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Taufiq Choudhry
Jacek Mizerka *Editors*

# Contemporary Trends in Accounting, Finance and Financial Institutions

## Proceedings from the International Conference on Accounting, Finance and Financial Institutions (ICAFFI), Poznan 2016

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# Preface

The field of finance is very broad. It includes both macroeconomic (e.g. public finance, monetary policy) and microeconomic issues (e.g. corporate finance, accounting, investment decision on capital market). The field of finance is also very vital. This is evidenced by research undertaken by contemporary researchers. Some of the results of these researches were presented during the International Conference on Accounting, Finance and Financial Institutions. Theory Meets Practice (ICAFFI), which took place in Poznań, on 19–21 October, 2016. A part of the papers discussed during ICAFFI have been presented to the wide audience in this book. We tried to choose this volume articles representing a broad scope of financial issues. The issues related to decisions taken in the capital market are represented by three articles: Leszek Czapiewski, Jarosław Kubiak, *Investor Reactions to Dividend Announcements of Companies Listed on the Warsaw Stock Exchange*, Krzysztof Piasecki, Joanna Siwek, *Two-Asset Portfolio with Triangular Fuzzy Present Values—An Alternative Approach*, Szymon Stereńczak, *Stock Market Liquidity and Company Decisions to Pay Dividends: Evidence from the Warsaw Stock Exchange*. The paper of L. Czapiewski and J. Kubiak concerns the impact of changes in the quality of dividends paid and changes in the dividend rate on the return of excess rate of companies whose shares were listed on the Warsaw Stock Exchange (WSE) in 1996–2014. The article written by K. Piasecki and J. Siwek proposes an alternative approach to the characteristics of a two-asset portfolio in a case of present value estimated by a triangular fuzzy number. The goal of Sz. Stereńczak's paper is to investigate the relationship between stock liquidity and both companies' propensities to pay dividends, and the level of dividend payments.

Two articles concern corporate finance: Józefa Gryko, *Managing of Financial Flexibility* and Sanjeev Kumar, K. S. Ranjani, *Financial Constraints and Cash Flow Sensitivity to Investment in Indian Listed Manufacturing Firms*. The paper of J. Gryko focuses on showing the importance of financial management in creating the flexibility of the company and identifying conditions affecting the decision on the company's financial flexibility. The article of S. Kumar and K. S. Ranjani is an effort to test the validity of cash flow sensitivity to investment as a measure of

financial constraints in Indian manufacturing firms using panel data for 768 listed firms over a period of 6 years (2010–2016).

A paper proposed by A. Wójcicka, *Credit-Risk Decision Process Using Neural Networks in Industrial Sectors*, concerns the assessment of credit risk. The author focuses on factors determining credit risk; she proposes using neural networks in the process of credit-risk management.

The paper of K. Charoontham and T. Amornpetchkul, *Impact of Pay-for-Performance on Rating Accuracy*, discusses the role of credit rating agencies (CRAs). The authors analyse whether the pay-for-performance scheme can encourage to issue accurate ratings under an investor-pay model.

The article of M. D. Stasiak, *Modelling of Currency Exchange Rates Using a Binary-Temporal Representation*, proposes methodical point of view. The author presents a new method for modelling exchange rates with a binary-temporal representation.

The field of public finance is represented by the article *The Role of Tax Havens in Tax Avoidance by Multinationals* written by M. Kutera. The main purpose of this publication is to present the scale of tax avoidance by multinational firms and the possible impact of that avoidance on the capital flows in the global economy.

Astonishing, but interesting, research problem was taken by A. Pavković, K. Dumičić, and B. Žmuk in the article *Number of Automated Teller Machines in Selected European Countries: Exploration of Trends and Development Indicators Impacts*. The authors discovered and compared variability and trends in the number of automated teller machines (ATMs) in the recent history in the European Union member states. They also studied the influence of selected factors on the number of ATMs.

The paper of I. Pyka and A. Nocoń, '*Repolonization*' *Process of Domestic Banks. Analysis of Conditions and Opportunities*, has a more journalistic character and concerns the 'hot' issue of the so-called repolonization of the banking sector in Poland.

