoSalute)
Their mission	*"Health at the right price"*	*"With us a smile costs less"*
Market share	Meets the growing consumer need for high quality specialized medicine that is economical and accessible.	Services at affordable prices to contrast medical tourism output by offering patients local care at fair prices and import patients from other countries.
Price	Prices are 30–40% below comparable market prices.	Prices are 30–40% below comparable market prices.
Customer satisfaction and orientation	Patients seeking good health care with waiting lists of 1 week or less, in pleasant surroundings to get quality care with minimum stress.	The strategies to contain costs benefit patients who are offered quality services at lower prices than those of the competition, with minimum waiting lists and easy access to care.
Location	8 locations with 108 clinics that offer more than 30 specialties. In the center of Milan, the offices are easy to reach and cater to a vast and diverse socio-economic clientele.	35 locations, in north, center and south Italy, ample parking, near airports, and motorway exits, very diverse socio-economic clientele. Seven clinics are owned by other franchise agreements.
Type of goods and services	Out-patient surgery furnishing careful and individual attention, aimed at supporting patients in every aspect of their care, especially the doctor/patient relationship, with plenty of time for dialogue, free consulting services and transportation, child care areas.	Highly specialized dental clinic with state of the art equipment. Provides medical tourism services for foreigners seeking treatment in Italy.

Source: Author's elaboration, year 2016

Table 5 Revenus Centro Medico Santagostino, and OdontaSalute

	2008	2009	2010	2011	2012	2013	2014	2015
OdontoSalute								
N. locations	1	1	4	6	8	17	20	21
Revenu (000)	2916	6316	11,898	20,643	26,673	31,100	34,487	45,500
Centro Medio Santagostino								
N. locations		1	1	1	3	4	5	8
N. clinics		20	20	21	29	53	68	108
Revenu (000)		632	1486	2698	3453	5153	8200	10,547

Source: Author's elaboration

The cases analyzed (Eisenhard 1989) are all in line with the parameters of the study, in fact they all adhere to the low cost/high value philosophy, all offer, either directly or indirectly, a variety of health services or medical prosthesis, they operate in different geographical areas and they are first movers. They are successful in the competitive market and are financially secure. They are providers for private care insurance policies, associations and company health care plans, or other organizations that could potentially become partners.

In their performance, the two companies share a common organizational model. For management and non-management personnel, paramedics and doctors, the two companies review performance, raise salaries and grant promotions on the basis of merit. Implementing organizational routines in the offices guarantees quality and efficiency and is useful when opening new branches or franchise ventures. Career and economic incentives are offered mainly to professional employees; at the OdontoSalute doctors are granted commissions on a percentage of the prosthetic work they perform, in the Centro Medico Santagostino, upward career mobility is the incentive. The IT systems are suitable and convenient for the type of business involved and, with cost control in mind, they use standard programs modified to suit specific demands. Branches are designed with functional features in mind, so as to provide efficient work environments and services.

If on one hand venues are designed with people in mind, taking into account hospitality and good use of space, on the other hand the layout is functional to containing costs. The OdontoSalute has come up with clinics that make the most of their investments by having 10–17 dentists' chairs that work for 6 days a week, in two shifts.

The two organizations are in a large market and the strategy to seek many customers at a low price versus few at a high price is a winning choice. Despite the period of economic crisis the revenues are constantly growing (Table 5).

6 Conclusions

Large volumes of sales and narrow margins are the philosophy of both companies and suppliers have had to conform to this same policy. Just 1 of the 14 dental clinics of the OdontoSalute group invoices, in 1 month, what a traditional dental clinic invoices in a year, giving it a strong bargaining position with suppliers, which are never very numerous. The two companies examined are first movers in their fields (Lieberman and Montgomery 1988), so their procedures are constantly being up-dated. The learning process isn't only aimed at people who do repetitive jobs more efficiently, but also involves the layout, better programming, changes in methods of production and improvements in production organization to reach an ideal balance of costs versus quality. If, at first, the business choices and organization of the two companies were motivated by the recession and shrinking consumer income, from the research it appears that this consumption trend will last over time, regardless of the economic downturn.

Being able to look beyond the boundaries of the core business and interact with the main economic players (suppliers, partners and customers), co-operating to generate income, is the reason for the success of Low Cost/High Value enterprises. The value of these enterprises has its roots in this strategic ideas: they offer customers/patients an incentive to take advantage of what is being offered, that is a complex variety of goods and services, so that they will be satisfied with their choice, to constantly strive to come up with proposals that involve customers and suppliers, sympathizers and business partners, in an effort to put together new consumer packages which is possible by constantly re-thinking relationships and business choices. Finally it is important to consider a competitive advantage as the sum of the efforts of all the people involved, communicating with customers to repeat winning strategies. Value must be aggressively pursued to ensure a "dynamic overhaul of the enterprise" (Norman and Ramirez 1998). It is particularly evident in health care that low cost/high value enterprises offer a satisfactory choice of quality services at substantially lower prices. In a society where welfare is suffering, and political choices are shifting towards multiple providers in health care, the volume of services and turnover of low cost/high value care, indicates that people consider it the answer to their demand for treatment at fair prices (Del Vecchio and Rappini 2010).

The sustainability of efforts to improve the quality and value of health care is based on a culture of continuous improvement. It is important to work on all the elements of the chain of value in order to increase the volume of sales and lower profit margins by standardizing supplies and strategies and repeating them in other spheres and enterprises. Evaluating tasks and processes to identify better approaches allows companies to reduce waste, improve outcomes, and obtain savings. This requires a management system built on the tenants of respect for all people in the organization, in which leadership behaviour is focused on humility, facilitation, and mentorship.

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The Heterogeneous Diversity of the Real Estate Transfer Tax in the EU

Petra Jánošíková and Radka MacGregor Pelikánová

Abstract The real estate transfer tax is a factor in the economic policy of the EU member states and even the EU as such. Although, both EU and EU member states have been working towards the achievement of economic sustainable growth and financial stability in a harmonized manner, the national direct taxations are in the power of EU member states and have not grown any similar. A critical and comparative Meta-Analysis study of this heterogeneity is illustrative, provides practical information about the real estate transfer tax rates and testifies about the often overlooked inherent particularities and diversities of the EU member states, their laws and fiscal policies. The real estate transfer tax suggest that the EU and its policies and strategies, including Europe 2020, cannot crossed the Rubicon, represented by fiscal particularities generated by different legal, cultural, historical and other traditions and this is correct, except few countries.

1 Introduction

The recent global, and other, crises, including the financial and real estate crises, had a negative impact on all of Europe. The confidence of the single internal market, as well as of national market participants, was lost (Cvik and MacGregor 2016) and many previous well established economic rules of thumb collapsed. The set-in-stone real estate paradigms about price down—demand up ended, i.e. real estate prices went down but so did demand for real estate leading to a huge increase in unfinished and incomplete building projects (Hajnal 2015). The profitability downturn, in a variable extent and intensity, was identified across EU member states, industries and all sizes of businesses (Lacina and Vavřina 2014) and had a negative impact basically on the entire population. Both the EU and EU member states have launched various instruments and even reforms to reverse such a deplorable situation. The issue of taxation of real estate transfers emerged and due to the distribution of competencies, namely the principle of conferral along with principles of subsidiarity and proportionality, the EU did not have, nor

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_23

currently has, the standing to directly harmonize direct taxations, including real estate transfer taxes in EU member states. Nevertheless, the EU tries to be proactive and develop strategies, like Europe 2020, in this direction. Yet despite these endeavors, it seems that the EU member states and their legal, cultural, historical, social, political and other traditions remains heterogeneously diverse re real estate transfer tax. It can even be argued that the differences between EU member states are at least, perhaps even more, as wide as between states belonging to the USA. In addition, the transaction costs for real estate transfers are dramatically different and can go from 1% to 10% of the value and even above and at least part of these cost can be made basically mandatory. Further, equilibrium bargaining framework highlights that taxation and transaction cost affects the ultimate allocation in this search market (Kopczuk and Munroe 2015).

The multidisciplinary research of prima and secondary data along with the case study about the evolution of the Czech real estate transfer tax yields interesting information which can be processed using description, comparison and Meta-analysis. The resulting data is to be commented on and glossed in order to go above and beyond dry static numbers of a quantitative nature to dynamic information of qualitative nature bringing new lights and perspectives. Hence the ultimate goal of this paper is to demonstrate the differences in the real estate transfer tax in countries looking prima facia and to suggest reasons for that. The understanding of causes of the disparity and diversity teaches us about the real estate transfer tax, direct taxation in general and even about the differences in states making up the EU.

2 EU and (Dis)Harmonized Real Estate Transfer Taxation

The constitutional trio of modern EU law consists of the consolidated version of the Treaty on EU ("TEU"), the Treaty on the Functioning of the EU ("TFEU") and the Charter of Fundamental Rights of the EU ("Charter"). The Art. 4 of the TEU states that competences not conferred upon the EU remain with the EU member states. According to Art. 5 TEU, this principle of conferral is completed for the use of the conferred competences by principles of subsidiarity and proportionality. Art. 3 TFEU states the exclusive conferred competences and Art. 4 TFEU states the shared conferred competences. In the first group is named the monetary policy regarding EURO and in the second group is named the economic cohesion. However the fiscal policy is not included and thus clearly stays with the EU member states. Nevertheless, a thorough study of the TFEU leads to several provisions at least close to the real estate transfer taxation, see Art. 63 et foll. TFEU, Art. 110 et foll. TFEU, Art. 114 et foll. TFEU, Protocol No. 7, etc. Regarding the secondary sources of the EU law, it must be pointed out the complex set of EU economic and financial legislation. Its mapping reveals that the EU has been very active in this field, generating a battery of Directives dealing with direct taxation, indirect taxation and administrative cooperation (Gellings et al. 2014). These include Council Directive 2003/48/EC on taxation of savings income in the form of interest payments, Council Directive 2003/49/EC a common system of taxation applicable to interest and royalty payments, Council Directive 2009/133/EC on the common system of taxation applicable to mergers, divisions, etc., and the Council Directive and Council Directive 2011/96/EU of November 2011 on the common system of taxation applicable in the case of parent companies and subsidiaries of different Member States. These Directives deal with the taxation of passive income and cross-border corporate asset deals and have an indirect impact on the real estate transfer taxation, e.g. when real estate is the key asset of the company. In re the supplementary sources of the EU law, the majority of Court of Justice of EU ("CJ EU") cases mentioning real estate transfer tax deal basically with the value added tax or free movement of capital or with state aids, i.e. not with real estate transfer tax per se. Yet occasionally the CJ EU has an opportunity to express its opinion, at least via *obiter dictum*, regarding real estate transfer tax, e.g. *C-132/10 Halley v. Belgium* about inheritance tax on assets (see Art. 63 TFEU) or *C-258/08 European Commission v. Belgium* about the purchase of immovable property intended as a new principal residence. Here, it was confirmed that the tax advantages for purchases of residential real estate in the Flemish region can be compatible with the EU, i.e. CJ EU has *previously held that the need to safeguard the cohesion of the tax system may justify rules that are liable to restrict fundamental freedoms (… C-300/90 Commission v Belgium… C-157/07 Krankenheim Ruhesitz am Wannsee-Seniorenheimstatt …"* The cohesion of the national real estate transfer tax may, in qualified cases, have the priority over the protection of certain rights and duties provided by the EU, namely the above mentioned constitutional trio. Can this opinion of the CJ EU, which even went against the European Commission, be considered as the last word and along with the lack of direct conferral competencies lead to the conclusion that the EU can go only as far as it went with the above mentioned quarter of Directives? Such a conclusion would be premature due to the European Commission's ferocious endeavors. Indeed, in 2010 the European Commission presented COM(2012) 531 final Communication from the Commission Europe 2020, A strategy for smart, sustainable and inclusive Growth, i.e. launched strategy Europe 2020, as a new massive root measure for one decade which (allegedly) addresses the overcoming of the (hopefully past) economic and other crises and improves the entire integration model while focusing on smart, sustainable and inclusive growth (MacGregor 2014). Especially the third of the priorities trio, inclusive growth, seems to be nearing the sphere of the real estate transfer taxation. It is logical, because if the EU, especially the European Commission, is serious about its goal to reach an employment rate of 75% and reducing the number of Europeans living in, or bordering, poverty (under 20 million), then it cannot ignore various national fiscal, social or other strategies establishing national real estate transfer tax systems crippling EU employment efforts, fighting poverty and freeing many from various national particularities and discrimination. The European Commission does not live any more in its golden era and cannot legislate for the EU, but it is still very serious about Europe 2020 and the lack of explicit provisions in the TEU and TFEU does not slow it down even if the real estate transfer tax is involved. The CJ EU appears to be conservative, but so far has clashed with the European Commission only indirectly on the asset taxation, see above. Perhaps the Commission is open towards the approximation of real estate transfer taxes in EU member states, but it has not yet taken a direct strong action and it is hardly predictable how the CJ EU would in such a situation react. Yet EU member states demonstrate a massive diversity in their approach and setting of real estate transfer taxes, a determination to have their way and no enthusiasm to embrace approximations pushed by the EU.

3 Diverse Real Estate Transfer Taxation in EU Member States

A fiscal policy rule is a permanent constraint on fiscal policy (Przybylska-Mazur 2015) and the majority of states opted to have such a quasi-permanent restriction regarding real estate transfers. Most developed countries opted to tax changes in ownership of real estate, and thus their national tax systems include, in some form, the inheritance tax, gift tax and transfer tax regarding real estate (Japalli et al. 2014). Each country has undergone a long national process of forming the approach and setting regarding real estate transfer taxation and thus the resulting systems are, and operate, differently. Despite its different setting, the yield of the real estate transfer tax in the OECD countries oscillates around 1% of the total state budget revenues (Růžičková and MacGregor 2014). Although this number is rather low, the real estate transfer tax is considered critical and is the subject of an intense debate involving a myriad of arguments—economic, legal, social, cultural, historical, political, etc. (Japalli et al. 2014). Real estate transfer taxation is a typical feature of tax systems of EU member states, but there are significant differences in the perception of their foundation and function. Since European integration is less pronounced in this arena, it devolves upon each and every member state to select its own approach to the transfer taxation and how it projects into the national (intra-state) law (Růžičková and MacGregor 2014). Involved aspects touch economic and social priorities which are not easy to be reconciled and make this field prone to particular national legislation. It is illustrative to recap the rate of real estate transfer tax in EU member states, while keeping in mind that each state (i) determines differently the basis on which the given tax percentage is applied and (ii) provides for a different reductions, exemptions, etc. and mandatory fixed registration fees, making the data in Table 1 only as benchmarking.

