Springer Proceedings in Business and Economics

Krzysztof Jajuga
Hermann Locarek-Junge
Lucjan T. Orłowski
Karsten Staehr *Editors*

Contemporary Trends and Challenges in Finance

Proceedings from the 4th Wroclaw International Conference in Finance

Springer

Springer Proceedings in Business and Economics

More information about this series at http://www.springer.com/series/11960

Krzysztof Jajuga • Hermann Locarek-Junge •
Lucjan T. Orłowski • Karsten Staehr
Editors

Contemporary Trends and Challenges in Finance

Proceedings from the 4th Wroclaw International Conference in Finance

Springer

Editors
Krzysztof Jajuga
Finance Management Institute
Wroclaw University of Economics
Wroclaw, Poland

Hermann Locarek-Junge
Faculty of Management and Economics
Dresden University of Technology
Dresden, Germany

Lucjan T. Orłowski
Jack Welch College of Business
Sacred Heart University
Fairfield, CT, USA

Karsten Staehr
Department of Economics and Finance
Tallinn University of Technology
Tallinn, Estonia

ISSN 2198-7246 ISSN 2198-7254 (electronic)
Springer Proceedings in Business and Economics
ISBN 978-3-030-15580-3 ISBN 978-3-030-15581-0 (eBook)
https://doi.org/10.1007/978-3-030-15581-0

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

Preface

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

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

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

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

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

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

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

We wish to thank the authors for making their studies available for our volume. Their scholarly efforts and research inquiries made this volume possible. We are also indebted to the anonymous referees for providing insightful reviews with many useful comments and suggestions.

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

Wroclaw, Poland	Krzysztof Jajuga
Dresden, Germany	Hermann Locarek-Junge
Fairfield, CT, USA	Lucjan T. Orłowski
Tallinn, Estonia	Karsten Staehr
December 22, 2018	

Contents

About the Editors

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

Hermann Locarek-Junge is Professor of Finance and Financial Services at TU Dresden, Faculty of Management and Economics. He graduated in the field of business and economics and earned his Ph.D. at the University of Augsburg (Germany); he also studied business informatics and has been appointed Professor in that field at Essen University. Since then, he has been visiting professor and research fellow at some international institutions and universities. During his academic career, he did research work for several banks.

Lucjan T. Orłowski is a professor of economics and finance and a Director for the Doctor of Business Administration (DBA) in Finance Program at Sacred Heart University in Fairfield, Connecticut. His research interests include monetary economics and stability of financial markets and institutions. He has authored numerous books, chapters in edited volumes, and over 80 articles in scholarly journals. He is a Doctor Honoris Causa recipient from the Wrocław University of Economics.

Karsten Staehr is professor of international and public finance at Tallinn University of Technology, Estonia. He is also employed part-time as a research supervisor at Eesti Pank, the central bank of Estonia. He holds a master's degree from the Massachusetts Institute of Technology and a master's degree and a Ph.D. from the University of Copenhagen. He undertakes research and policy analysis within macroeconomics, public economics, monetary economics, and transition economics. He is an associate editor of the *Baltic Journal of Economics* and on the editorial board of several other journals.

Part I
Banking

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

Ewa Dziwok

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

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

1 Introduction

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

E. Dziwok (✉)
University of Economics in Katowice, Katowice, Poland
e-mail: ewa.dziwok@ue.katowice.pl

K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*,
Springer Proceedings in Business and Economics,
https://doi.org/10.1007/978-3-030-15581-0_1

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

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

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

2 A Yield Curve Construction

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

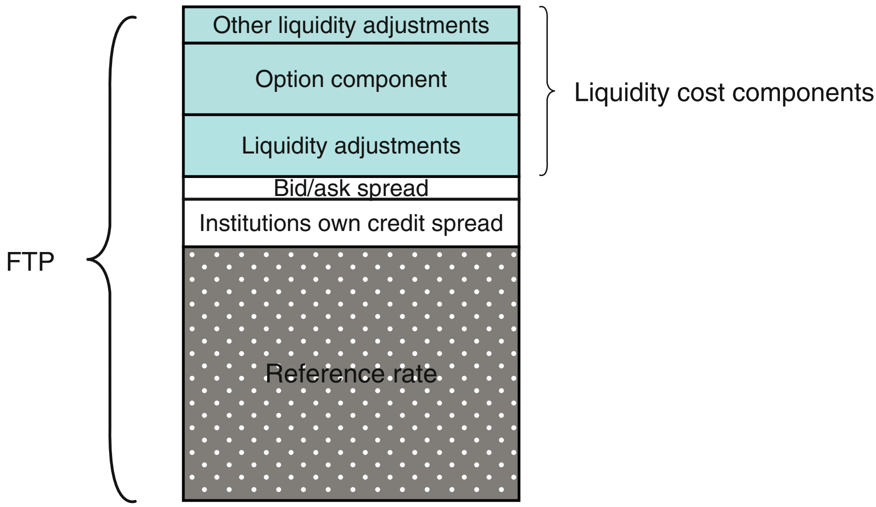

Fig. 1 FTP mechanism—a construction of the yield curve. Source: CEBS, Guidelines on liquidity cost benefit allocation, p. 10

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

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

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

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

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

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

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

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

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

Definition 2 The function $\delta : \mathfrak{R}_+ \to (0; 1]$ is called the discount function and is expressed as:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

where: $f(\tau)$—instantaneous forward rate
$[\beta_0, \beta_1, \beta_2, \nu]$—vector of parameters describing the curve:
β_0—parameter which shows a limit in infinity, $\beta_0 > 0$
β_1—parameter which shows a limit in infinity, $\beta_0 + \beta_1 \geq 0$
β_2—parameter which shows a strength of curvature
υ_1—parameter which shows a place of curvature, $\upsilon_1 > 0$