Finally, we would like to thank all the contributing authors and the reviewers for their contribution to this book. We also wish an interesting reading to academics and practitioners.

Poznań, Poland — Jacek Mizerka
Southampton, UK — Taufiq Choudhry
January 2018

# Contents

# Investor Reactions to Dividend Announcements of Companies Listed on the Warsaw Stock Exchange


**Leszek Czapiewski and Jarosław Kubiak**

**Abstract** The aim of the article is to assess the impact of changes in the quality of dividends paid and changes in the dividend rate on the return of excess rate of companies whose shares were listed on the Warsaw Stock Exchange (ESE) in 1996–2014. Following the theory of the dividend information content, according to which the dividend value is a signal to investors that higher rates of return should be expected in the case of companies which increase the dividend value or rate. The event analysis method was used as that most often used in this type of research, with the cumulative surplus return rate CAAR as a measure of investor response to change in the value of dividends paid. Three models were used as a benchmark: index, market and CAPM. The conducted studies do not give a clear picture of the results, however in the case of companies for which the dividend rate was growing a positive reaction can be observed in the event window. The published research results contain data for all cases in which a change in dividend values could be stated from year to year by companies listed on the WSE in 1996–2014.

**Keywords** Dividend policy · Dividend rate · Signalling theory
Event analysis

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## 1 Introduction

Dividend policy is one of the most important areas of financial decisions in an enterprise. In the case of public companies, the investor preference for the payment of dividends and capital gains should be taken into account when making this decision. A number of theses presenting the "pro-dividend" and "anti-dividend" positions can be found in the literature. This paper examines the approach related to the theory of dividend information content, according to which the dividend value is a signal to investors, indicating the managers' predictions relating to the future financial situation of the company. Therefore, the dividend is treated as a signal determining the company's quality.

The purpose of the article is to examine the impact of changes in the dividend policy of non-financial companies whose shares were listed on the WSE in 1996–2014 for the amount of excess return rates. This impact will be studied using the methodology of event study analysis. The message about the decision of the General Meeting of Shareholders (GMS) about the amount of dividends per share will be the event.

## 2 Dividend Payments and Market Reaction—A Brief Literature Review

Views on the reaction of stock prices to the change in a company's dividend policy are related to the dispute over the impact of dividends on a company's value. Advocates of the "pro-dividend" approach say that companies paying relatively high dividends will show a higher market value than companies with a similar profile of activity but typified by a low dividend rate. M. J. Gordon (1959) and J. Lintner (1956) argued that investors are more likely to value a guaranteed dollar which they receive from a dividend than one from expected capital profits. The fundamentals of the "pro-dividend" approach can also be sought in other theories, especially regarding the shaping of the capital structure, for example in the agency theory (Jensen 1976). Usually, the positive market reaction to the decisions to share profits with shareholders is explained in the context of signalling theory.

In accordance with the theory of dividend information content, their level is a signal for investors which indicates the managers' predictions relating to the future financial situation of the company. The initiation of a dividend payment, or an increase in their value, is a positive sign determining the company's quality (Bhattacharya 1979; Miller and Rock 1985). It should be noted that investors often react not to the dividend amount, but to its change. Recent studies (Pettit 1972; Aharony and Swary 1980; Brickley 1983; Healy and Palepu 1988; Michaely et al. 1995) mostly point to a positive correlation between a change in the dividend value and the share price. In addition, a share price increase is observed in the event of the initiation of dividend payments, and a decrease in the event of ceasing dividend payments.

The issue of stock price reactions to changes in dividend policy has also been studied in relation to companies listed on the WSE. The authors of these studies rightly point out that, given the relatively short history of the WSE, the emerging nature of this market, as well as the relatively great reluctance to share profits with investors, results may differ from those obtained for developed markets.