The EU member states set a different percentage rate to be assessed and they are considering different criteria for it. Plus, the basis on which this percentage is to be assessed is set differently—declared sales price, fair market value, table determined amount, adjusted tax basis, etc. Further, EU member states identify differently who pays (who is the payor)—the seller, the buyer, both jointly and severally, etc., and provide various temporary or permanent exemptions. It is beyond the extent of this paper to go in detail regarding these features, and the focus will be basically on the

Table 1 Real estate transfer tax in selected EU member states

Member state	Real estate transfer tax	Comments—factors
Austria	3.5% other cases, 2% relatives	Nature of parties
Belgium	12.5% Valons, 10% Vlams	Region
Bulgaria	0–3%	Location of real estate
Croatia	5%	
Czech Republic	4%	
Denmark	0.6%	
Germany	6% and above Berlin, Saarland, 4.5% Hamburg, 3.5% general	Bundesland (Only Bayern and Sachsen keep gen. 3.5%)
Greece	6% (3% state tax, 3% municipal tax)	
France	5–6%	Location of real estate
Hungary	10%, 4%, but only 2%, 0% residential	Nature of real estate
Italy	Proportional amount between 2% and 9%	Value of real estate
Netherlands	6%, but only 2% if residential	Nature of real estate
Poland	2%	Exemption for farms
Portugal	6.5% other property or 6% residential	Nature of real estate
Romania	3% or 2% <3 years, 2% or 1% >3 years	Value of real estate, time
Slovakia	0%	
Spain	3%	
Sweden	4.25% but only 1.5% for individuals	Nature of parties
UK	4%, 3%, 1%, 0% (proportionate)	0% if to GBP 150,000

rate and its criteria, while the basis and payor information will be added just for demonstration. A cursory overview of the percentage rate for real estate transfer tax indicates that this percentage rate is between 0% and 15% in EU member states. Interestingly enough, there are similar patterns on both sides of the Atlantic. About 20% of the states in the USA and 20% of EU member states have this rate close or even at 0% and the remaining 80% of the states in the USA have a rate 1–5% and 80% of the EU member states have a rate between 1% and 15% (Růžičková and MacGregor 2014), but mainly the transfer real estate tax oscillates around 3% and the costs for contracting and registration between 1% and 2% (Schmid et al. 2005). Certain EU member states and regions, which are considered as "wealthy" and with a strong drive for social re-distribution, do not hesitate to set the rate over 10%, e.g. the Valon region (Cinnamon 2008) or rich German towns and Bundeslands opting to increase their generally set rate of 3.5%. The EU member states seem to be inclined to have one or more fixed rates, nevertheless there are states such as the UK applying a very progressive rate. The calculation of the basis to which this percentage is to be assessed is an issue per se and there are many methods for real estate valuation (Pagourtzi and Assimakopoulos 2003). Some EU member states require an official property appraisal in the case of real estate transfers, while others pass on it. For example, in Poland both the tax on civil law transactions (Group IV of taxation system) and property tax (Group I of taxation system) are in the category of taxes which may require a property appraisal (Cymerman 2013). There are many reasons and causes for a higher percentage rate, in addition to the above mentioned solidarity (social policy), it can be the fear of a massive deficit budget (fiscal policy), an attempt to steer the population (housing policy) or to agricultural and rural development (CAP). More pragmatic factors enter in the picture. Perhaps the high rate can be the historic-cultural heritage of local shrinking or over-populating with high or low income individuals (France, Bulgaria) or the result of frustration due to the massive cheating and under-reporting. The PIGS acronym created by the Eurozone crises applies even here and, e.g., Spain made a legislative change to use as the basis the fair market value and not the low number from the contract but still the tax evasion has continued (Schmid et al. 2005). There is a diverse setting and collection of transaction costs and thus the ultimate appreciation of the impact of the real estate transfer tax makes real estate should be done in the light of the transaction costs of the value at the stake. In certain countries the proceeds from the real estate transfer tax go into local budgets (Greece) and the real estate transfer tax can be the result of the interaction between the state and local government. Table 1 reflects as well real estate mobility, i.e. the slow or fast frequency of real estate transfers. It should be distinguished between residential and commercial real estate. Certain states moved to explicitly set a lower real estate transfer tax for residential real estate (Hungary, the Netherlands) while others do not dwell over the residential status and give a lower rate to individuals (Sweden) or to relative's deals (Austria). The motivation to "not fiscally punish" a slow move in bigger houses can be detected (Romania, Hungary) as well as the will to support modern agricultural development (Poland) and intergeneration solidarity along with general donation and transaction drive (Italy) (Jappelli et al. 2014). Since 2014, in the Slovak Republic it is a flat income tax rate and a flat value added tax rate, while the real estate transfer tax is abolished due to its complexity leading to low efficiency, too much work for less than 1% of the budget revenue (fiscal efficiency) and other social, labor mobility, etc. concerns. The Czech Republic went in the opposite direction, the rate is 4% while the discussion is about the determination of the basis and of the payor—a good case study.

4 Case Study: Czech Real Estate Transfer Taxation

The real estate transfer tax has a long and uninterrupted tradition in the territory of the current Czech Republic. Its history goes back to Act No. 74/1901 of the Habsburg Austrian-Hungary monarchy, which had been valid until 1957. The first exclusively Czech(oslovak) statute on the real estate transfer tax was Act No. 26/1957 Coll., which was replaced by Act. No. 24/1964 Coll. and this Act was replaced by Act No. 146/1984 Coll. The last of this trio of "communistic" statues was updated by Act No. 201/1990 Coll. and replaced by Act No. 357/1992 Coll. The last mentioned Act was recently replaced by Senate Measure—Act No. 340/2013 Coll. In addition, these many statutes were subject to many

Table 2 The historic evolution of the rate of the real estate transfer tax in CZ

Act no.	Real estate transfer tax	Comments
26/1957	6–13% general, 1–5% relatives	2% surcharge if private ownership
24/1964	6–13% general, 1–5% relatives	3% surcharge if private ownership
201/1990	1–20%	
357/1992	3%, later on 4%	!!!This Act was 52 times updated!!!
340/2013	4%	!This Act was updated once!

amendments and updating. Hence, the Czech real estate transfer tax legislation and rates are far from being stable, see Table 2.

Changes of the legal regulation of this tax is related to changes in the CZ tax system (Jánošíková 2015). In the Czech Republic, real estate transfer tax is conventionally seen as a direct and transfer tax with a stable revenue. The 2008 crises proved that the financial and real estate markets can be severely impacted, real estate prices and transaction volume decreased leading to a dramatic drop of real estate transfer tax revenue in the Czech Republic in 2009, which continued until 2013. However, a similar drop occurred as well in 2005 and partially even in 2000 (Andrlík 2010). The stability of revenue from real estate transfer taxes in the Czech Republic is not truly stable, and this even during these short times when no legislative changes occur. Parallels with economic growth and recession, issues linked to a home-owner rate of almost 80% (Růžičková and MacGregor 2014) and non-consumption expenses reaching only 10% of total expenditure of households (Malá and Červená 2012), etc. can be detected but do not suffice for the explanation. As much as the stability of the Czech real estate transfer tax and its revenue are questionable, so much can the real estate transfer regulations testify about the political situation and state priorities. The communistic trend to charge 13% plus 2 % extra for the private ownership transfers seems as a hidden partial expropriation and progressive abolition of the "worse" form of ownership—the private ownership. The inherent instability, political historical context and current interaction between the state and local governments influenced the decision to assign all its revenue to the state and not to the concerned municipalities and regions. These factors, along with the general tax payment reluctance, contribute to the ongoing need to update its system and work hard on its enforcement. The collection of real estate transfer tax was considered as heavily bureaucratic and with high establishment and collection costs. The new Act should bring more simplicity, but so far the general public demonstrates a low awareness (Růžičková and MacGregor 2014), skepticism and confusion. The planned changes of this new Act reshuffling the determination of the payor, changing forms and deadlines and other parliamentary discussions about real estate transfer tax makes the scenery even more ambiguous. Perhaps a little bit of consistency, continuation and EU harmonization might be helpful. However, the EU does not have the competency to do this directly, and so the Czech seasonal real estate transfer tax parade continues.

5 Conclusion

The setting of real estate transfer tax and of transaction costs is a mirror of the nation, its history and priorities. Each EU member state has undergone an evolution in this respect, but not all states reach a stage compatible with the demand for the sustainable, smart and inclusive growth dictated by the Europe 2020. Although the EU does not have a competency to step in directly, it arguably developed certain initiatives in this field. Considering the heterogonous diversity and the many policies and functions, for which the real estate transfer tax can be employed, the national particularities must be observed and fit-all ideas should not be developed and pushed upon EU member states. At the same time, there are still a few EU member states struggling with the setting and collecting of real estate transfer taxes, such as the Czech Republic, and it would be perhaps less evil if these states would rather follow some EU guidance (or similar EU member state's model) than continue their eternal amendments of amendments along with excessive bureaucratic requirements, which make real estate transactions less certain, more costly and not customer friendly. Indeed, a deeper and open-minded discussion can generate precious information and impulses for politicians, economists and legislators, for the conceptual, theoretical and practical improvement of the real estate transfer tax on the EU territory.

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Impact of Financial Policies of Local Authorities on Entrepreneurship: Comprehensiveness of Policy Matters

Tomasz Skica, Jacek Rodzinka, and Rusłan Harasym

Abstract The article is dedicated to the issues of promoting entrepreneurship by local governments on municipal level in Poland. The authors conducted an analysis of the financial policy's impact of local government units on the development of entrepreneurship. As explanatory variables in the article, the authors adopted instruments of entrepreneurship support that were based on the revenue side and the expenditure side of the budget. The list of these variables is as follows: total tax income on real estate, total tax income on transport, total income from property, total expenditure on property, product of variables describing tax income and property expenditure. As outcome variable, the authors adopted level of entrepreneurship in municipalities measured by the number of newly registered business entities per capita. While the control variable was the ratio called population density. The output dependent variable was divided by the number of working age population, while the output independent variables (revenue and expenditure instruments of financial policy of local authorities) were divided by the total population. Analysis was performed based on logarithmic averages for annual data that was collected at the commune level. Based on collected data, authors had constructed six models that were later estimated. The estimation of parameters of models was done using linear regression. Regression model for averages proved that local government units fiscal policy expressed in tax instruments strongly affect entrepreneurship, with assumption of simultaneous usage of several stimulants. Income instruments most strongly influence the development of entrepreneurship. Among these instruments the biggest impact on entrepreneurship have tax instruments, in particular the real estate tax. Expenditure instruments that most

The article was prepared based on results of the project that was financed from the funds of National Science Centre given by decision with number DEC-2013/11/B/HS4/01022.

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_24

strongly influence entrepreneurship are capital expenditures. Finally, the effectiveness of financial forms of support is conditioned by stability and continuity of fiscal policies implemented by local governments. Analyzed model positively verifies opinions from literature that use by local authorities single instruments of entrepreneurship support (especially taxes) brings weaker results than the use of a set of a tax-including instruments.

1 Introduction

The role of local authorities in promoting entrepreneurship is a subject of continuous debate. Entrepreneurship as well its determinants were many Times analyzed and scientifically approached in the past. Parker (2009) presented their full list. The most interesting issues on appearance of entrepreneurship in literature, are the analysis that took into consideration impact of institutional environment on the development of economic initiatives (Estrin et al. 2013), in particular their regional and local dimension (Fritsch and Storey 2014, Huggins et al. 2015). These issues are especially important in the case of the countries as Poland, i.e. countries that are characterized by large regional and local differentiation and on the same time administrative governance that allows to create entrepreneurship supporting solutions on the local level. The role of just mentioned solutions was stressed by Audretsch (2015). The concern of taxation in the processes of entrepreneurship stimulation was from the other had taken by Bruce and Deskins (2012), Hansson (2012), Baliamoune-Lutz and Garello (2014) and Baliamoune-Lutz (2015). Whereas Mason and Brown (2013) in the complex way described the assumptions of proper public policy that are aimed to support entrepreneurship development.

At the same time it should be noted that the specificity of solutions aimed to entrepreneurship stimulation is strictly linked to the legislation of the country. It allows local authorities to act and sets real limits for stimulation activities of local authorities. The scale and specificity of stimulation activities look a bit different in countries with different levels of fiscal capacity of local budgets, different levels of decentralization and the autonomy of local authorities. As a result, the scale and range of possible forms of support in Poland and other countries looks quite different. Often these differences are significant enough to prevent conduction of transnational comparisons of local governments range enshrinement in the area of possible stimulation activities.

Due to territorial dimension of the analysis contained in this article, which takes into consideration local governments in Poland, the authors referred to existing, national research experiences that are related to attempts to stimulate entrepreneurship by communes. This issue was risen in the research works of following papers: Arzeni and Pellegrin (1997), Maciejuk (2004), Słomińska (2007a, b) as well as Kochmańska (2007), Makieła (2008) and Grodzka (2008). The indicated problems were also the subject of research interest in the work undertaken by Banasiak (2013), Gołębiowski and Korolewska (2013) and Radacz (2013). It is also present in the most recent studies devoted to the analyzed issues that belong to the following authors: Walenia (2014), Bania and Dahlke (2014), Dyrda (2014), Grycuk and Russel (2014), or Korolewska (2014), Rapacz and Jareman (2014).

As it was shown in the above papers, there was a mistake in attempts taken to relativize the scale of instruments that are available for local authorities in Poland and other countries and then interference on the effectiveness of support policies basing on this relativization. Thus, the correct approached should be considered as the one that combine the effects of domestic support policies with the existing Polish legal system framework that support entrepreneurship. The presented research and its results that refer to national experiences designed to stimulate entrepreneurship by municipalities shows that the topic of support of entrepreneurship by local authorities is determined individually by the structure of the territorial division of each country and the level of autonomy of local authorities in their efforts to stimulate economic initiatives (Sztando 1998). Parallel to the structure of the territorial division of the country, the local government finance system affects the scale of capabilities in the area of entrepreneurship support. The potential of local government support looks different in the Netherlands, where revenues from local taxes are only 2% of total revenues, and otherwise in Austria, in which local taxes account for approx. 65% of local government budget revenues (Kosek-Wojnar and Surówka 2007).

Therefore, the larger the potential for creation of own revenues through local governments, the greater the ability to create solutions to support entrepreneurship in a bottom-up way. Obviously, these activities though they are interdependent, they do not always go hand in hand. Municipalities with high income potential are not "automatically" the units with the highest level of entrepreneurship (Skica et al. 2013). It happens that local governments do not consciously decide to use financial instruments (including fiscal stimuli), to support economic initiatives, but there are much more common situations, in which local governments use support instruments incompetently (Skica and Bem 2014).

There is analogical approach to use financial stimulants by the local government units that bases on expenditure side of the budget. Due to the nature and economic characteristic of the various categories of expenditure, the instruments based on asset-related spending [especially capital expenditure (Maciejuk 2004; Makieła 2008)] has an important role in supporting entrepreneurship. In this place, there is also recommended to take certain kind of duality in the approach to deal with the government's policy to promote entrepreneurship. The one thing is ineffectiveness in used forms of support, and another thing is lack of any measures to stimulate entrepreneurship (Skica and Bem 2014).

It must be added to this picture that there are some inappropriately chosen measures of the effectiveness of the stimulus (on both revenue and expenditure side) or even the lack of any measures of the effectiveness of the above actions—what only enhances the scale of the negative consequences that are result of politics of entrepreneurship stimulation understood in the wrong way (Gołębiowski and Korolewska 2013). Such an approach has the result of inadequate financial policy on both the point of view of directly concerned budgetary implications and possibility of costly evaluation of effectiveness of the solution supporting entrepreneurship that were applied by the local authorities. The background highlights some aspects of the underlying causes for research analyzes. The first of these is the need to structure instruments of entrepreneurship support that are based on revenue and expenditure structure of the budget. The second is to verify the impact of the instruments used by local governments in order to support development of the entrepreneurship. Finally, the third layer refers to investigate the interrelation of individual instruments of support.

The assumption of research problems that were mentioned above, was used to shape the aim of this article, which was set on studying the impact of the financial policy of local authorities on entrepreneurship. Examined issue will be considered from the point of view of research problems outlined above, and the objective scope of the analyses will take into account the level of activity of local government at the municipal level in Poland. Municipal level government, due to the highest degree of financial independence among units of territorial division of the country, offers the broadest instruments supporting entrepreneurship. Thus, the scale of the impact on the bottom-up opportunities to create conditions for the development of entrepreneurship in relation to municipalities is the largest (see: Bania and Dahlke 2014; Dropek 2014; Banasiak 2013).

According to the research studies of the authors mentioned above, the dominant form of classification of instruments of entrepreneurship support is its division onto income-oriented instruments and expenditure-oriented instruments. Keeping above findings in mind, the research part of this article will focus on the impact of income and expenditure-oriented instruments of support, which were used in particular area by local government units at the municipality level up to the level of entrepreneurship. Summary of financial stimulators with the measures of their effectiveness (i.e. the level of entrepreneurship) will determine the actual relationship between the financial support granted by the municipality and its effects that are considered from the entrepreneurship level perspective. The analysis that is designed this way provides some answers on key questions from the perspective of fiscal policy of municipality, namely whether the most commonly used financial instruments are the best drivers of local entrepreneurship.

2 Data, Methods, and Model Specification

For the analysis, the authors used a data from the collections of the Local Data Bank provided by the Central Statistical Office of Poland. The spatial scope of the analysis includes 2481 municipalities in Poland. In the process of preparation of data for the analysis, the output dependent variable (the number of newly registered enterprises) was divided by the number of working age population, while the output independent variables (revenue and expenditure instruments of financial policy of local authorities) were divided by the total population. Further analysis was performed based on logarithmic averages for annual data that was collected at the municipal level (dependent variable—the average for the variable at the level of individual municipalities for the years 2009–2013; the independent variables—the average for variables at the level of individual municipalities for the years 2003–2008). Preparation of data in this way was dictated by both the availability of data (the dependent variable available only for the years 2009–2013) and the desire to examine the impact of the previous periods independent variables on the dependent variable in the final period.

In order to examine the interaction of independent variables with the dependent variable, the authors of the analysis used two additional independent variables, which are the products of particular groups of independent variables. In the model presenting the impact of the financial policy of local authorities on entrepreneurship, the following variables were used:

1. Dependent variable that describe level of entrepreneurship on municipality level:
   - ln_newly_regist_entities (Number of newly registered business entities);
2. Independent variables describing financial policy of local authorities;
   - ln_prop_sale_income (Income from property sale);
   - ln_real_estate_tax_income (Total tax income on real estate);
   - ln_transp_tax_income (Total tax income on transport);
   - ln_property_income (Total income from property (Income from renting and leasing property of local government units));
   - ln_property_expen (Total expenditure on property);
   - ln_share_pub_road/total_expend (Share of expenditure in public roads in the total expenditure);
   - ln_prod_tax_income*property_expend (Product of variables describing tax income and property expenditure);
   - ln_prod_tax_income_var (Product of only variables describing tax income).
3. Control variable, which allows to examine the interdependency between the level of enterpreneuship and the size of municipality under examination
   - ln_pop_density (population density).