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

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

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

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

and between market and theoretical rates:

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

where: $P_l - \overline{P_l}$—a price error of l-th asset
$i_l - \overline{i_l}$—a yield error of l-th asset
k—number of bonds

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

3 Data and Results

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

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

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

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

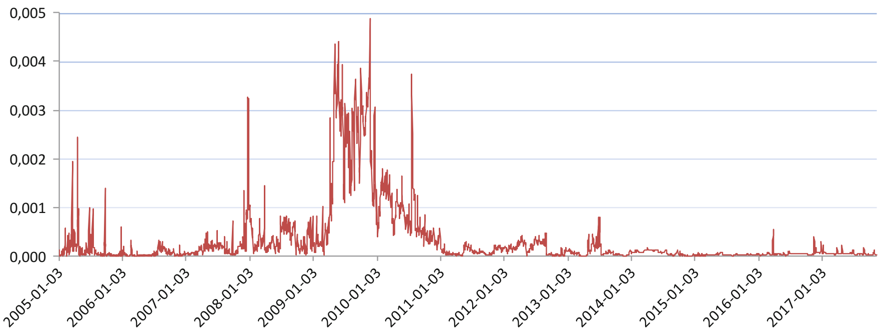

Fig. 2 MSE errors between market and theoretical rates. Source: Own calculations

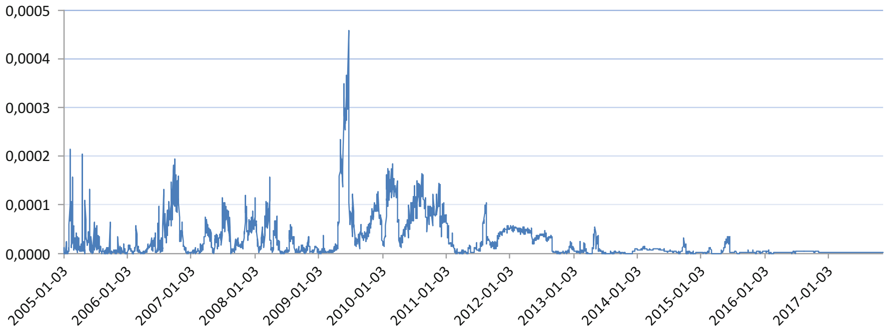

Fig. 3 MSE errors between market and theoretical prices. Source: Own calculations

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

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

4 Summary

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

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

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

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

References

Anderson N, Sleath J (2001) New estimates of the UK real and nominal yield curves. Bank of England working paper

Audley D, Chin R, Ramamurthy S (2002) Term structure modeling. In: Fabozzi FJ (ed) Interest rate, term structure and valuation modeling. Wiley, Hoboken, NY, pp 93–136

BSBC (2008) Principles for sound liquidity risk management and supervision. BIS. http://www.bis.org

CEBS (2010) Guidelines on liquidity cost benefit allocation (CP 36). EBA. https://www.eba.europa.eu

Cox J, Ingersoll J, Ross S (1981) A re-examination of traditional hypoteses about the term structure of interest rates. J Financ 36:769–799

de La Grandville O (2001) Bond pricing and portfolio analysis. MIT Press, Cambridge

Elliot V, Lindblom T (2015) Funds transfer pricing in banks: implications of Basel III. In: Eliot V (ed) Esseys on performance management systems, regulation and change in Swedish banks. BAS Publisher, Gothenburg

Fisher I (1930) The theory of interest. Macmillan, London

Fisher M, Nychka D, Zervos D (1995) Fitting the term structure of interest rates with smoothing splines. Finance and Economics Discussion Series, 95-1, Federal Reserve Board

Hicks J (1946) Value and capital [Polish edition, PWN, Warszawa 1975]

James J, Weber N (2000) Interest rate modelling. Wiley, Chichester

McCulloch JH (1971) Measuring the term structure of interest rates. J Bus 44:19–31

McCulloch JH (1975) The tax-adjusted yield curve. J Financ 30:811–830

Nawalkha SK, Soto GM, Beliaeva NA (2005) Interest rate risk modeling. Wiley, Hoboken, NJ

Nelson CR, Siegel AF (1987) Parsimonious modeling of yield curves. J Bus 60:473–489

Svensson LEO (1994) Estimating and interpreting forward interest rates: Sweden 1992–1994. NBER working paper series #4871

Waggoner D (1997) Spline methods for extracting interest rate curves from coupon bond prices. Federal Reserve Bank of Atlanta, Working Paper 97-10

Wyle RJ, Tsaig Y (2011) Implementing high value funds transfer pricing systems. Moody's Analytics Inc.

http://www.reuters.pl

Towards a Generalized Measure of Systemic Risk: Systemic Turbulence Measure

Marta Karaś and Witold Szczepaniak

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

1 Introduction

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

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

M. Karaś · W. Szczepaniak (✉)
Department of Financial Investment and Risk Management, Wrocław University of Economics, Wrocław, Poland
e-mail: marta.karas@ue.wroc.pl; witold.szczepaniak@ue.wroc.pl

K. Jajuga et al. (eds.), *Contemporary Trends and Challenges in Finance*,
Springer Proceedings in Business and Economics,
https://doi.org/10.1007/978-3-030-15581-0_2