These issues were dealt with by, among others, T. Słoński and B. Zawadzki, who published the results of their analyses in two articles. In the article *The analysis of investors' reactions to the change of the value of the dividend paid by the companies listed on the WSE in Warsaw* (2012a), 263 observations of companies were analysed, which in 2005–2009 changed the value of the dividend paid. The authors did not find a correlation between the direction of changes in dividend policy and average return rates. The mere fact of the dividend payment, regardless of its value or the direction of changes, caused an average increase in stock above the expected value (although a statistically significant increase was noted only in one case). In addition, the reaction of stock prices to the change of dividend value was studied in groups of enterprises created according to the criterion of their capitalization (small, medium, large). It was noted that the link between dividend policy and above-average return rates is very weak.

In the second article, *The Impact of a Surprise Dividend Increase on a Stock's Performance. The Analysis of Companies Listed on The Warsaw Stock Exchange* (2012b) Słoński and Zawadzki primarily dealt with the issue of market reactions to the occurrence of unexpected dividends. The study covered the period of 2005–2010. The authors identified 21 cases of unexpected dividends, i.e. those, whose value approved by the GMS differed from the announcement of the Board. Their occurrence led to the acquisition of a statistically significant, positive surplus of return rates. In addition, the authors also examined the market reaction to changes in the dividend value paid determined at GMS at a level consistent with the announcement of the management boards of the companies. It was found that statistically significant positive surpluses only occurred in the case of relatively higher dividend increases (higher than the median of all increases).

Studies of investor reactions to dividend payments were conducted by Perepeczo (2013). The research sample included companies which in 1992–2011 paid a dividend at least once. The author used two models that form the estimation of extraordinary return rates. Research where the surplus of return rates was statistically significant (median adjusted model) was based on 113 cases and showed a positive relation between the dividend payment and stock value.

Frasyniuk-Pietrzyk and Walczak (2014) focused on investor reactions to dividend payments only in companies which regularly paid dividends. In the years 2005–2013, the authors identified 13 such companies. In the event of a rise in the dividend value, the surplus return rate was positive, in the event of a dividend decline—negative. However, it should be noted that the surplus return rate was statistically significant only on the GMS day (*t0*).

Summing up the above research results, it should be noted that they are not clear. It is noted that in cases of dividend increases, abnormal returns are positive, but not always statistically significant.

## 3 Research Method and Description of the Sample

The article analysed dividend payments in 1992–2014, but due to the lack of data concerning the dates of General Meetings of Shareholders (GMS), the study covered the period of 1996–2014. The data was taken from GPW Infostrefa, the Warsaw Stock Exchange operation base and the Stock Exchange Yearbooks. The studies were performed on the basis of the companies corrected with the stock market operations.

The study included dividend payments which occur year after year, which made it possible to measure changes in dividend policy. Two measures of dividend policy were applied, mainly the change in value of the dividend payment, and the change in dividend yield. The study was conducted separately for cases of increases and decreases in the value of dividends or dividend yields, respectively.

The most popular indicators that allow the determination of the size of the dividend payments include: the dividend per 1 share and the dividend rate.

One of the basic dividend indicators is the dividend per share indicator (*DPS*). It is calculated using the following formula:

$$DPS = \frac{Dividends}{Number\ of\ Shares} \tag{1}$$

The ratio of dividend per share makes it possible to determine the profitability of an investment, to a limited extent, into shares of the given company, which is why its cognitive value is small. However, it is an important element of successive indicators, thanks to which it is possible to compare the level of dividend payments for individual companies more accurately.

The dividend rate index (*DRI*) is an important indicator, used when comparing dividend strategies of companies, which is calculated using the formula:

$$DRI = \frac{DPS}{Share\ Price} \tag{2}$$

The dividend rate indicator makes it possible to compare the return rates from different stocks, individual industries and the entire market. The dividend rate is primarily of interest for all investors who want to receive regular cash flows from investments, not only those who expect benefits from the increase of the stock value.

Event analysis was the research method used (Fig. 1). The date of resolution adopted at the GMS was the event day *t0*. The estimation window consisted of 120 quotes preceding the event window $t - 126;\ t - 6$, while the event window included 11 days: $t - 5;\ t + 5$.