The selection of the independent variables was dictated by the analysis of the legislation that regulates activities of local government in Poland as well as its financial management. The regulations provide a framework for developing solutions that support entrepreneurship and that is available to local governments on regional level. Examination of existing regulations is required to determine the scope of the local government power in creation and individualization of conditions for business development, which are expressed in the instruments presented in the article. On the other hand, the selection of dependent variable was based on analysis of introduced literature sources, authors' consultation with Global Entrepreneurship Monitor (GEM) team that conducts regular international research dedicated to entrepreneurship, as well as availability of statistical data, which allowed maintaining time continuity of observation and building panel models. Analysis of the correlation matrix showed that the most of independent variables taken for analysis has an influence on dependent variable. In the case of only one variable Income from property sale, the correlation coefficient is higher than -1 and less than 1, which as adopted stresses very weak strength of the relationship, or lack of a it.

The weak strength of the relationship was calculated between the dependent variable, and the variable Total income from property (Income from renting and leasing assets of local government units), while the average strength noted between the number of newly registered business entities and: Total tax income on transport, Total expenditure on property and Share of expenditure in public roads in the total expenditure and Population density.

A strong strength of the relationship between the variables was pointed by the correlation coefficient between the dependent variable, and the variable Product of variables describing tax income and property expenditure. The correlation coefficient formed on a similarly high level for a variable Total tax income on real estate.

Due to the administrative division of the Polish, according to which Polish communes are divided by type on urban, rural and urban-rural, it seems to be seems to be proper to research the influence of independent variables on the dependent variable, in the case of all communes together and for each type of commune individually.

In the next step, the above variables were used to estimate the models of following algebraic form:

1. models were calculated basing on observations for all types of communes (urban communes, rural communes and rural-urban communes)

$$
\begin{aligned}
\ln\_newly\_regist\_entities = {} & \beta 0 + \beta 1\,(\ln\_prop\_sale\_income) \\
& + \beta 2\,(\ln\_real\_estate\_tax\_income) + \beta 3\,(\ln\_transp\_tax\_income) \\
& + \beta 4\,(\ln\_property\_income) + \beta 5\,(\ln\_property\_expen) \\
& + \beta 5\,(\ln\_share\_pub\_road/total\_expend) + \beta 6\,(\ln\_pop\_density) \\
& + \mu \qquad \text{(Model 1)}
\end{aligned}
$$

In order to investigate the interrelation of independent variables associated with instruments of income and expenditure (used by local governments) on the dependent variable, the authors prepared two additional models containing additional variables: ln_prod_tax_income*property_expend (Product of variables describing tax income and property expenditure oraz ln_prod_tax_income_var (Product of only variables describing tax income).

$$\begin{aligned} \ln\_newly\_regist\_entities = {} & \beta 0 + \beta 1\ (\ln\_prop\_sale\_income) \\ & + \beta 2\ (\ln\_real\_estate\_tax\_income) \\ & + \beta 3\ (\ln\_transp\_tax\_income) + \beta 4\ (\ln\_property\_income) \\ & + \beta 5\ (\ln\_property\_expen) \\ & + \beta 6\ (\ln\_share\_pub\_road/total\_expend) \\ & + \beta 7\ (\ln\_pop\_density) \\ & + \beta 8\ (\ln\_prod\_tax\_income * property\_expend) + \mu \end{aligned} \tag{Model 2}$$

$$\begin{aligned} \ln\_newly\_regist\_entities = {} & \beta 0 + \beta 1\ (\ln\_prop\_sale\_income) \\ & + \beta 2\ (\ln\_real\_estate\_tax\_income) \\ & + \beta 3\ (\ln\_transp\_tax\_income) + \beta 4\ (\ln\_property\_income) \\ & + \beta 5\ (\ln\_property\_expen) \\ & + \beta 6\ (\ln\_share\_pub\_road/total\_expend) \\ & + \beta 7\ (\ln\_pop\_density) \\ & + \beta 8\ (\ln\_prod\_tax\_income\_var) + \mu \end{aligned} \tag{Model 3}$$

2. model calculated basing on observations for urban communes

$$\begin{aligned} \ln\_newly\_regist\_entities = {} & \beta 0 + \beta 1\ (\ln\_prop\_sale\_income) \\ & + \beta 2\ (\ln\_real\_estate\_tax\_income) \\ & + \beta 3\ (\ln\_transp\_tax\_income) + \beta 4\ (\ln\_property\_income) \\ & + \beta 5\ (\ln\_property\_expen) \\ & + \beta 5\ (\ln\_share\_pub\_road/total\_expend) \\ & + \beta 6\ (\ln\_pop\_density) + \mu \end{aligned} \tag{Model 4}$$

3. model calculated basing on observations for rural communes

$$\begin{aligned} \ln\_newly\_regist\_entities = {} & \beta 0 + \beta 1\ (\ln\_prop\_sale\_income) \\ & + \beta 2\ (\ln\_real\_estate\_tax\_income) + \beta 3\ (\ln\_transp\_tax\_income) \\ & + \beta 4\ (\ln\_property\_income) + \beta 5\ (\ln\_property\_expen) \\ & + \beta 5\ (\ln\_share\_pub\_road/total\_expend) + \beta 6\ (\ln\_pop\_density) \\ & + \mu \end{aligned} \tag{Model 5}$$

4. model calculated basing on observations for semi-urban communes

$$\begin{aligned} \ln\_newly\_regist\_entities = {} & \beta 0 + \beta 1\ (\ln\_prop\_sale\_income) \\ & + \beta 2\ (\ln\_real\_estate\_tax\_income) + \beta 3\ (\ln\_transp\_tax\_income) \\ & + \beta 4\ (\ln\_property\_income) + \beta 5\ (\ln\_property\_expen) \\ & + \beta 5\ (\ln\_share\_pub\_road/total\_expend) + \beta 6\ (\ln\_pop\_density) \\ & + \mu \end{aligned} \tag{Model 6}$$

The estimation of parameters of models was done using linear regression with the application of Stata 14 software. Detailed results of the regression analysis will be presented in the next part of this article.

3 Results

Estimation results of a parameter' of particular models, are presented in Table 1. It consists results of regression that were conducted for all six examined models.

The authors presented above six models. In the case of first three 1790 observations for municipalities, rural and semi-urban communes were used. This number is smaller than the total number of municipalities in Poland, due to the fact that the calculations were made only on these units (municipalities), for which all the data for selected variables was available. The fourth model took into account 234 municipalities, the fifth 1115 rural communities, while the sixth considered 441 semi-urban communes.

Regression model for averages proved that local government units fiscal policy expressed in tax instruments strongly affect entrepreneurship, with assumption of simultaneous usage of several stimulants. In examined model, there was no limit to only one tax, but set of several taxes and its simultaneous spread enlargement by capital expenditures. These combined elements created set of consonance instruments that present municipalities' financial policy on possible activities of entrepreneurship stimulation. Model verified opinions from literature that states that impact of single stimulants on entrepreneurship (especially taxes) is decidedly weaker than set of tax-including instruments. Moreover model exposed capital expenditures' importance in process of creating conditions to develop entrepreneurship. Importantly, such combination of instruments creates a relationship of cause and effect. If municipalities increase capital expenditures, it stimulates entrepreneurship and increase income from local taxes, what creates possibilities of further entrepreneurship support.

On the basis of conducted analyzes, the authors took a number of additional research arrangements. The most important from them are presented as follows. Income instruments that remain at the disposal of the local government most strongly influence the development of entrepreneurship. Among these instruments the biggest impact on entrepreneurship have tax instruments, in particular the real estate tax. Analyzes proved that the impact of tax instruments on entrepreneurship is enhanced when several types of tax are used as incentives. In the set of own-incomes, the income from businesses with private legal status least affects entrepreneurship. It is deserved to be noticed that the impact of single fiscal stimuli on entrepreneurship is weaker than the impact of a set of instruments that contain both income and expenditure instruments. Expenditure instruments that most strongly influence entrepreneurship are capital expenditures. Moreover, incurring capital expenditure by municipalities stimulates entrepreneurship, primarily, it has a direct impact on their incomes from local taxes, and it also helps create

Table 1 Regression results

Independent variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
ln_prop_sale_income	0.008**	0.008**	0.008**	0.155**	0.008**	−0.000
	(0.0024)	(0.0024)	(0.0024)	(0.0514)	(0.003)	(0.0042)
ln_real_estate_tax_income	0.191***	0.106***	0.131***	− 0.109	0.195***	0.146***
	(0.1345)	(0.0219)	(0.0197)	(0.0643)	(0.0153)	(0.0325)
ln_transp_tax_income	0.060***	−0.025	(omitted)	0.048	0.058***	0.035
	(0.0106)	(0.0217)		(0.0354)	(0.0125)	(0.0226)
ln_property_income	0.031***	−0.053**	−0.029	0.051**	0.013	0.045***
	(0.0075)	(0.0175)	(0.0131)	(0.0148)	(0.0102)	(0.0116)
ln_property_expen	0.085***	(omitted)	0.085***	0.219***	0.083***	0.067**
	(0.0169)		(0.0169)	(0.0405)	(0.0217)	(0.0303)
ln_share_pub_road/total_expend	−0.041***	−0.041***	−0.041***	−0.009	−0.048***	−0.035**
	(0.0082)	(0.0082)	(0.0082)	(0.0179)	(0.0109)	(0.0171)
ln_pop_density	0.068***	0.068***	0.068***	−0.018	0.098***	0.054**
	(0.0070)	(0.0070)	(0.0070)	(0.0269)	(0.0155)	(0.0209)
ln_prod_tax_income*property_expend		0.085***				
		(0.0169)				
ln_prod_tax_income_var			0.060***			
			(0.0106)			
Constant	−6.615***	−6.615***	−6.615***	−5.821***	−6.637	−6.150
	(0.1233)	(0.1233)	(0.1233)	(0.3594)	(0.1529)	(0.2715)
N	1790	1790	1790	234	1115	441
F	197	197	197	7.60	69.39	15.93
R^2	0.450	0.450	0.450	0.286	0.355	0.265
RMS error	0.263	0.263	0.263	0.243	0.264	0.241

Robust standard errors in parentheses
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

entrepreneurship. Finally, it is worth to be emphasized that the efficacy (effectiveness) of financial forms of support is conditioned by stability and continuity of fiscal policies implemented by local governments.

In this article, the authors divided surveyed municipalities' population by their types and it was found that determination of three separate models for municipalities, semi-urban and rural areas, was a correct decision. The explanatory variables affect the outcome variable in the different way, when you consider different types of communes. In particular, the authors observed a significant difference in the effect on the dependent variable between urban communes and other types of municipalities. In the case of these mentioned in first order, the number of newly registered businesses was mostly affected by variables: capital expenditures, total tax income on real estate as well as total income from property. In the case of rural and semi-urban areas the most important variable is: tax revenue from the property. The variables of high importance were also: capital expenditure and population density. In the case of municipalities, he last mentioned variable did not play a substantial role in shaping the number of newly registered businesses, while variable total tax income on real estate was of great importance for municipalities and quite marginal for other communes.

4 Discussion and Conclusions

Policy of entrepreneurship support by the local authorities is an object of interest for both literature and the practice. A characteristic of supporting entrepreneurship by local authorities is conditioned by level of autonomy of local authorities in efforts to stimulate economic initiatives. The accent in field of possible stimulation activities is divided in different way in example of self-governments based on dualistic model (these with large autonomy of self-government activities) and in a different matter in those based on unitary model (i.e. in central-governed countries). Parallel, self-government financial system has also impact on scale of possibilities in area of entrepreneurship supporting.

As it was presented above, the selection of independent variables adopted for the construction of models, was determined by literature review. Many authors like the Maciejuk (2004), Dziemianowicz et al. (2000), Richert-Kaźmierska (2010), Braziewicz-Kumor and Bury (2011), Wyszkowska (2012), Matejun (2012), divides instruments on income and expenditure ones. These authors point a great importance of all the variables adopted in this article in order to explain the analyzed issue, but adopted variables were never used in such a configuration. This fact represents a significant added value to this article. Undoubtedly a major achievement of the authors is also the accurate indication of the strength and direction of the impact of individual independent variables on the dependent variable.

This article, besides the fact that it compares different elements of fiscal policy, also analyses the effectiveness of the various support tools and confronts them with the degree of the possibility of achieving the intended effects of the stimulation effects. Research that was conducted by authors proved that particular support instruments are characterized by different efficiency, and thus different degrees of impact on the budgets of local governments that apply them. This position is also confirmed by the results of surveys conducted among others by Skica and Bem (2014). Thus, the construction of effective policies to support entrepreneurship is decided by applying number of factors all together (Mason and Brown 2013; Huggins et al. 2015).

It is particularly important to be careful when comes to solutions on introducing minor fiscal preferences. Research shows that properly designed and selected fiscal stimulators translate into minimal catalytic effects and in parallel effectively drain the budget by reducing the possibilities of creating development policies in the future (cf. Dziemianowicz et al. 2000; Aničić et al. 2016). It is also pointless to decide on the use of particular forms of support in 1 year and then withdraw from it in the next year. High frequency of solutions modification—thereby eliminating the continuity and predictability of policy support—results in an increased risk of decision on placing capital in the area (Bończak-Kucharczyk et al. 1998). Similarly negatively assessed should be implementation of solutions with a longer time of impact, and then withdrawing them before they produce tangible benefits for budget. Another equally common mistake in local politics is to implement support instruments without measuring their effectiveness (see eg Atkinson 2002). These are mistakes that only be described as the primary in policy of entrepreneurship support.

Finally, besides considered selection of instruments and the continuity of their application, the last component of effective support policy should be to skillfully combine them together. In the era of universal knowledge on the necessity of competing for investors (cf. eg Hoyt 1990), it is of crucial not just to implement individual forms of support, but to compile them in such way that local capacity will be enhanced and competitive advantages strengthened. In addition to that the unit should be recognized as the one that is friendly to investors and capital as well as predictable and stable in the decisions that shape a "healthy" fiscal policy (see Marples 2006). To make this statement real, the construction of fiscal policy should be organized with co-operation of the recipients of planned actions, i.e. companies (cf. eg Florida 2003; Bruce and Deskins 2012).

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Part VI
Corporate Finance

Are Capital Structure Determinants Different Depending on Firm Size and Debt Maturity? Evidence from European Panel Data

Julia Koralun-Bereźnicka

Abstract The aim of the study is to verify whether and how the determinants of capital structure vary depending on the firm size and debt maturity. A number of firm-specific factors, as well as country and industry characteristics are compared across three size groups of firms in terms of their impact on various measures of capital structure. The study employs the BACH-ESD database provided by the European Commission and covers 11 EU countries during the period 2000–2013. Using panel data models for different size groups and for different measures of debt, findings provide evidence that both the direction and the significance of capital structure determinants vary along with the firm size, as well as depending on the debt maturity. As for the size-dependent findings, it appears that financing decisions of small firms generally seem to support the pecking order theory more, while medium and large-sized firms tend to follow the trade-off predictions on leverage. The results also indicate that the trade-off theory is more applicable for short-term debt, whereas pecking order predictions on capital structure are more suitable for long-term debt. The research confirms the prevalence of the country effect over the industry effect in the capital structure, although the difference between the importance of the two effects tends to decrease as firms grow larger.

1 Introduction

The amount of corporate finance literature dedicated to the capital structure should discourage from addressing the same issue all over again. However, the contradictions found between the results of studies aiming to verify the significance of various factors of leverage (reported in the following literature review section) imply the need for further research in this already heavily explored area in order to explain the reasons for the heterogeneity of empirical findings. This study provides more insights into the determinants of debt by introducing two additional

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_25

constraints in the form of firm size and debt maturity as factors not only affecting corporate financing decisions directly, but also as indirect determinants of capital structure, potentially diversifying the impact of primary determinants of debt. Moreover, most of the hitherto studies in the field refer to public companies, whereas this one contributes to the existing research by comparing the importance of capital structure determinants across three size groups of private companies: small, medium and large-sized firms, as well as for three measures of debt, i.e. with regard to the debt maturity.

The two leading theories explaining corporate financing choices include the static trade-off theory of debt (TOT) by Modigliani and Miller (1958) and the pecking-order theory (POT) by Myers and Majluf (1984), both of which have been empirically verified on multiple occasions. Although corporate finance literature provides a number of other theoretical explanations of capital structure, only the TOT and POT will be verified, as the most relevant theories in terms of SMEs.

2 Literature Review on Capital Structure Determinants

From the plethora of factors which have been either theoretically or empirically found to explain capital structure, this section presents a selection of those that are most frequently reported in studies aiming to verify their significance. Table 1 provides a synthetic summary containing the expected sign of the relation between a given factor and debt according to the POT and (or) the TOT, as well as the explanation of the direction.