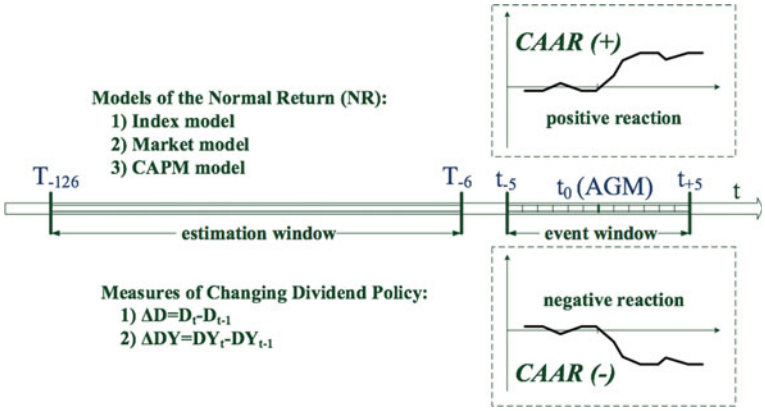


**Fig. 1** The event analysis method—parameters used

Below are the formulae patterns used to estimate models determining the normal return rate (*NR*):

– Index model:

$$NR = R_{M,t} \tag{3}$$

where: $R_{M,t}$—the return of a market index on day $t$,

– Market model:

$$NR = \alpha_i + \beta_i R_{M,t} \tag{4}$$

where: $\alpha_i$, $\beta_i$—the intercept and the slope resulting from the regression analysis, $R_{M,t}$—the return on a market index on day $t$.

– CAPM model:

$$NR = R_{F,t} + \beta_i (R_M - R_F) \tag{5}$$

where: $R_{F,t}$—the risk free rate on day $t$,
$(R_M - R_F)$—the market risk premium.

## 4 The Results of the Empirical Research

First, the market reaction to changes in the values of dividends paid were to be examined through the analysis of increases and decreases, respectively.

Table 1 and Fig. 2 show the results of excess return rates (from the given day and cumulative for the event window) of all increases in the value of the dividend paid in the studied period for the entire population of companies. 511 cases have been identified. The table also includes the significance of the results using the parametric t-student test.

**Table 1** Reaction to dividend value increase—*AAR* and *CAAR* value (%)—511 cases

| t | Index model | | Market model | | CAPM model | |
|---|---|---|---|---|---|---|
| | AAR | CAAR | AAR | CAAR | AAR | CAAR |
| t − 05 | 0.00 | −0.37*** | −0.08 | −0.33*** | −0.04 | −0.21** |
| t − 04 | 0.21** | 0.10 | 0.16 | 0.08 | 0.20* | 0.18 |
| t − 03 | 0.18* | 0.64*** | 0.06 | 0.43*** | 0.07 | 0.17 |
| t − 02 | −0.01 | 0.47** | −0.13 | 0.23 | −0.11 | −0.05 |
| t − 01 | 0.08 | 0.01 | −0.03 | −0.15 | −0.05 | −0.42* |
| T 0 | 0.26** | 0.15 | 0.20** | −0.01 | 0.22** | −0.36 |
| t + 01 | 0.49*** | 0.70*** | 0.44*** | 0.50* | 0.50*** | 0.00 |
| t + 02 | 0.00 | 0.67** | −0.06 | 0.43 | 0.02 | 0.26 |
| t + 03 | 0.08 | 0.43 | −0.04 | 0.08 | 0.05 | 0.19 |
| t + 04 | 0.02 | 0.32 | −0.02 | −0.12 | 0.02 | 0.16 |
| t + 05 | 0.25** | 0.62* | 0.20** | 0.06 | 0.25** | 0.44 |

Significance at level: ***0.01; **0.05; *0.1

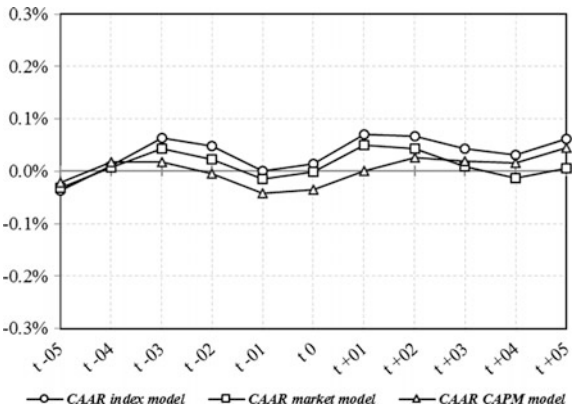


**Fig. 2** Reaction to the increase in the value of dividends paid

In the event of an increase in dividend value, a statistically significant but relatively weak positive market reaction can be observed for all benchmarking models on the event day (t0), on t + 1 and t + 5.

Table 2 and Fig. 3 show the results of excess return rates of all decreases in the value of the dividend paid.

In the event of a decline of dividend value, the response expressed both by the AAR and CAAR rates is stronger than for a dividend increase and statistically significant for cumulative return rates on the event day and the three subsequent days. This may indicate that investors on the WSE in Warsaw facing the relatively rare cases of dividend payments respond positively to the mere fact of a dividend payment.

**Table 2** Reaction to a decrease in dividend value—the *AAR* and *CAAR* values (%)—271 cases

| t | Index model | | Market model | | CAPM model | |
|---|---|---|---|---|---|---|
| | AAR | CAAR | AAR | CAAR | AAR | CAAR |
| t − 05 | −0.08 | 0.14 | −0.06 | 0.16 | −0.11 | 0.32** |
| t − 04 | −0.23 | 0.05 | −0.21 | 0.12 | −0.21 | 0.28 |
| t − 03 | 0.25* | 0.30 | 0.23* | 0.35 | 0.23 | 0.44* |
| t − 02 | −0.02 | 0.60** | −0.10 | 0.53** | −0.12 | 0.47* |
| t − 01 | 0.14 | 0.64** | 0.05 | 0.38 | −0.04 | 0.10 |
| T 0 | 0.35** | 1.01*** | 0.36** | 0.71** | 0.38** | 0.46 |
| t + 01 | 0.14 | 1.36*** | 0.09 | 0.91** | 0.09 | 0.67* |
| t + 02 | 0.29** | 1.81*** | 0.25* | 1.28*** | 0.14 | 0.85** |
| t + 03 | 0.10 | 1.95*** | 0.03 | 1.35*** | 0.00 | 0.86** |
| t + 04 | −0.25* | 1.01** | −0.32** | 0.45 | −0.31** | 0.24 |
| t + 05 | 0.21 | 0.50 | 0.17 | −0.06 | 0.16 | −0.42 |

Significance at level: ***0.01; **0.05; *0.1

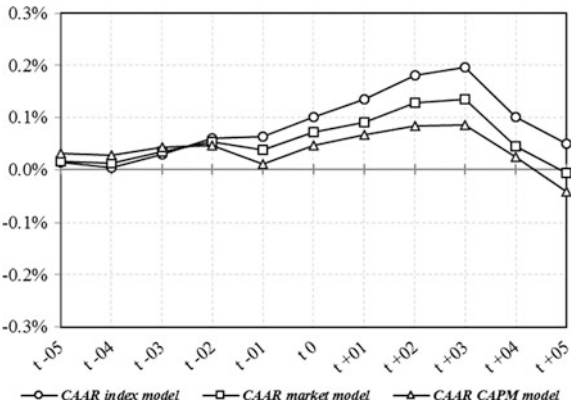


**Fig. 3** Reaction to a decline in the value of dividend paid

In the authors' opinion, the dividend rate is the measure which best reflects the company's policy in terms of profit-sharing, more than the change in dividend value. This rate takes into account the issue value (share price) which must be incurred by the investor to be entitled to receive dividends. The next two Tables 3 and 4 and the diagrams formed on their basis (Figs. 4 and 5) show the investor reaction to an increase and decrease of dividend rate, respectively.