One of the external factors considered in this paper is the business sector (industry). Most of the literature examining the relationship between the industrial classification and debt reports that companies located in different industries also differ in terms of leverage (Harris and Raviv 1991). Although the impact of industrial factors on capital structure is a widely accepted view, there are also studies denying the relevance of industry in terms of capital structure (Hatfield et al. 1994). The existing research reports that corporate capital structure is not only affected by firm characteristics, but also by the country specificity (La Porta et al. 1997; Rajan and Zingales 1995; Wald 1999; Bancel and Mittoo 2004), which indicates that including the country dummies is also justifiable.

Considering the above theories of capital structure and the hitherto empirical findings concerning individual capital structure determinants, the following research hypotheses are formulated: (1) the firm characteristics (tax burden, assets tangibility, financial liquidity, growth, profitability, working capital, depreciation, firm size), its industry and country have a significant effect on capital structure; (2) the significance and (or) the direction of the impact of firm characteristics (except size), its industry and country on debt vary depending on the firm size; (3) the significance and (or) the direction of the impact of firm characteristics, its industry and country on debt vary depending on the maturity of debt; (4) the relative

Table 1 Determinants of leverage according to the leading capital structure theories

Factor, predicted sign	Empirically found sign of the relation, explanation of the relation	
Tax burden POT +	+	The higher the taxes, the greater the benefits from the interest tax shield (Bancel and Mittoo 2004).
	–	Tax incentives for listed companies motivate IPOs; an increase in the corporate income tax leads to an increase in equity (Abor and Biekpe 2005).
Collateral POT, TOT +	+	More collateral means more possibilities of increasing debt (Frank and Goyal 2003).
Liquidity TOT + POT –	+	Due to lower bankruptcy costs, higher liquidity increases debt availability (Anderson and Carverhill 2012).
	–	Due to the conflict of interests between debtholders and shareholders concerning the degree of liquidity, excessively liquid firms can raise less debt than less liquid firms (Udomsirikul et al. 2011).
Growth TOT – POT +	–	The agency cost problem is more severe for growing companies, due to the greater flexibility in the choice of future investments, which implies an inverse relationship between long-term debt and growth opportunities (Hall et al. 2004).
	+	Firms with growth opportunities are more likely to use short-term debt in order to avoid the agency costs (Abor and Biekpe 2005).
Profitability TOT + POT –	+	Profitable companies should have higher leverage to compensate taxes; market is reluctant to offer funds to unprofitable companies (Frank and Goyal 2003).
	–	Firms generating high returns may have less debt, since internal financing is preferred (Hall et al. 2004).
Working capital POT –	–	Companies with higher leverage tend to choose more aggressive working capital strategies in order to ensure the internal financing and avoid the issuance of debt and equity (Nazir and Afza 2009).
Risk (earnings volatility) TOT – POT –	–	It is more difficult for investors to predict profits for companies with highly variable earnings, and lenders expect a higher premium for the offered funds, which increases the cost of debt (Bancel and Mittoo 2004).
	+	The positive relationship between risk and short-term debt is due to the rationing of credit: firms with limited opportunities in terms of long-term debt, turn to financing with short-term debt (Oppong-Boakye et al. 2013).
Non-debt tax shields TOT –	–	Companies using other non-debt tax shields have less need for the tax benefits of debt (substitutability hypothesis) (Graham et al. 2004).
	+	Companies with non-debt tax shields usually have considerable assets that can be used as collateral for debt (Leary and Roberts 2005).
Firm size TOT +	+	Large companies tend to have more diversified business, better reputation in the credit market and bear lower costs of obtaining information (Frank and Goyal 2003).

importance of the country and industry effect in capital structure depends on the firm size and on the debt maturity.

Verifying the above hypotheses through an extensive empirical research should partly cover the gap in the literature concerning the way capital structure factors affect financing decisions of firms depending on their class size and debt maturity.

3 Dataset Characteristics

The data provided by the BACH-ESD[1] database (Banque de France 2015) includes comparable information on the financial statements of companies aggregated by sector and by size class for the following eleven EU countries: Austria, Belgium, Czech Republic, France, Germany, Italy, Netherlands, Poland, Portugal, Slovakia and Spain. The empirical analysis includes companies of three group sizes: small (S), medium (M) and large (L) in sixteen industries according to the NACE classification[2] at the section level: A, B, C, D, E, F, G, H, I, J, L, N, P, Q, R, S. Several industries were excluded from the analysis due to lack of cross-industry comparability resulting from differences in reporting. The variables express the values of ratios calculated with the use of such accounting terms as assets, liabilities or equity averaged for all enterprises in a given category of size, country, industry and year. The same applies to the explanatory variables describing firm characteristics. The construction of ratios employed as dependent and explanatory variables is shown in Table 2.

4 Methodology Description

The data is four-dimensional as there is a time series for each object in the three cross-sections (countries, industries, size groups), which implies the application of panel data modelling to detect the hypothesized effects. The general formula of the panel data model employed in this study is as follows:

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

[2] Nomenclature Statistique des Activités économiques dans la Communauté Européenne.

Table 2 Definition of variables

Variables	Definition
Dependent variables	
Debt to assets ratio (D/A)	Total debt/total balance sheet
Long-term debt to assets (LTD/A)	Non-current debt/total balance sheet
Short-term debt to assets (STD/A)	Current debt/total balance sheet
Explanatory variables	
Tax burden (TAX)	Tax on profit/EBT
Assets tangibility (TAN)	Tangible fixed assets/total balance sheet
Liquidity (LIQ)	Cash and bank/total balance sheet
Assets growth (GRT)	(total assets $_{t}$−total assets $_{t-1}$)/total assets $_{t-1}$
Return on equity (ROE)	Net profit or loss for the period/equity
Earnings variability (RSK)	(EAT_t−EAT_{t-1})/EAT $_{t-1}$
Depreciation (DPR)	Depreciation and amortization on intangible and tangible fixed assets/net turnover
Working capital ratio (WCR)	Operating working capital/net turnover
Industry	A, B, C, D, E, F, G, H, I, J, L, N, P, Q, R, S
Country	AT, BE, CZ, DE, ES, FR, IT, NL, PL, PT, SK
Size	S, M, L

Notes: EBT—earnings before tax, EAT—earnings after taxes, industry symbols as in NACE

$$\begin{aligned} D_{icst} = {} & \delta_0 + \delta_1 TAX_{icst} + \delta_2 TNG_{icst} + \delta_3 LIQ_{icst} + \delta_4 ROE_{icst} + \delta_5 DPR_{icst} \\ & + \delta_5 WCR_{icst} + \delta_6 GRW_{icst} + \delta_7 RSK_{icst} + \sum_{c=1}^{11} \alpha_c D\_ct_c + \sum_{i=1}^{16} \beta_i D\_ind_i \\ & + \sum_{t=1}^{13} \gamma_t D\_yr_t + \varepsilon_{icst}. c = 1, \ldots, 11, \quad i = 1, \ldots, 16, s = 1, 2, 3, t = 1, \ldots, 14 \end{aligned} \tag{1}$$

where: D is one of the three aforementioned debt measures, δ, α, β and γ are structural parameters reflecting the strength and direction of impact of each variable or effect on the dependent variable and $\mathcal{E}_{icst}$ is the random error. The variables defined as D_ct represent 11 dummy variables for each country, D_ind correspond to 16 dummy variables for industries, whereas D_yr is a set of 14 year dummies. The above model corresponds to the fixed effects model described by Baltagi (2008). The Hausman specification test in most cases indicated the appropriateness of the fixed effects model. In order to verify which group of effects was more significant in the estimated models, a detailed interpretation of the Akaike's information criteria (AIC) was performed. The above model was estimated separately for each of the three debt measures and for each size group of firms, as well as for all size groups of firms in total. Obviously, the size dummies were only included in the general models, that is for all size groups.

Table 3 Estimation results of panel regressions for the D/A as the dependent variable

Variable	All firms (SML)			Small firms (S)			Medium firms (M)			Large firms (L)		
	Estimate		Std. error	Estimate		Std. error	Estimate		Std. error	Estimate		Std. error
const.	0.628	***	0.012	0.583	***	0.021	0.640	***	0.020	0.618	***	0.023
TAX	0.000		0.000	–0.001	*	0.001	0.000		0.000	0.001	**	0.000
TNG	–0.066	***	0.014	0.177	***	0.026	–0.157	***	0.023	–0.226	***	0.026
LIQ	–0.040		0.048	0.223	***	0.085	–0.061		0.080	–0.031		0.083
ROE	0.023	***	0.008	–0.026		0.017	0.037		0.024	0.037	***	0.010
DPR	0.199	***	0.048	0.032		0.085	0.579	***	0.080	0.373	***	0.103
WCR	0.014	**	0.006	0.016	*	0.008	0.039	*	0.020	0.019	*	0.010
GRW	–0.008	***	0.002	–0.006		0.004	–0.021	***	0.006	–0.006	***	0.002
RSK	0.000	***	0.000	0.000		0.000	0.000		0.000	0.000	***	0.000
S	0.008	**	0.004									
L	0.000		0.004									
BE	–0.110	***	0.007	–0.141	***	0.010	–0.071	***	0.011	–0.117	***	0.014
CZ	–0.158	***	0.007	–0.193	***	0.010	–0.128	***	0.012	–0.164	***	0.014
DE	–0.019	***	0.006	–0.063	***	0.009	–0.009		0.010	0.010		0.012
ES	–0.113	***	0.007	–0.166	***	0.009	–0.126	***	0.012	–0.041	***	0.013
FR	–0.019	***	0.007	–0.024	**	0.010	0.001		0.011	–0.018		0.013
IT	–0.006		0.007	–0.045	***	0.010	0.017		0.011	0.005		0.013
NL	–0.082	***	0.010	–0.143	***	0.014	–0.007		0.014	–0.081	***	0.020
PL	–0.193	***	0.008	–0.262	***	0.011	–0.144	***	0.012	–0.172	***	0.014
PT	–0.005		0.007	–0.024	**	0.011	0.001		0.012	0.001		0.013
SK	–0.055	***	0.008	–0.055	***	0.011	–0.043	***	0.013	–0.129	***	0.020
B	–0.025	***	0.009	–0.021	*	0.012	–0.049	***	0.015	0.040	*	0.021
C	0.026	***	0.009	0.083	***	0.013	–0.014		0.014	0.061	***	0.019
D	0.024	***	0.009	0.019		0.013	0.008		0.015	0.098	***	0.019
E	0.035	***	0.009	0.026	**	0.012	–0.007		0.014	0.135	***	0.020

F	0.144	***	0.009	0.183	***	0.014	0.123	***	0.014	0.186	***	0.019
G	0.089	***	0.009	0.146	***	0.015	0.056	***	0.014	0.135	***	0.019
H	0.064	***	0.009	0.088	***	0.012	0.023		0.014	0.162	***	0.019
I	0.096	***	0.009	0.133	***	0.012	0.076	***	0.015	0.075	***	0.020
J	0.034	***	0.010	0.106	***	0.015	0.006		0.015	0.038	*	0.022
L	0.038	***	0.010	0.003		0.014	0.023		0.016	0.137	***	0.022
N	0.157	***	0.009	0.127	***	0.013	0.123	***	0.014	0.275	***	0.020
P	0.035	***	0.012	0.070	***	0.015	−0.026		0.017			
Q	0.027	***	0.010	0.008		0.014	0.017		0.015	0.110	***	0.021
R	0.070	***	0.010	0.080	***	0.013	0.014		0.016	0.103	***	0.023
S	0.083	***	0.010	0.105	***	0.013	0.048	***	0.014	0.108	***	0.028
2001	0.051	***	0.009				0.058	***	0.013	0.027		0.018
2002	0.048	***	0.009				0.054	***	0.014	0.028	*	0.017
2003	0.036	***	0.008				0.036	***	0.014	0.012		0.016
2004	0.032	***	0.008				0.036	***	0.013	0.014		0.015
2005	0.022	***	0.008				0.027	**	0.013	−0.003		0.016
2006	0.017	**	0.008	−0.021	**	0.008	0.026	**	0.012	−0.005		0.016
2007	0.023	***	0.008	−0.013		0.009	0.034	***	0.012	0.006		0.015
2008	0.016	**	0.008	−0.028	***	0.008	0.029	**	0.013	0.005		0.015
2009	0.019	***	0.007	−0.028	***	0.008	0.024	**	0.012	0.014		0.014
2010	0.017	**	0.007	−0.031	***	0.008	0.024	**	0.012	0.006		0.014
2011	0.013	*	0.007	−0.036	***	0.008	0.024	**	0.012	−0.004		0.015
2012	0.024	***	0.008	−0.027	***	0.008	0.033	***	0.012	0.010		0.014
No. obs.			4379			1621			1531			1227
R^2			0.419			0.577			0.471			0.507
Adj. R^2			0.413			0.566			0.455			0.489
Hausman test		37.81 [0.009]		24.82 [0.073]			16.29 [0.699]			52.40 [0.000]		

(continued)

Table 3 (continued)

Variable	All firms (SML)		Small firms (S)		Medium firms (M)		Large firms (L)	
	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
Joint significance								
size	10245 [0.213]							
country	−15.388 [0.000]		−15.848 [0.000]		−6.390 [0.000]		−7.342 [0.000]	
industry	8.454 [0.000]		8.001 [0.000]		2.631 [0.009]		7.238 [0.000]	

Notes: * —significant at the 10% level, ** —5%, *** —1%

Table 4 Values of Akaike's information criterion for models explaining D/A

Effects included in the model	SML	S	M	L
All effects (size[a], country and industry)	−7552.7	−3427.1	−2874.7	−1989.0
Country and industry (size effect omitted)	−7552.0			
Size[a] and industry (country effect omitted)	−6214.6	−2477.6	−2444.9	−1660.2
Size[a] and country (industry effect omitted)	−6743.6	−3005.5	−2566.1	−1608.3

[a]Note: where relevant, that is only in the model for SML

5 Empirical Results

The estimation results for the four panel regression models explaining the variability of total debt to assets (D/A) are displayed in Table 3. When interpreting the influence of firm-specific variables on capital structure, it can be noticed that this impact depends on the size group of firms.

The Wald's joint significance test for size indicates relatively weak impact of the firm size on capital structure, as opposed to the country effect as well as industry effect, both of which proved significant in all four models. The values of the AIC for the models explaining D/A are shown in Table 4.

In each case the omission of a given group of effects results in an increase of the AIC value. The omission of the size dummies practically has no effect on the AIC, which indicates that within the analysed sample the size effect is almost irrelevant in terms of capital structure. However, when the other two effects are taken into account, it appears that the drop of explanatory power is considerable. Moreover, it appears that in the models where only country effects were included, the AIC was clearly lower than in the models with industry effects only. This is the case for all size groups in total, as well as for small and medium firms, which indicates that the impact of the country specificity on total financial leverage is greater than the industry specificity. In addition, the changes in the AIC values are quite varied across size groups. It can be seen that the country impact in the small-sized firms is much bigger than that of industry. The difference between these two effects is considerably smaller for medium firms. As for the large firms, the comparison of the AIC indicates that these are the industry-specific features which matter more than country characteristics, although the difference between the importance of these two effects is the smallest here. It can be explained by the fact that large firms more often than small ones are international companies, whose activity is more likely not to be restricted to local markets, but has a wider, more global range. As a result, such companies are less exposed to country-specific, domestic factors. Nevertheless, the country features are of the key importance for the enterprises of small size. The above model was also estimated for long-term debt (LTD/A) and for short-term debt (STD/A)—in each case for the same size groups. Although the detailed results are not reported here, the conclusions section captures these findings.

The heterogeneity of the results can be explained twofold. First, the size-related differences stem from the fact that small and medium-sized firms tend to be qualitatively quite dissimilar from large, often public companies, which have easier access both to capital markets and funds offered by banks. Therefore, it is also likely that their financing decisions may be driven by other factors. Second, the differences related to debt maturity may result from, and at the same time confirm the fact that the motives for incurring long-term debt and short-term debt are utterly different. While long-term debt policy is often reasoned by tax benefits, short-term financing decisions may derive from relations with suppliers.

6 Conclusions

The study provides support for the significance of several firm characteristics, as well as the industry and country effect in capital structure, as mentioned in the first research hypothesis. However, neither the significance nor the direction of their impact on leverage is uniform across all size groups, as well as with regard to the debt maturity, which in turn provides support to hypotheses 2 and 3. As for the way certain capital structure determinants affect financial leverage depending on which debt measure is taken into account, their impact is much more varied in this cross-section than across size groups. This conclusion is in line with the findings of e.g. Bevan and Danbolt (2002), whose survey of British companies indicates that the determinants of debt vary considerably between short-term and long-term debt. Also Degryse et al. (2012) report differences between the significance of variables related to debt maturity, although only for small Dutch firms.

With reference to hypothesis 4, the hierarchy of the country and industry effect in terms of their importance for capital structure does depend on the firm size, but only in the case of total debt ratio. Given the direction of the impact of the analysed variables on capital structure measured by the share of total debt in the capital, companies tend to be more in line with the TOT. The research findings also indicate that the TOT is also more applicable for short-term debt, whereas POT predictions on capital structure are more suitable in the case of long-term debt. These predictions, however, are not homogeneous neither for all variables, nor across all size groups of firms, as there are some size-wise regularities noticeable concerning the compliance with the capital structure theories. It appears that financing decisions of small firms seem to support the POT more, while medium and large-sized firms are more in line with the TOT hypotheses on debt.

The research results adhere to the existing theories of capital structure by finding the importance of the size effect and the debt maturity effect not only in capital structure as such, but also in the relation between debt level and its various primary determinants. This approach could be defined as the search for secondary (indirect) factors of capital structure.

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Value Creation in a Firm Through Coopetition: Real Options Games Approach

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Abstract The main goal and the original contribution of this paper is to find and describe (wait or invest) decision rules of firms based on market conditions (competition or coopetition), the net present value of a project and the investment option value. Investment decision making is described as a game between two players. Since a real options approach is used to find the value of an investment project, the paper falls in the field of real options games (ROG). Analysis of these games may help explain some aspects of firm behavior and give guidelines for managers. It appears that in a purely competitive environment a real options framework will only be applicable when the classic NPV is definitely negative, even if economic calculations indicate its use at positive NPV. Firms which create a coopetition relationship should be more interested in using real options approach. Furthermore, in order for firms to keep their coopetition agreement and receive greater benefits, high-risk projects should be a greater incentive than low-risk projects.

1 Introduction

In the face of a rapidly changing environment firms, firms are forced to seek new winning strategies to gain advantage in the market and to create value for their owners. Co-opetition is one of the ways of creating value they can choose. In a co-opetitive relationship firms interact in accordance with two different logics of interaction: cooperation and competition (Brandenburger and Nalebuff 1996). However, co-opetition is not simply joining the competition and cooperation issues. It implies that cooperation and competition merge together in order to make a new kind of strategic interdependence between firms, resulting in a coopetitive system of value creation (Dagnino and Padula 2002, 4). Value creation, which requires combining complementary resources and unique competences of both partners and sharing its value, is a hallmark of co-opetition.

The main goal and the original contribution of this paper is to find and describe (*Wait* or *Invest*) decision rules for firms based on market conditions (competition or

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_26

coopetition), the net present value of a project and the investment option value. We investigate in what way the type of market system in which a company operates, influences strategic investment decisions and the value creation. Investment decision making is described as a game between two players, a real options approach is used to find the value of the investment project; thus the paper falls in the field of real options games (ROG) (Grenadier 2000; Smit and Trigeorgis 2004; Chevalier-Roignant and Trigeoris 2011; Trigeorgis and Baldi 2013). We will examine the impact of risk (measured by volatility) on the firm's investment strategy in competitive and coopetitive relationships. Furthermore, we will indicate, under what circumstances a company would be willing to cooperate with its competitor and/or use ROA, and when it would not.

2 The Model of Interaction Between Firms: Option Game

Consider two identical risk neutral firms (A and B) operating in a competitive market. For each of them arises a new investment opportunity. Both competitors share the same investment opportunity—it is a shared option (Smit and Trigeorgis 2004, 35). Each of the firms may exercise the option by paying an investment expenditure I, $I > 0$. We assume that the lifetime of the project is infinite.

Firms can invest immediately, or defer an investment for time T, keeping the investment option waiting for new information from the market.

If the two firms invest at the same time, they share benefits from the market. Since the firms are identical the distribution is equal. If only the one firm invests at the initial moment t = 0, it appropriates all the project benefits and the firm deferring investment is left with nothing.

Companies can operate in pure competition conditions or can decide to cooperate in project financing, and consequently enjoy the benefits of the project in a competitive market, which means creating a co-opetition relationship.

The project generates cash flows (Y_t), which evolve in accordance with the geometric Brownian motion, with drift $\mu, \mu > 0$ and volatility $\sigma, \sigma > 0$ under the risk-neutral measure. A risk-free asset yields a constant rate of return r, $r > \mu$ and the convenience yield is a constant proportion ($\delta, \delta > 0$) of the project's cash flows. The present value of the project is determined by the discounting and accumulating of its future cash flows. It is equal to $V(Y_t) = \frac{Y_t}{\delta}$ (Dixit and Pindyck 1994, 181).

2.1 Pure Competition

There are four cases under pure competition. The decision to invest or to defer is made at time t = 0, so therefore functions of payments are as follows:

(1) Firms A and B invest immediately and simultaneously. Then they share (equally) the project's benefits, and the payment for each firm is the net present value of the project:

$$NPV_0^D := NPV(0{,}5 \cdot Y_t)\big|_{t=0} = V(0{,}5 \cdot Y_0) - I.$$

(2) Firms A and B defer and keep the investment option. In this case the payment for each of them is the call option value from the Black-Scholes-Merton model (the underlying asset is the present value of the project determined with a half of project's benefits $(0{,}5 \cdot Y_t)$, and the exercise price is the investment expenditure I):

$$F_0^D := F(0{,}5 \cdot Y_t)\big|_{t=0}.$$

(3) Firm A invests immediately and appropriates the whole market. Its payment is the net present value of the project:

$$NPV_0 := NPV(Y_t)\big|_{t=0} = V(Y_0) - I,$$

firm B defers and its payment is zero.

(4) Firm A defers and firm B invests right away. Then their payments are corresponding to these of case 3.

To analyze games, assume a basic set of parameters: investment expenditure $I = 6$ (in monetary unit), expiration date $T = 2$ (years), volatility of the project's benefits $\sigma = 20\%$ (low risk) or $\sigma = 80\%$ (high risk), convenience yield $\delta = 4\%$, risk free rate $r = 5\%$. Assumptions about the parameters reflect the situation of real companies (a similar approach use the authors of cited papers).

We will formulate games and define strategies at time t = 0 for different initial values of the cash flows generated by the project $Y_0 > 0$ and hence, for different present values of the project $V_0 > 0$.

Figure 1 presents the option value (F_0^D) and the benefits of instantaneous investment for the only investor (NPV_0) and when the firms invest immediately and simultaneously (NPV_0^D).

In the standard Real Options Analysis the investment rule (invest or delay) is a comparison between the value of the investment option and the present net value of the project. A firm formulates its investment decision in isolation, disregarding interactive competition. Similarly as in the ROA, also in the ROG concept a strategic decision (wait or invest) is determined by the relationship between the value of the investment option and the benefits of immediate investment. However, the movement of a competitor must also be taken into account. If the investment decision is delayed, a firm can recognize the market better and wait for more demand information. But in a competitive environment such firm's behavior could be risky. If an investment opportunity is a shared option, delaying the investment decision may reduce the option value for the rival's decision of

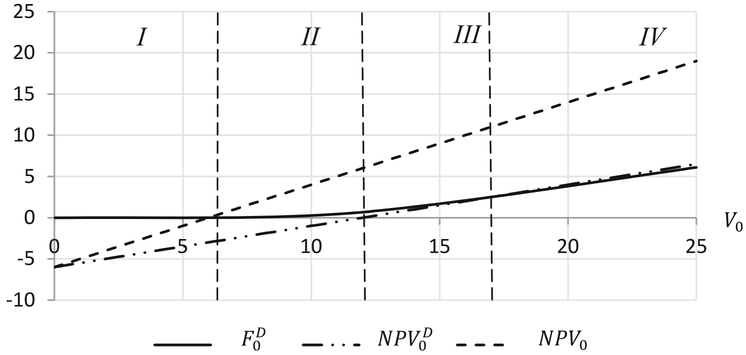

Fig. 1 The pure competition case: the investment option value (F_0^D), the net present value for the only investor (NPV_0) and the net present value when firms invest immediately and simultaneously (NPV_0^D) for different present values of the project (V_0) and regions of firms' interactions. Base case parameters, low risk

instantaneous investment. Therefore, in a competitive environment an investment strategy appears as the outcome of an option game between firms. A normal form of this game is as follows (Table 1):

The type of the game, the way it is played and the payments depend on the relationship between the values (payments): NPV_0, NPV_0^D, F_0^D and 0. Depending on these values, four ranges of the present value of the project's benefits (V_0) appear; in each region firms are playing different games.

In **region *I*** the net present value of the project is very low, it is lower than the investment option value ($NPV_0 < F_0^D$ and $F_0^D > 0$). Sample payoffs in the game for this region are presented in Table 2.

A dominant strategy is *Wait*, keep the investment option. Since a strictly dominant strategy exists for each player in the game, the game has the only one unique Nash equilibrium ($W; W$). This strategy profile gives the highest payments for both players ($F_0^D; F_0^D$). In this region, when the benefits of the project are low, waiting is the optimal decision.

The situation changes entirely when the net present value of the project for the only investor exceeds the value of the investment option, but at the same time the net present value of the project, when both firms invest, remains negative ($NPV_0^D < 0 < F_0^D \leq NPV_0$ **region *II***). It means that if the company is the only investor in the market, it benefits; if both firms invest at the same time they suffer losses—the market does not provide revenues cover expenditures for both of them. However, players can risk the implementation of the project despite of the existing threat. Sample payoffs in the game for this region are presented in Table 3.

This game has two pure non-equivalent and non-interchangeable equilibria: ($W; I$) and ($I; W$); there is also a mixed strategy equilibrium where each player *Waits* with probability p ($p \cdot W, (1-p) \cdot I; p \cdot W, (1-p) \cdot I$). This is the most difficult situation for both players; benefits are the hardest to achieve. This game has no dominant

Table 1 Payoff matrix in a competitive environment

		FIRM B	
		WAIT (W)	INVEST (I)
FIRM A	WAIT (W)	$(F_0^D; F_0^D)$	$(0; NPV_0)$
	INVEST (I)	$(NPV_0; 0)$	$(NPV_0^D; NPV_0^D)$

Table 2 Example of payoff matrix for region I ($V_0 = 5,5$); low risk (a) or high risk (b)

	WAIT (W)	INVEST (I)		WAIT (W)	INVEST (I)
WAIT (W)	$(0,01; 0,01)$	$(0; -0,5)$	WAIT (W)	$(0,58; 0,58)$	$(0; -0,5)$
INVEST (I)	$(-0,5; 0)$	$(-3,25; -3,25)$	INVEST (I)	$(-0,5; 0)$	$(-3,25; -3,25)$
	(a)			(b)	

Table 3 Example of payoff matrix for region II ($V_0 = 10$); low risk (a) or high risk (b)

	WAIT (W)	INVEST (I)		WAIT (W)	INVEST (I)
WAIT (W)	$(0,25; 0,25)$	$(0; 4)$	WAIT (W)	$(1,76; 1,76)$	$(0; 4)$
INVEST (I)	$(4; 0)$	$(-1; -1)$	INVEST (I)	$(4; 0)$	$(-1; -1)$
	(a)			(b)	

strategy for any player. Each of them may seek different equilibria making a decision *Invest*—the worst possible and giving the lowest possible payments of both players $(I; I)$. We note that both of them could achieve a better result at the strategy profile $(W; W)$.

A slightly improved, but still suboptimal situation is in the **region *III*** $(0 < NPV_0^D < F_0^D < NPV_0)$. The game in this region is the prisoner's dilemma. This game has the only one dominant strategy (*Invest*) and the only one Nash equilibrium—strategy profile $(I; I)$. In this case, the simultaneous investment does not lead to losses (NPV_0^D is slightly above zero), but even so, both companies would benefit from waiting, keeping the investment option and observing the market. The payoff amounts in strategy profile $(W; W)$ are higher than in profile $(I; I)$. Sample payoffs in the game for this region are presented in Table 4.

When the net present value of the project for both companies exceeds the value of the investment option ($0 < F_0^D < NPV_0^D$ **region *IV***), the optimal strategy for both players becomes the strategy profile $(I; I)$. It is the dominant strategy leading to Nash equilibrium and the payoffs in this strategy profile are the best for both players. For high values of the project, *Invest* is the best natural decision. Sample payoffs in the game for this region are presented in Table 5.

The higher the project risk, the greater the difference between the Nash equilibrium strategy payoff and the payoff in the strategy profile, giving both the highest payments. This large difference means that if we could work out the device for inducing players to act in the name of group rationality, the firm would achieve greater benefits than in the case of isolated, uncoordinated individual actions.

Note also that these considerations enable us to formulate conclusions about possible managers' interest in using Real Option Analysis in decision making

Table 4 Example of payoff matrix for region III ($V_0 = 16$); low risk (a) or high risk (b)

	WAIT (W)	INVEST (I)		WAIT (W)	INVEST (I)
WAIT (W)	$(2,08; 2,08)$	(0; 10)	*WAIT (W)*	$(3,81; 3,81)$	(0; 10)
INVEST (I)	(10; 0)	(2; 2)	*INVEST (I)*	(10; 0)	(2; 2)
	(a)			(b)	

Table 5 Example of payoff matrix for region IV ($V_0 = 38$); low risk (a) or high risk (b)

	WAIT (W)	INVEST (I)		WAIT (W)	INVEST (I)
WAIT (W)	$(12,11; 12,11)$	(0; 32)	*WAIT (W)*	$(12,88; 12,88)$	(0; 32)
INVEST (I)	(32; 0)	(13; 13)	*INVEST (I)*	(32; 0)	(13; 13)
	(a)			(b)	

process. In the purely competitive environment, the ROA will only be applicable in the case when the classic NPV is distinctly negative, even if the economic calculations recommend its use at positive NPV.

2.2 Coopetition

We will assume that firms can share investment expenditures and increase their economic profits through increasing the size of the business pie (underlying market value is enlarged by a multiplier) (Ritala 2012, 309).

Arrangement between two firms may involve the adoption of a concerted strategy (*Wait* or *Invest*), but each of the parties will eventually make autonomous decisions and might reject the conditions of the cooperation agreement—both firms are competitors in the market. There are five cases under coopetition and the functions of payoffs (at time t = 0) are as follows:

(1) Firms A and B invest immediately and simultaneously. There is a coopetition arrangement between them; they share (equally) project's expenditures and benefits; the underlying market value is enlarged by a multiplier m and the payment for each firm is the net present value of the project:

$$NPV_0^{coop} := NPV(0,5 \cdot m \cdot Y_t)\big|_{t=0} V(0,5 \cdot m \cdot Y_0) - 0,5 \cdot I,$$

m—a multiplier of enlarging the underlying market value ($m \geq 1$).

(2) Firms A and B maintain the coopetition agreement, defer and keep the investment option. In this case the payment for each of them is the call option value from the Black-Scholes-Merton model (the underlying asset is the present value of the project determined with a half of project's benefits ($0,5 \cdot Y_t$), and the exercise price is a half of investment expenditure ($0,5 \cdot I$):

$$F_0^{coop} := F(0,5 \cdot m \cdot Y_t)\big|_{t=0}.$$

(3) There is a coopetition arrangement between firms but firm A breaks the agreement and invests immediately. Therefore, it appropriates the whole market and bears all the investment expenditure, its payment is the net present value of the project:

$$NPV_0 := NPV(Y_t)|_{t=0} = V(Y_0) - I,$$

firm B defers and its payment is zero.

(4) Firm A defers and firm B breaks the coopetition agreement and invests immediately. Then their payments are corresponding to these of case 3.

(5) There is a coopetition arrangement between firms but both of them break it and invest immediately—there are no benefits of cooperation and for both, the payments are:

$$NPV_0^D := NPV(0,5 \cdot Y_t)\big|_{t=0} = V(0,5 \cdot Y_0) - I.$$

Figure 2 shows the values of all possible payoffs.

When both firms invest immediately in the framework of coopetition, their payments are equal (NPV_0^{coop}) and there is no problem with keeping agreement. A market game appears when both parties negotiate a coopetition agreement to defer the execution of the project and keep an investment option. However, following this agreement, they can make different decisions and investment strategies. This game can be presented in a normal form (Table 6):

The type of the game, the way it is played and the payments depend on the relationship between the values (payments): NPV_0, NPV_0^D, NPV_0^{coop}, F_0^{coop} and 0. Depending on these values, four ranges of the present value of the project's benefits (V_0) appear; in each region firms are playing different games (Table 7).