In the case of the dividend increase, the market response expressed by CAAR, practically in the entire 11-day event window, is positive and statistically significant for all three models used for the measurement of so-called normal return rates. A relatively strong and statistically significant positive reaction to an increase in dividend rate was also observed in the case of all three models on the first day after the day of a General Meeting of Shareholders. These results can be read as

**Table 3** Reaction to an increase of dividend rates—*AAR* and *CAAR* values (%)—449 cases

| | Index model | | Market model | | CAPM model | |
|---|---|---|---|---|---|---|
| t | AAR | CAAR | AAR | CAAR | AAR | CAAR |
| t − 05 | 0.04 | −0.17* | −0.06 | −0.17* | −0.03 | 0.00 |
| t − 04 | 0.05 | 0.46*** | 0.00 | 0.32** | 0.01 | 0.45*** |
| t − 03 | 0.16 | 1.02*** | 0.09 | 0.70*** | 0.12 | 0.81*** |
| t − 02 | −0.07 | 1.02*** | −0.15 | 0.65*** | −0.14 | 0.66*** |
| t − 01 | 0.04 | 0.97*** | −0.05 | 0.58** | −0.12 | 0.52** |
| t 0 | 0.08 | 1.29*** | 0.05 | 0.82*** | 0.05 | 0.70** |
| t + 01 | 0.45*** | 1.39*** | 0.41*** | 0.88*** | 0.48*** | 0.76** |
| t + 02 | 0.09 | 1.44*** | 0.04 | 0.82*** | 0.13 | 0.87*** |
| t + 03 | 0.02 | 1.41*** | −0.09 | 0.71** | 0.01 | 1.07*** |
| t + 04 | −0.06 | 1.61*** | −0.09 | 0.90** | −0.07 | 1.34*** |
| t + 05 | 0.30*** | 1.94*** | 0.24** | 1.19*** | 0.29*** | 1.80*** |

Significance at level: ***0.01; **0.05; *0.1

**Table 4** Reaction to a decline of dividend rates—*AAR* and *CAAR* values (%)—392 cases

| | Index model | | Market model | | CAPM model | |
|---|---|---|---|---|---|---|
| t | AAR | CAAR | AAR | CAAR | AAR | CAAR |
| t − 05 | −0.06 | 0.07 | −0.13 | 0.04 | −0.07 | 0.30** |
| t − 04 | −0.10 | −0.51*** | −0.19 | −0.65*** | −0.08 | −0.06 |
| t − 03 | 0.21* | −1.03*** | 0.07 | −1.37*** | 0.19* | −0.67*** |
| t − 02 | −0.02 | −1.14*** | −0.11 | −1.43*** | −0.01 | −0.61*** |
| t − 01 | 0.25** | −0.87*** | 0.06 | −1.40*** | 0.09 | −0.53** |
| t 0 | 0.49*** | −0.31 | 0.36*** | −1.03*** | 0.46*** | −0.04 |
| t + 01 | 0.31*** | −0.35 | 0.15 | −1.30*** | 0.23* | −0.17 |
| t + 02 | 0.13 | −0.33 | 0.02 | −1.47*** | 0.12 | −0.06 |
| t + 03 | 0.13 | −0.31 | −0.06 | −1.56*** | 0.03 | 0.04 |
| t + 04 | −0.18 | −0.38 | −0.31*** | −1.71*** | −0.19* | 0.11 |
| t + 05 | 0.31** | −0.51 | 0.21* | −1.91*** | 0.31** | 0.13 |

Significance at level: ***0.01; **0.05; *0.1

confirming the thesis of dividend information content, according to which the growing dividends can be perceived as a signal of a company's good quality.

The results presented in Table 4 and Fig. 5 do not provide clear conclusions. The market reaction expressed by CAAR, in almost the entire 11-day event window, is statistically significant only in the case of using the market model as benchmark. This reaction is negative. In the case of two other models, the reaction is small—especially in the period after the day of a General Meeting of Shareholders.