3 Benefits of Coopetition

3.1 Coopetition vs. Competition

For $NPV_0^{coop} > NPV_0^D$ and $F_0^{coop} > F_0^D$ the differences between the payments in the case when the coopetition agreement is set up and kept and the payments under pure competition conditions are (almost) always positive (the problem of determining this difference appears in the region II, where it is difficult to predict how a game will be played and what its solution will be (there is no dominant strategy)). Furthermore, it is easy to calculate that the higher the risk of the project and the longer the maturity option, the greater the benefits of coopetition. It means that in

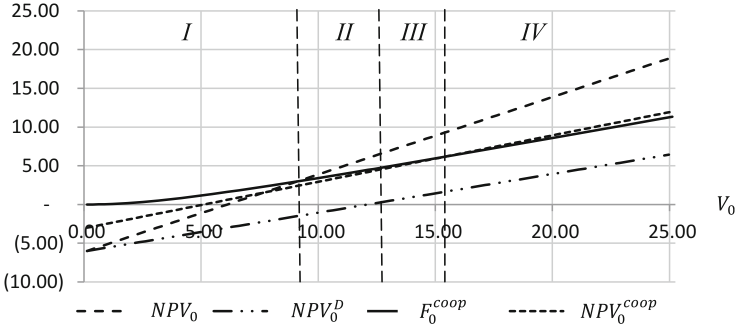

Fig. 2 The coopetition case: the investment option value (F_0^{coop}), the net present value for the only investor (NPV_0) and the net present value when both firms invest immediately and simultaneously with benefits of cooperation (NPV_0^{coop}) or without them (NPV_0^D) for different present values of the project (V_0) and regions of firms' interactions. Base case parameters, high risk

Table 6 Payoff matrix in a coopetition case

		FIRM B	
		WAIT (W)	INVEST (I)
FIRM A	WAIT (W)	$\left(F_0^{coop}; F_0^{coop}\right)$	$(0; NPV_0)$
	INVEST (I)	$(NPV_0; 0)$	$\left(NPV_0^D; NPV_0^D\right)$

these cases, firms should be more interested in establishing a coopetition relationship in order to stabilize the benefits and create more value from the project.

3.2 Coopetition: Loyalty vs. Disloyalty

First of all, it is important to note that for very low present values of the project V_0 (when $NPV_0 < F_0^{coop}$, region *I*), as well as for relatively high values (when $NPV_0^{coop} > F_0^{coop}$, region *IV*), there is no threat to keeping a coopetition agreement. When V_0 is low, both firms defer the investment decision; when V_0 is high, both of them invest immediately and enjoy the benefits of cooperation The threat of a breakdown of coopetition agreement exists when the present value of the project's benefits (V_0) belongs to regions *II* or *III*. There is no dominant strategy in region *II* and players aiming for the best possible individual result can lead to a situation when both of them lose (receive the worst possible payments). In the region *III* the dominant strategy exists (it is a breach of the contract) and leads to lower payments than in the case of keeping the coopetition agreement.

Let V_0^W, V_0^D and V_0^I mean the present values of the project when (adequately): $F_0^{coop} = NPV_0$, $NPV_0^D = 0$ and $NPV_0^{coop} = F_0^{coop}$. When $V_0 \in \left[V_0^W, V_0^I\right]$ (regions *II* and *III*) a threat of breakdown of the coopetition agreement exists. (Fig. 3).

Table 7 Investment rules in a coopetition case in the Real Option Games approach

Region	The relationship between the benefits of immediate investment and the option value	Nash Equilibrium		The highest payoff simultaneously for BOTH players	
		Strategy profile	Payment	Strategy profile	Payment
I	$NPV_0 < F_0^{coop}$ and $F_0^{coop} > 0$	$(W;W)$	$(F_0^{coop};F_0^{coop})$	$(W;W)$	$(F_0^{coop};F_0^{coop})$
II	$NPV_0^D < 0 < F_0^{coop} \leq NPV_0$	$(W;I)$ $(I;W)$ $(p\cdot W,(1-p)\cdot I;$ $p\cdot W,(1-p)\cdot I)$	$(0;NPV_0)$ $(NPV_0;0)$ $(p\cdot F_0^{coop};$ $p\cdot F_0^{coop})$	$(W;W)$	$(F_0^{coop};F_0^{coop})$
III	$0 < NPV_0^D < NPV_0^{coop} \leq F_0^{coop} < NPV_0$	$(I;I)$	$(NPV_0^D;NPV_0^D)$	$(W;W)$	$(F_0^{coop};F_0^{coop})$
IV	$0 < F_0^{coop} < NPV_0^{coop}$	Immediate investment in the framework of the cooperation agreement; payment for each party is NPV_0^{coop}			

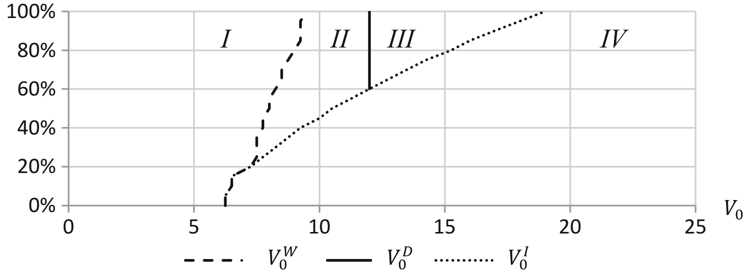

Fig. 3 Coopetition: regions of firms' interactions for different risk levels (σ)

When the project risk is low (e.g. $\sigma = 20\%$), there is no threat of breakdown of the coopetition agreement, no matter what the present value of the project is. The threat of a breakdown of the coopetition agreement exists, when the project risk is very high and the present value of the project belongs to regions *II* or *III* (e.g. if $\sigma = 80\,\%$, $V_0 \in [9, 15]$). Conclusion: the more risky the project, the much more attention and consideration have to be paid to create a coopetition relationship.

However, we can also calculate the benefits from keeping an agreement (the difference between the payment in the pessimistic scenario (both firms break the contract and invest independently), and the payment in the optimistic scenario (both sides keep the agreement and hold the investment option)). It appears that the higher the project risk in this problematic range is, the larger the benefits. This could mean that riskier projects should be a greater incentive for firms in order to keep their coopetition agreement.

4 Conclusion

The results of this study shed a light on the sources of benefits of a coopetition relationship between firms. Obviously, the benefits depend on the present value of the project. However, we can also specify other factors which affect these benefits: the type of market game, the risk of the project and the maturity of the investment option. Arguments developed in the paper lead to two key findings:

(1) A coopetition relationship is easy to set up and keep for low-risk projects, but for high-risk firms it requires the much more attention and consideration. However, keeping a coopetition agreement gives more benefits to firms where the project risk is higher. It means that high-risk projects should be greater incentive for firms in order to keep their coopetition agreement and to receive the greater benefits.
(2) In a purely competitive environment the Real Option Analysis (ROA) will only be applicable when the classic NPV is definitely negative, even if the economic calculations recommend its use at positive NPV. This may be one of the reasons

why despite of the initial enthusiasm, ROA has proven difficult to put into practice and its implementation tends to be slow.

We can notice a greater capability to use ROA with firms which create a coopetition relationship. A rising importance of coopetition relationships and their dynamic development gives us hope that the significance of ROA in the strategic decision-making process will increase.

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Part VII
Household Finance

Does a Household's Wealth Determine the Risk Profile of Its Financial Asset Portfolio?

Katarzyna Kochaniak

Abstract The aim of this study is to identify and analyse the risk profiles of household financial asset portfolios and their determinants in 15 euro area countries. Financial assets relate to deposits, managed accounts, mutual fund units, bonds, shares, private lending, voluntary pension plans and whole life insurance contracts, private businesses, and others. The study uses a fractional multinomial logit model to recognise the importance of safe, relatively safe, and risky components of portfolios for households assigned to 5 wealth classes. The main results prove the primary importance of deposits for households in almost all the member states. Moreover, the features influencing the structure of portfolios lead to conclusions about the greater exposure to financial risks of wealthier respondents than those less affluent. However, the study identifies the countries where contrary preferences characterise households with real assets of high values.

1 Introduction

Despite the long-term integration period of the European Union (EU) member states, including the attempts taken to create a single financial market with consumers in the role of key participants, households' financial investments remain heterogeneous. Domestic conditions, such as living or cultural standards appear as crucial factors determining investment abilities and interests of individuals and thus risk profiles of their portfolios. For that reason, an attempt to analyse and compare the investment preferences of euro area households regarding financial assets is undertaken.

The aim of this paper is to identify and explain households' preferences in financial asset accumulation taking into consideration their risk profile in 15 euro area countries. The financial investments under consideration consist of deposits, mutual fund units, bonds, shares, private lending, pension plans or whole life insurance contracts, non-self-employment private businesses, and others

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_27

(e.g. options, futures, and index certificates). Their differentiated risk exposure allows classifying them into three categories: "safe", "relatively safe", and "risky", which constitute portfolio parts. The study answers the following research questions: Do the households perceive the same type of financial assets as a component of primary importance for their wealth across the euro area? Are their investment preferences uniform in the Eurozone or formed within certain subsets of member states? Is the structure of portfolios significantly shaped by households' net wealth and its components in individual countries? At which value of assets possessed and debt incurred does the risk profile of a portfolio change most significantly?

2 Related Literature

Part of the literature on household finance describes differences in the composition of households' portfolios in cross-country comparisons or between certain demographic groups of particular interest. The importance of risky assets is discussed by, e.g., Guiso et al. (2002) and Haliassos (2002). Safe or relatively safe components of portfolios remain in the literature without further distinction. However, the recent global financial crisis has highlighted their significant position among other financial assets (Du Caju 2013; Teppa et al. 2015).

The factors influencing household investment decisions have been intensively investigated, leading to conclusions about the importance of, e.g., risk attitudes (Guiso and Paiella 2008), values of real assets (Cocco 2005) or debt (Kukk forthcoming). Bilias et al. (2008) identify household features, including wealth, which may explain the investment behaviour of individuals on the stock markets. The study by Christelis et al. (2011) confirms the significance of households' characteristics; however, it emphasises the importance of the economic environment.

The main contribution of this study to the literature is the knowledge of the significance of households' wealth for the risk profiles of their financial asset portfolios. This wealth covers both assets and debt. Thus, it fills an existing gap in the studies on household portfolio choices, as well as the growth potential of retail financial markets. Moreover, the results presented provide a starting point for the analysis of changes in household preferences, caused by persistent financial and economic instability in the euro area, based on the second wave data of the Eurosystem Household Finance and Consumption Survey (HFCS).

Table 1 General information about domestic samples of households from the first wave of the Eurosystem HFCS

Country	No. of households with financial assets	Fractions of households with financial assets in the sample (in %)	Surveying period
AT	2,315	97.3	09.2010–05.2011
BE	2,275	97.8	04.2010–10.2010
CY	1,108	89.6	04.2010–01.2011
DE	3,474	97.4	09.2010–07.2011
ES	5,956	96.1	11.2008–07.2009
FI	10,989	100.0	01.2010–05.2010
FR	14,868	99.1	10.2009–02.2010
GR	2,219	74.7	06.2009–09.2009
IT	6,590	92.9	01.2010–05.2010
LU	936	98.5	09.2010–04.2011
MT	814	96.6	10.2010–02.2011
NL	1,261	96.9	04.2010–12.2010
PT	4,143	94.1	04.2010–07.2010
SI	300	87.5	10.2010–12.2010
SK	1,910	92.9	09.2010–10.2010
EA	59,158	94.6	11.2008–07.2011

3 Data and Methodology

The study uses quantitative household-level data on 59,158 euro area households who possessed at least one type of financial asset. These data stem from the first wave of the Eurosystem HFCS which was conducted in 15 countries, i.e. Austria (AT), Belgium (BE), Cyprus (CY), Germany (DE), Spain (ES), Finland (FI), France (FR), Greece (GR), Italy (IT), Luxembourg (LU), Malta (MT), the Netherlands (NL), Portugal (PT), Slovenia (SI) and Slovakia (SK). Household samples are arranged to be representative of particular country and of the euro area as a whole. However, it should be noted that institutional and macroeconomic heterogeneity of the member states may limit their use for cross-country analysis (ECB 2013). The survey was conducted by national central banks and statistical institutions. Table 1 presents information about the sizes of domestic samples and surveying periods.

The variables applied in the study comprise quantitative data (in EUR) regarding households': Financial assets—sight deposits (*D_S*), saving deposits (*D_V*), bonds (*B*), deposits on managed accounts (*MA*), money owed to households (*MO*), mutual fund units (*MF*), non-self-employment private businesses (*NSEB*), shares publicly traded (*S*), voluntary pension plans or whole life insurance contracts (*VP_WLI*), other assets (*OA*), total financial assets (*TFA*) denoting the value of all financial assets of a household; Real assets—total real assets (*TRA*) representing the value of all real assets (real estate, vehicles, valuables, etc.) possessed by a household; Liabilities—total financial debt (*T_LIAB*) referring to debt from loans; Net wealth (*NW*)—a sum of TFA and *TRA* minus *T_LIAB*.

The risk profiles of households' portfolios are described by the shares of the following categories of financial assets: Safe (*S*)—sight deposits (*D_S*) and saving deposits (*D_V*); Relatively safe (*RS*)—bonds (*B*) and voluntary pension plans or whole life insurance contracts (*VP_WLI*); Risky (*R*)—the remaining ones (*MA*, *MF*, *MO*, *NSEB*, *OA*, and *S*). The latter covers all household investments, where the loss of invested capital is highly likely. The middle one is applied because most assets are neither completely safe nor entirely risky. The consensus among empirical researchers is to regard equities or financial instruments based on them as apparently risky, while sight and saving deposits—as clearly safe. Thus, the remaining assets are subsumed into the intermediate category. In the study, the main concerns pertain to the classification of bonds due to a lack of deep insight into their composition and risk. Households can invest in government bonds (considered to be almost risk-free) as well as in corporate bonds (facing significantly higher risk levels). Thus, this dilemma results in their assignment into the intermediate category. A similar uncertainty is related to private lending. Lack of knowledge about the borrower's financial situation leads to the inability to assess and manage the risks involved in such investments and their assignment to the risky part of portfolios.

The analysis of household financial investment decisions shall take into consideration the values of the characteristics in individual countries, due to institutional and macroeconomic differences in the euro area, including the standard of living. For that reason the variables *TFA*, *TRA*, *T_LIAB* and *NW* are converted into dummies, denoting the affiliation of a household to one of the following classes: *Class 1*—the lowest range of the variable's value: $x < 50\%\bar{x}$; *Class 2*—low range of the variable's value: $50\%\bar{x} \leq x < 100\%\bar{x}$; *Class 3*—medium range of the variable's value: $100\%\bar{x} \leq x < 150\%\bar{x}$; *Class 4*—higher range of the variable's value: $150\%\bar{x} \leq x < 200\%\bar{x}$; *Class 5*—the highest range of the variable's value: $x \geq 200\%\bar{x}$. The ranges are estimated regarding the variables' arithmetic mean in the national and euro area samples. In the majority of cases, more than 50% of populations belong to class 1 (Table 2).

This conversion permits analysis of the impact of the considered factors on portfolio structure within individual populations, as well as in cross-country comparisons, set against the background of the Eurozone. The first class is assumed to be the basis for comparison. Thus, the transformation allows displaying the differences in portfolio structure between the least involved household in assets and liabilities (characterised by the lowest wealth or debt) and a household classified as

Table 2 Fractions of households (in %) characterised by variables' values from class 1

	AT	BE	CY	DE	ES	FI	FR	GR	IT	LU	MT	NL	PT	SI	SK	EA
1	55	32	56	52	65	35	50	39	36	42	43	25	49	36	32	45
2	67	64	63	59	78	62	75	64	59	59	48	44	67	62	59	66
3	82	70	54	73	76	62	74	77	83	65	80	51	74	73	82	73
4	56	42	59	53	68	42	56	41	38	48	43	36	52	40	34	50

1st column: 1—*TRA*; 2—*TFA*; 3—*T_LIAB*; 4—*NW* more involved (wealthier or more indebted). Moreover, analysing these structures class by class, the evolution of investment preferences can be seen.

The analysis of the determinants of portfolio structure is based on a fractional multinomial logit model (Mullahy 2011; Murteira and Ramalho 2013), which permits estimation of the conditional mean for the shares of financial assets in a portfolio that together comprise the underlying total. The decision to choose this model is due to its suitability for carrying out the study on all the households with financial assets, regardless of the degree of diversification of their portfolios.[1] It should be noted that in HFCS, many respondents declared a lack of selected components. Moreover, some of them were focussed solely on one type of financial asset. The implementation of the fractional multinomial logit model for Stata® is provided by Buis (2008) in an ado file named *fmlogit*. The following formula describes the model:

$$E\left[y_{ij}|x_i\right] = \Lambda\left(x_i\beta_j\right) = \frac{\exp\left(x_i\beta_j\right)}{\left[\sum_{h=1}^{J}\exp(x_i\beta_h)\right]} \tag{1}$$

where: y_{ij}—j-th asset held by the i-th individual ($j = 1\ldots$J); x_i—financial asset portfolio of the i-th individual; β—vector of regression coefficients.

The model reflects the bounded nature of each share (i.e. $0 \leq y_{ij} \leq 1$ for $j = 1$...J) as well as the fact that shares add up to unity (i.e. $\sum_{j=1}^{J} y_{ij} = 1$). It implies that the predicted shares from the model should also lie between 0 and 1 (i.e. $E[y_{ij}| x_i] \in (0,1)$ for j=1…J) and add up to one (i.e. $\sum_{j=1}^{J} E\left[y_{ij}|x_i\right] = 1$). Following Mullahy (2011) and Murteira and Ramalho (2013), the estimation of the conditional mean for all the shares jointly is based on the quasi-maximum likelihood estimator for the multinomial logit specification. A contribution of individual household to the likelihood is:

$$L_i(\beta) = \prod_{j=1}^{J} E\left[y_{ij}|x_i\right]^{y_{ij}} \tag{2}$$

The sum of the individual log-likelihoods is maximised to obtain the estimator for β:

$$\widehat{\beta} = \arg max_\beta \sum_{i=1}^{N} \log L_i(\beta) \tag{3}$$

The study incorporates the model in 2 variants characterised by the following sets of covariates: (I) dummies denoting an affiliation of a household to a certain class of *NW*; (II) dummies denoting an affiliation of a household to a certain class of *TRA*, *TFA*, and *T_LIAB*.

[1]It allows recovering the regression function for the fractional variable even with data at the extreme values of zero and one.

4 Results: Portfolios' Description

The highest average values of financial asset portfolios, ranging from EUR 132,424.35 to EUR 213,065.17, characterised households from Belgium, France, Luxembourg, and Spain. Their comparison to the values of average portfolios in the remaining member states revealed a significant diversity of financial wealth among the Eurozone samples. In the rest of countries, average portfolios were limited to five-figure sums. The subgroup of member states with the lowest average values of financial asset portfolio was comprised of Greece (EUR 15,028.46), Slovenia (EUR 13,839.75) and Slovakia (EUR 6897.18).

Safe assets (S) were perceived by respondents as necessary components of their portfolios. From all the Eurozone households possessing financial assets, 99% declared them, and 49% reported them as the sole item. An average portfolio in the euro area consisted of 72% in safe assets, but half of all households surveyed possessed safe assets which constituted at least 99% of the values of their portfolios. The second favoured asset category in the Eurozone was relatively safe (RS) with an average share in household portfolios equal to 16%. The least significant risky assets (R) formed 12% of an average portfolio in the whole group of countries. However, in the case of the two latter asset categories, they did not appear in the financial asset portfolios of more than 63% of the Eurozone households.

In the comparison of portfolios between the countries, deposits emerged as a component possessed by at least of 82% of each population. Their most prominent average shares in financial assets were displayed in Greece (93%), Portugal (87%), Austria (86%), and Slovakia (84%). In these countries, at least 67% of households surveyed were characterised by portfolios comprised solely of deposits. Moreover, safe assets could be proclaimed as the dominant item in all the countries except Cyprus. Cypriot households divided their funds between safe assets (47% of the average portfolio) and those relatively safe (39% of the average portfolio) leaving themselves as the sample with the largest proportion totally without deposits (18%). Similarly, the limited significance of relatively safe assets (37% of the average portfolio) appeared in the Netherlands.

Relatively safe assets (RS) were recognised as items of secondary importance in the average financial asset portfolio in the Eurozone. In individual member states, apart from Cyprus and the Netherlands, they appeared in this role in Belgium, France, Germany, Italy, Luxembourg, Malta, and Slovenia, with the average proportions ranging from 9% to 25%. It is worth noting that more than 50% of households who possessed any value of assets from this category were identified only in Belgium, Cyprus, Germany, and the Netherlands. Households with solely relatively safe portfolio components constituted marginal parts of the samples (up to 2%). Those with larger proportions were recognised in Cyprus (9%) and the Netherlands (4%).

In the entire group of member states, the lowest importance was assigned to risky assets (R). However, in individual countries, their position in portfolios was not so evident. In Austria, Finland, Greece, Portugal, Slovenia and Spain their average proportions ranged from 7% to 18% placing them in the second position according to household investment preferences. But even there, risky items could not be assessed as commonly occurring, as less than 50% of households surveyed declared their possession.

The heterogeneity of average domestic portfolio structures provided an incentive to group countries according to a similar composition of assets. On the background of Ward's method, the following sub-groups of the Eurozone member states could be identified:

(1) Austria, Greece, Portugal, and Slovakia;
(2) Belgium, Cyprus, Germany, the Netherlands;
(3) Finland, France, Italy, Luxembourg, Malta, Slovenia, and Spain.

Comparing Euclidean distances between the subsets, the greatest differences in portfolio structures were found between the countries from the first subset and the other two. It is worth noting that the Eurozone's average portfolio profile appeared as comparable with those obtained for the member states from the last subset. In the first sub-group, the closest similarities were displayed between the structures of Austrian and Portuguese average portfolios. In the second one, Belgian and German households' financial investment preferences were assessed as particularly tight. The last one implied evident resemblance to average structures in Italy and Malta.

5 Results: Fractional Multinomial Logit Regression

To explain the structures of financial asset portfolios held by households in each country and the Eurozone, the fractional multinomial logit model in two versions was adopted in the study. General outcomes are presented in Tables 4 and 6. It should be explained that the households with negative values of net wealth (*NW*) became excluded from the analysis. The pilot study indicated this subset as mainly isolated in the Eurozone and requiring separate consideration. In the entire group of countries, households with negative net wealth constituted 3.6% of the sample. Thus, their rejection did not distort the patterns among the variables.

Version 1 of the model permitted analysis of the impact of a household's net wealth (*NW*) on its portfolio structure. According to the assumptions in Sect. 3, a household characterised by *NW* from the lowest range became the basis for comparison. Households fulfilling this criterion constituted significant segments of the populations. The predicted structures of a financial asset portfolio of such a household in each of countries and the Eurozone significantly differed. The least oriented regarding safe assets was a respondent from Cyprus (51% of a portfolio), while the one from Greece had accumulated 97% of its funds in these items (Table 3).

The level of *NW* was found as a feature significantly affecting households' preferences regarding the structure of portfolios (Table 4). In the Eurozone, greater *NW* had been gradually discouraging individuals from investing in safe assets and

Table 3 The predicted structure of an average financial asset portfolio (in %) of a household characterised by NW from the class 1 in individual countries and the Eurozone

	AT	BE	CY	DE	ES	FI	FR	GR	IT	LU	MT	NL	PT	SI	SK	EA
1	90	72	51	64	80	82	80	97	85	73	84	61	91	77	85	81
2	4	20	38	24	11	8	14	1	12	19	12	34	4	12	10	12
3	6	8	11	12	9	10	6	2	3	8	4	5	5	11	5	7

1st column: 1—*S*/*TFA*; 2—*RS*/*TFA*; 3—*R*/*TFA*

Table 4 The classes of *NW* with the greatest differences (in p.p.) in portfolio structure in comparison to class 1

	S/TFA	RS/TFA	R/TFA
AT	5 (−21.85)	5 (11.86)	5 (9.99)
BE	5 (−37.61)	4 (9.66)	5 (28.78)
CY	4 (−13.95)	2 (10.86); 5 (−11.60)	5 (17.33)
DE	5 (−23.26)	5 (8.11)	5 (15.15)
ES	5 (−46.76)	4 (5.25)	5 (42.86)
FI	5 (−32.09)	5 (9.31)	5 (22.79)
FR	5 (−53.42)	5 (29.09)	5 (24.33)
GR	5 (−12.25)	5 (5.42)	5 (6.83)
IT	5 (−34.88)	5 (19.08)	5 (15.80)
LU	5 (−22.02)	x	5 (2.77)
MT	5 (−35.44)	4 (26.81)	5 (15.03)
NL	5 (−21.38)	3 (11.01)	5 (18.65)
PT	5 (−16.05)	5 (7.09)	5 (8.96)
SI	5 (−29.92)	x	5 (19.97)
SK	5 (−8.67)	x	5 (6.48)
EA	5 (−34.85)	5 (13.97)	5 (20.89)

Numbers preceding parentheses show the classes of *NW* with the greatest changes in portfolio structure in comparison with *NW* from class 1. The scale of change is reported in parentheses (in p. p.)

redirecting their interests primarily towards risky items. The shares of relatively safe assets of households from classes 2–5 were also subject to increase. However, regarding classes 3–5, they kept a shorter distance from that in a portfolio of a household from class 1.[2] The above results led to the conclusion that a significant appetite for risky investments was demonstrated along with the multiplication of wealth in the Eurozone. Analysing household investment preferences in individual countries, it can be found that the substitutability of safe assets by the remaining categories was present in all of them. However, the results also revealed opposing tendencies towards relatively safe assets in the Cypriot sample, between a household with *NW* from class 2 and a household with *NW* from class 5. The first one was better equipped with relatively safe items than the basis for comparison (higher

[2]The changes in the predicted structure of a portfolio (in p.p.) caused by increasing *NW* from class 1 to 5: *S:* −10, −17, −23, −35; *RS*—6, 8, 11, 14; *R*—4, 9, 12, 21.

Table 5 The predicted structure of an average financial asset portfolio (in %) of a household characterised by *TRA*, *TFA*, and *T_LIAB* from the class 1 in individual countries and the Eurozone

	AT	BE	CY	DE	ES	FI	FR	GR	IT	LU	MT	NL	PT	SI	SK	EA
1	92	77	61	69	83	86	82	98	90	80	90	74	95	85	90	84
2	3	16	28	20	8	4	13	0	8	14	7	22	2	5	5	10
3	5	8	11	11	8	10	5	2	2	6	3	4	4	10	5	6

1st column: 1—*S*/*TFA*; 2—*RS*/*TFA*; 3—*R*/*TFA*

share by 11 p.p.), while a household belonging to class 5 possessed them of lower value (lower share by 12 p.p.). In Austria, Finland, France, Germany, Greece, Italy and Portugal, the greatest differences in portfolio structures occurred between those predicted for class 1 and class 5 (representing the wealthiest households). However, in some of them (Austria, France, and Italy) the decline of interest in safe assets has motivated a typical household to greater engagement in relatively safe assets rather than risky ones. In the remaining countries (Germany, Finland, Greece, Portugal, and Spain) a household from the richest class was focussed the most on risky components of its portfolio.

Version 2 of the model assumes the influence of the values of total financial assets (*TFA*), total real assets (*TRA*) and total liabilities (*T_LIAB*) on the structure of household portfolios. The adoption of three independent variables allowed to obtain extended results which are partially presented in Table 6. Detailed results are discussed in the text. The basis for comparison remained a household, characterised by the values of all covariates from the lowest range (class 1). The proportions of its safe, relatively safe, and risky assets varied between the member states (Table 5).

In the Eurozone, possessing real or financial assets of the highest values tended to downplay the importance of safe assets and raised the importance of the other categories (Table 6). Thus, a household holding them was more oriented to relatively safe and risky assets than the basis for comparison. However, precise outcomes showed that increasing *TRA* (class by class) made risky assets more attractive, while increasing *TFA*—those relatively safe. The greater risk exposure was noted for a household with liabilities exceeding the debt level established for class 1. It means, the more actively debt was used as a funding source, the more risk-oriented investments in financial assets became. However, detailed results disclosed that increasing *T_LIAB* caused a growth rather in the shares of relatively safe assets than risky ones.[3] In individual countries, portfolio structure has not maintained itself in such an unambiguous manner. In Finland, France, and Italy any value of *TRA* exceeding class 1 resulted in a reduction of the share of deposits and favoured the other asset categories, but the greatest changes occurred between portfolios of households with real assets from class 1 and class 5. From the impact of the value of TFA on the portfolio's structure, a general conclusion could be drawn: the value beyond class 1 stimulated greater interest in relatively safe or risky assets. Complete results for Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, Malta and Portugal prove that this interest was focussed on both of

[3]Average increase (in p.p.) of *RS* by: 5, 6, 6, 5, while of *R* by: 1, 1, 1, 2.

Table 6 The classes of *TFA*, *TRA*, *T_LIAB* with the greatest differences in portfolio structure in comparison to class 1

	S/TFA			RS/TFA			R/TFA		
	TFA	TRA	T_LIAB	TFA	TRA	T_LIAB	TFA	TRA	T_LIAB
AT	5 (−)	3 (+)	4 (−)	5 (+)	5 (−)	5 (+)	5 (+)	3 (−)	3 (−)
BE	5 (−)	4 (−)	2 (−)	2 (+)	4 (+)	3 (+)	5 (+)	5 (+)	x
CY	5 (−)	x	5 (−)	x	5 (−)	5 (+)	5 (+)	4 (+)	x
DE	5 (−)	2 (+)	5 (−)	4 (+)	2 (−)	5 (+)	5 (+)	x	3 (−)
ES	5 (−)	4 (−)	2 (−)	2 (+)	4 (+)	2 (+)	5 (+)	4 (+)	5 (+)
FI	5 (−)	5 (−)	5 (−)	5 (+)	5 (+)	5 (+)	5 (+)	5 (+)	2 (−)
FR	5 (−)	5 (−)	2 (−)	5 (+)	5 (+)	x	5 (+)	5 (+)	5 (+)
GR	3 (−)	5 (−)	5 (−)	3 (+)	x	x	5 (+)	5 (+)	5 (+)
IT	5 (−)	5 (−)	4 (−)	5 (+)	5 (+)	4 (+)	5 (+)	5 (+)	5 (+)
LU	5 (−)	x	4 (−)	2 (+)	5 (−)	4 (+)	4 (+)	x	x
MT	5 (−)	5 (−)	5 (−)	5 (+)	3 (+)	5 (+)	5 (+)	5 (+)	x
NL	3 (−)	3 (+)	5 (−)	3 (+)	4 (−)	5 (+)	5 (+)	5 (+)	3 (−)
PT	3 (−)	x	3 (−)	3 (+)	3 (+)	3 (+)	5 (+)	2 (−)	3 (+)
SI	3 (−)	x	5 (−)	3 (+)	3 (−)	2 (+)	x	x	5 (+)
SK	5 (−)	4 (+)	3 (−)	4 (+)	5 (−)	3 (+)	5 (+)	x	x
EA	5 (−)	4 (−)	5 (−)	5 (+)	5 (+)	4 (+)	5 (+)	5 (+)	5 (+)

Numbers preceding parentheses show the classes of *TRA*, *TFA*, and *T_LIAB* with the greatest changes in portfolio structure in comparison to class 1; (−) decreased share of portfolio's part, (+) increased share of portfolio's part

their types. In the case of *T_LIAB*, detailed outcomes confirmed positive influence of all debt classes above class 1 on the shares of relatively safe assets in portfolios of households residing in Belgium, Cyprus, Germany, Luxembourg, Portugal, and Spain.

Moreover, the detailed results from version 2 of the model revealed sub-groups of countries with the following consequences of the values of *TFA*, *TRA* and *T_LIAB* from classes 2–5 for the portfolio structure:

(1) Belgium, France, Greece, Italy, Malta, and Spain: generally, lower proportions of safe assets were accompanied by increased proportions of relatively safe and risky assets. The Eurozone portfolio's profile corresponded to this structure;
(2) Austria, Germany, the Netherlands, and Slovakia: total financial assets (*TFA*) from classes 2–5 led to a lower proportion of safe assets in the portfolio and higher shares in two other asset categories. In contrary, total real assets (*TRA*) from classes 2–5 strengthen the position of safe assets.

The greatest sensitivity of the structures of financial asset portfolios appeared at different values of total financial assets (*TFA*), total real assets (*TRA*) and total liabilities (*T_LIAB*) in the Eurozone member states. In Portugal, notable changes could be observed when the values of covariates were assigned to classes 2–3. On the other hand, there was a group of countries, where the most prominent differences occurred when the values of covariates were from classes 4–5. This lesser sensitivity of portfolios' risk profiles could be observed for the populations of Cyprus and Italy, and with small exceptions of Finland, France, Italy, Luxembourg, and Malta. The same could be concluded for the Eurozone as a whole.

6 Conclusions

Despite the development of the financial market since the 1990s, deposits appeared as a standard component of households' portfolios. Moreover, in almost all the countries analysed they emerged as dominant. Households' investment preferences, expressed by average portfolio structure, could not be perceived as uniform in the entire group of countries. However, it was possible to identify three sub-sets of member states with similarities in this respect.

Analysing the impact of net wealth on the structure of households' portfolios in the Eurozone, the results from version 1 of the fractional multinomial logit model showed that a higher level of net wealth led to increases in the proportion of both risky and relatively safe assets. However, risky ones were present in the focus of interest of more affluent households. The results from version 2 of the model considering the whole group of countries suggested a positive impact of the greater value of total real assets on the shares of risky assets in portfolios, while total financial assets on the proportions of relatively safe ones. However, in certain countries increasing total real assets led to the growth in the shares of safe assets. According to the results derived from both variants of the model for separate countries, domestic preferences used to determine the structure of households' portfolios. There was no compliance in the importance of the safe, relatively safe and risky assets as well as in the direction of the impact of separate covariates on portfolio structure.

Acknowledgements The paper presents the results of a study carried out under a research project financially supported by the National Science Centre in Poland (grant number: DEC-2013/11/D/HS4/04056). The analysis is based on data provided by the Eurosystem Household Finance and Consumption Survey.

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Supporting Family to Their Utmost—People's over the Age of 50 Attitudes to Borrowing

Beata Lewicka

Abstract The aim of this paper is to indicate factors which have a significant impact on having a consumer credit or a mortgage loan among people over the age of 50. The article contains results of a research which was carried out in the period from April to May 2016. Respondents of this research were people over the age of 50 who live in lubelskie region (Poland). The sample reflects the proportion of age groups in tested population (stratified sampling). In order to reach the goal of this paper and verify stated hypotheses, statistical tests of significance and binary logistic regression were used. The conducted study revealed that supporting family is a strong motive, which has an impact on having or not consumer or mortgage loan. Moreover, the willingness to help family financially is much more important than any other financial reason or obstacle. At the same time, the level of trust in family is not important when people borrow money for them.

1 Introduction

Elderly people in Poland constitute a group which is said to be particularly vulnerable to financial exclusion. This situation is partly due to the fact that they often face difficulties in staying up-to-date with financial products (Smyczek and Matysiewicz 2014). Furthermore, some of them do not present sufficient level of financial literacy (Kuchciak 2014). Nevertheless, other researches revealed that it is not only the demand-side problem. Financial exclusion and consequently phenomena of unbanking or underbanking of people over the age of 50 may be caused by poor and not relevant offers available on the financial market (Ziemba et al. 2014). Moreover, older people frequently face limited access to loan instruments (Buk and Pustiowska 2013), especially mortgage loan, which cost should be calculated taking into account the possibility of creating income on retirement (Polish Financial Supervision Authority 2013).

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K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*, Springer Proceedings in Business and Economics, DOI 10.1007/978-3-319-54885-2_28

However, despite of all mentioned barriers, borrowing activity of "baby boomers" generation is similar to younger generation "X". According to Bureau of Credit Information (BIK) statistics, in 2015, 54.4% of people born between the years 1948 and 1967 had an active loan. In comparison, for people born between the years 1968 and 1981 this borrowing activity rate was 58%. What is the most surprising, among the eldest citizens (born before 1948), 38.2% were still active borrowers.

The reasons why Polish people over the age of 50 borrow money are not sufficiently examined in academic literature. Nevertheless, some problems are common for all European baby boomers, no matter from which region they come from. The reasons of borrowing can be diverse: having prior commitment, experiencing unexpected events, protecting existing assets or facing problems with making ends meet (Finney 2013).

Surprisingly, despite the fact, that so many of Polish elderly people are indebted, they are still generous for their families. The latest data collected by the Central Statistical Office (2016) has revealed that Polish pensioners in 2015 spent more than 3 billion zlotys on purposes connected with supporting their relatives (an average pensioners' household spent on this purpose yearly 670 zlotys per capita).

Intergenerational transfers can be divided into two groups: inter vivos –between living generations and bequests—transfers of wealth made after death (Albertini and Radl 2012). Another difference is that bequests are usually equally distributed across all children in the family, while inter vivos transfers are made unevenly and are more directed to the more needy children (Kohli and Künemund 2003). The latter also differ across countries and regions. For an instance, in Southern Europe, where adult children prolong their co-residence with parents, economic support from them is smaller than in Scandinavian countries, where independent living in early adulthood is preferred. Continental European countries are classified as middle-of-the-road (Albertini and Kohli 2013). Poland case is similar to Continental regime. Results from Polish sample in SHARE project revealed that children are mostly supported financially by their parents, whereas nonfinancial transfers flow from younger to older generation (Nicińska and Kalbarczyk 2009).

Using borrowing instruments, despite alleged financial exclusion as well as reported tendencies of increasing spending on support for kinship led to assumption that in Poland intergenerational transfers are partially "leveraged". The aim of this article is to find out factors which have a significant impact on having consumer or mortgage loan.

In this article three hypotheses are stated:

H1: Among people over the age of 50, supporting family is one of the motives underlying a decision to take out consumer credit.

H2: Among people over the age of 50, supporting family is one of the motives underlying a decision to take out mortgage loan.

H3: The role of trust in one’s family is not significantly important when making decision about borrowing money from banks to support one’s relatives.

Nowadays, issues touched in this article seem to be especially important taking into consideration population ageing process and all challenges which derive from demographic changes in Poland and, more broadly, in all developed countries.

Despite the fact that debt problems of households and their economic and social determinants are well-covered in subject literature (i.e. Cynamon and Fazzari 2008; Debelle 2004; Georgarakos et al. 2014), there is no specific research on borrowing of people over the age of 50 and role of family in their approach towards it. Hence, this article contribution is to begin a discussion about this difficult, partially economic and partially social issue.

2 Methods and Data

The data used in this paper comes from the research which was carried out in the period from April to May 2016. The respondents of this research were people over the age of 50 who live in lubelskie region. The minimum sample size (384) was calculated for margin error equal 5% and 95% confidence level. The sample (386 answers) reflects the proportion of age groups in tested population (stratified sampling). Nevertheless, this sample size is still a limit of the work, as larger sample would give more reliable results with greater power and precision.

The chi square test revealed that number of observations in each age category was not significantly different from the actual structure of the population for tested region. Respondents were asked to complete a paper-based questionnaire, which included questions about their financial literacy, borrowing habits and experiences from financial markets.

In order to confirm stated hypotheses (H1, H2) the binary logistic method was used. Reasons why this method was applied are that many variables in suggested model were dichotomous (Tranmer and Elliot 2008) and its interpretation is clear and readable. Variables which were taken into consideration were divided into four groups: the use of a financial product/service, types of experienced difficulties with access to financial services, main reasons for borrowing money and respondent characteristics (Table 1).

Selection of the variables included into model was carried out in five stages (Bursac et al. 2008, Canchola et al.):

(1) descriptive analyses of variables,
(2) univariable analysis of each variable,
(3) testing collinearity between candidate variables (testing Spearman correlation coefficients),
(4) multivariable analysis (using backward elimination method),
(5) evaluating all estimated models with Hosmer-Lemenshow Goodness-Of-Fit.

Table 1 Description of used variables

Name of variable	Variable-name abbreviation	Coding method
Declaration of using		
Checking bank account	S_CBA	0-no, 1-yes
Savings bank account	S_SBA	
Bank deposit	S_BD	
Brokerage account	S_BA	
Investment fund account	S_IFA	
Individual retirement account	S_IRA	
Credit card	S_CC	
Consumer loan	S_CL	
Mortgage loan	S_ML	
Main reasons for borrowing money		
Unexpected expenses	M_UE	0-no, 1-yes
Supporting family	M_SF	
Temporary financial problems	M_TF	
Lack of money to meet basic needs	M_BN	
Spending more than earn	M_SM	
High cost of expense	M_CE	
Types of experienced difficulties with access to financial services		
Problems with meeting all necessary requirements	D_NR	0-never, 1-very rarely, 2-rarely, 3-sometimes, 4-often, 5-very often
Ambiguous or unclear offer	D_AO	
Too much choice	D_CH	
Too small font in presented documents	D_SF	
Too long queues in agencies	D_LQ	
Incompetent staff	D_IS	
Lack of amenities for older people in agencies	D_LA	
Lack of suitable offer	D_LO	
Hidden costs	D_HC	
Too complex language in presented documents	D_CL	
Respondent characteristics		
Sex	SEX	0-Female, 1-Male
Age	AGE	1-50–55 years old; 2-56–65, 3-66–75, 4-over 75 years old
Declared financial literacy level	FLL	1- much lower, 2-lower, 3-similar, 4-higher, 5-much higher
Self-evaluation of financial situation (regarding to average)	EFS	1-very bad, 2-bad, 3-not bad, not good, 4-good, 5-very good
Monthly earnings per capita	ME	Standarised for model

Table 2 Number of replies estimated for categorical variables

Binary variable		Having taken out consumer credit		Having taken out mortgage credit	
		No	Yes	No	Yes
S_CBA	Yes	245	27	252	20
	No	110	4	109	5
S_SBA	Yes	88	2	84	6
	No	267	29	277	19
S_BD	Yes	141	7	144	4
	No	214	24	217	21
S_BA	Yes	10	0	9	1
	No	345	31	352	24
S_IFA	Yes	28	2	28	2
	No	327	29	333	23
S_IRA	Yes	20	0	20	0
	No	335	31	341	25
S_CC	Yes	56	8	57	7
	No	299	23	304	18
S_CL	Yes	X	X	26	5
	No	X	X	335	20
S_ML	Yes	20	5	X	X
	No	335	26	X	X
M_UE	Yes	84	17	92	9
	No	269	14	267	16
M_SF	Yes	34	13	40	7
	No	319	18	319	18
M_TF	Yes	48	8	54	2
	No	305	23	305	23
M_BN	Yes	10	2	12	0
	No	343	29	347	25
M_SM	Yes	4	1	4	1
	No	349	30	355	24
M_CE	Yes	79	8	71	16
	No	274	23	288	9
SEX	Male	134	17	138	13
	Female	218	17	220	12

x—factors not used as explanatory variable in selected model

In order to select variables which can be used in estimated models, descriptive analyses of collected data were carried out and presented in Tables 2 and 3. Categorical variables were examined if there are any zero frequencies, whereas for ordinal and linear variables their variability levels were tested.

Thereafter, univariable analyses helped to indicate associations of single variables with the outcome, which resulted in exclusion of unimportant variables—those having insignificant Wald test and p-value cut-off point of 0.25 (Bursac et al. 2008). Next, backward elimination method allowed to isolate those variables,

Table 3 Means and standard deviations calculated for ordinal and linear variables

	Having taken out consumer credit				Having taken out mortgage credit			
	No		Yes		No		Yes	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
D_NR	1.320	1.681	1.097	1.640	1.329	1.691	.920	1.441
D_AO	2.386	1.707	1.903	1.700	2.346	1.728	2.360	1.440
D_CH	2.252	1.766	2.065	1.413	2.248	1.769	2.080	1.256
D_SF	3.009	1.838	2.806	1.621	3.031	1.803	2.440	2.022
D_LQ	2.220	1.671	1.903	1.720	2.225	1.687	1.760	1.451
D_IS	1.620	1.557	1.258	1.527	1.624	1.572	1.120	1.236
D_LA	1.484	1.632	1.032	1.472	1.496	1.647	.760	1.012
D_LO	1.920	1.615	1.581	1.311	1.910	1.620	1.640	1.150
D_HC	2.783	1.886	2.516	1.411	2.730	1.871	3.200	1.528
D_CL	3.239	1.715	3.161	1.675	3.249	1.726	3.000	1.472
AGE	2.310	1.000	2.129	0.991	2.346	0.997	1.560	.712
FLL	2.847	1.054	3.387	1.022	2.877	1.072	3.080	.862
EFS	2.997	0.841	3.355	0.915	3.022	0.852	3.080	.862
ME	1161.12	730.83	1092.08	703.72	1148.14	730.59	1260.33	695.74

which explain why people over the age of 50 borrow money from financial institutions.

Finally, in an attempt to find out if the level of trust in family is not significantly different for people who support their families with their loans and those who do not do that (H3), the Mann-Whitney U test was carried out. This non-parametric test was chosen firstly because, the trust in family was measured on Likert-like-type rating scale, which should not be treated as interval scale (Jamieson 2004) and secondly, because the independent variable was not normally distributed.

3 Results

The results of the conducted research revealed, that among many aspects which describe borrowers from lubelskie region over the age of 50, those connected with motivation of borrowing are the most significant. The first model, which presents factors influencing on taking out consumer credit, indicates that supporting family (M_SF) and occurrence of unexpected expense (M_EU) hold a very strong meaning. Those who claim to support their families are five times (5.172) more likely to have a consumer credit (ceteris paribus). Whereas those who mention an unexpected expense as a reason of borrowing are only two times (2.211) more likely to get a consumer loan from bank or other institution. Another significant factor estimated in the model is holding a saving bank account (S_SBA). The probability of having a consumer credit for those who claim to have at least one saving account is 82% lower than for those who do not have it. The last significant factor is a declared level of financial literacy (FLL). The likelihood of taking out consumer credit grows with the self-evaluated financial literacy level.

The first model was tested with Hosmer-Lemenshow Goodness-Of-Fit (p-value 0.556). The value of Nagelkerke R^2 estimated for this model means that it is able to explain 24.4% of the variation based on the given variables (Table 4).

The second model indicates which factors impact on having mortgage loan by people who are over the age of 50 (Table 5). Again, those who support their family are more likely to have a mortgage credit (2.28 times more, ceteris paribus). Nevertheless, the likelihood increases the most for people who claim that too high cost of expense is their main borrowing motive (likelihood is 7.5 times higher). Contrary to the consumer credit model, for this type of loan, three barriers in access seem to be significant. Firstly, lack of suitable offer (M_LO) and secondly, small font in all necessary documents (M_SF). If a respondent experiences those obstacles more frequently, the likelihood of holding a mortgage is smaller. Third significant barrier works differently—for people who experience hidden costs more often, the likelihood of having a loan increases.

The goodness of fit for this model was assessed with Hosmer-Lemenshow test ($p=0.485$). The value of Nagelkerke R2 estimated for this model means that it is able to explain 24.4% of the variation based on the given variables.

Another tested hypothesis (H3) assumes that the level of trust in family is not important for people for whom family support is one of the main motivation for borrowing. Differences between level of trust in family for those who borrow

Table 4 Logit model for borrowers over the age of 50—consumer credit

Variable	Beta coefficient	Standard error	Wald	Exp(B)
S_SBA	−1.717	.777	4.880*	.180
M_UE	1.167	.410	8.101**	3.211
M_SF	1.820	.439	17.216**	6.172
FLL	.520	.203	6.532*	1.682
Constant	−4.658	.749	38.709**	.009

**p*-value<0,05
***p*-value<0,01

Table 5 Logit model for borrowers over the age of 50—mortgage loan

Variable	Beta coefficient	Standard error	Wald	Exp(B)
M_SF	1.189	.534	4.967*	3.284
M_CE	2.143	.468	20.923**	8.522
D_SF	−.294	.141	4.329*	.745
D_LO	−.314	.174	3.252*	.731
D_HC	.437	.154	8.093**	1.549
Constant	−3.838	.616	38.826**	.022

**p*-value<0,1
***p*-value<0,01

money to support their family and for those who do not do that are assessed as insignificant ($Z = -0.007$, $p = 0.994$).

4 Discussion

In both models, describing factors which impact on having consumer and mortgage loan, family support motive seems to be one of the most vital. In case of the consumer credit, this motivation is much stronger than occurrence of an unexpected expense. It may be treated as a signal that people over the age of 50 are more focused on their family wealth than their own comfort. In Polish media, there has been a lot of publicity on cases concerning overusing of seniors' generosity and their propensity to borrow for relatives. Sometimes, they take out a consumer loan for members of family who do not have creditworthiness. In many cases, they only sign a contract, whereas their relative promises to make payments. The problem appears, when relative breaks his promise and the older person is obliged to pay off the debt. This issue becomes more concerning, given the fact that level of trust in family is not important when people borrow money for them (which the research confirms).

Moreover, the model 1 reveals that people who feel more financially literate, are more likely to have a consumer loan. This means that there are more confident and not scared by all potential obstacles. One factor, which lessens the likelihood of having a consumer loan is connected with holding small savings, kept on saving account. This means that people over the age of 50 prefer using their own precautionary savings to borrowing from other institutions.

Obviously, in Poland, taking out a mortgage loan in older age may be difficult or even impossible because of a high risk for financing institutions (Polish Financial Supervision Authority 2013). It is visible in the model 2, where the barrier called "lack of suitable offer" lessens the likelihood of having a mortgage loan. However, the small font in documents, which is also considered to be a significant obstacle, is a barrier which banks can easily remove. Preparing more transparent forms and sample contracts may have a positive impact on building the trust between institution and older clients. An obstacle called "experience of hidden costs" works differently—those who experience it more often are more likely to have a mortgage. It may mean that people who have their mortgage credit already taken are more likely to find out that they have to pay extra fees or charges. Nevertheless, the biggest impact on having mortgage loan obviously has the "too high cost of expense" motive. The cost of buying a house or a flat is too high to be covered only by cash contribution. Still, the family support motive takes the next position. Partially, it can be a result of the case when people in their fifties or early sixties, who have a regular income, decide to be co-borrowers with their children who do not have sufficient creditworthiness. This assumption is made on basis of research of advisory sites for potential young mortgage borrowers, where many useful tips are presented. However, it is difficult to estimate how many people took a mortgage loan with their relatives in order to increase their credit score. So that, this may serve as a scope for further research.

5 Final Thoughts

The presented research reveals that inter-vivos intergenerational transfers from people over the age of 50 who live in lubelskie region can be partially financed with debt instruments. Supporting their families, especially children or grandchildren is a strong motive, which has an impact on having or not consumer or mortgage loan. The willingness to help family financially is much more important than any other financial reason or obstacle. Moreover, the level of trust in family is not important when people borrow money for them. This readiness to support relatives to the utmost can be dangerous and easily overused by frauds and, unfortunately, sometimes by family themselves. As for its importance, this issue requires being more covered in academic literature.

Conclusions from this paper indicate direction for future research on people's above 50 attitudes towards borrowing and supporting family. Because of cultural, social and economic diversity in specific countries, conducting comparative, more comprehensive analyses seems to be essential.

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