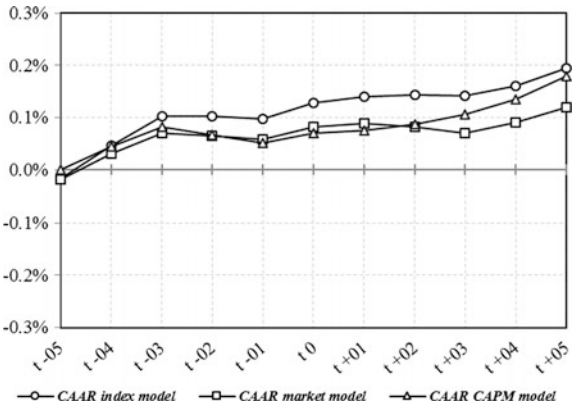


**Fig. 4** Reaction to an increase in dividend rates

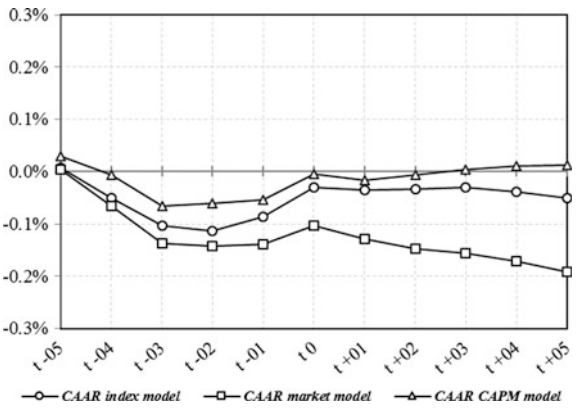


**Fig. 5** Reaction to a decline in dividend rates

## 5 Conclusion

The results are ambiguous. However, it can be concluded that the companies that increase the value of dividends reported positive cumulative abnormal returns in the event window. But in some cases, positive cumulative abnormal returns occurred when the value of dividends decreased. Thus, the mere fact of paying dividends—regardless of their amount or the direction of changes—resulted in an increase in share value over the benchmark, which is consistent with the results obtained by Słoński and Zawadzki (2012a). This may be due to the fact that the companies listed on the Warsaw Stock Exchange relatively seldom pay dividends. In consequence, the fact of paying a dividend can be perceived by investors positively, no matter if there was an increase or a decrease in its level.

The results depend on the means of measurement of dividend policy. In the authors' opinion, it is more correct to use dividend yield as a measure, because it

takes the necessary investor outlays into account. In the case of using this measure, market reactions were positive and statistically significant for all three models used as benchmarks.

One also needs to be aware that the market reaction to GMS decisions can be weakened by announcements of the board, which publishes a draft of the resolution through the GMS concerning the size of the dividend. Moreover, investor reactions can also be impacted by the stability of the dividend policy. Companies paying a dividend every year (where such cases on the WSE in Warsaw are relatively few) evoke a different reaction to companies that pay dividends irregularly. Therefore, further research is certainly needed to analyse the problems presented above.

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# Two-Asset Portfolio with Triangular Fuzzy Present Values—An Alternative Approach


**Krzysztof Piasecki and Joanna Siwek**

**Abstract** The basic tool for apprising the financial portfolio is a return rate. The main purpose of this article is to propose an alternative approach to presentation the characteristics of a to-asset portfolio in case of present value estimated by a triangular fuzzy number. For this case we justify the thesis that the expected discount factor is more convenient tool for profit analysis than expected return rate. Fuzzy expected discount factor for a portfolio and estimations of imprecision risk for that portfolio are calculated. As a result, the influence of portfolio diversification on imprecision risk is described.

**Keywords** Two-asset portfolio · Present value · Triangular fuzzy number Discount factor

## 1 Introduction

By the term of a financial asset we understand the authorization to receive future financial revenue, payable to a certain maturity. The value of this revenue is interpreted as anticipated future value (FV) of the asset. According to the uncertainty theory (Mises 1962), (Kaplan and Barish 1967), anyone unknown to us the future state of affairs is uncertain. The uncertainty theory, as it is viewed by Mises and Kaplan, is a result of our lack of knowledge about the future state of affairs. Yet, in the researched case, we can point out this particular time in the future, in which the considered state of affairs will be already known to the observer. This kind of Mises-Kaplan uncertainty will be further referred to as "uncertainty". Behind (Kolmogorov 1933, 1956; Mises 1957; Lambalgen 1996; Sadowski 1977,

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1980; Czerwiński 1960, 1969; Caplan 2001) we will accept that this is a sufficient condition for modelling the uncertainty with probability. Thus, the uncertainty is often also called a quantitative uncertainty. It is worth noting that FV is not burdened by the Knight (1921) uncertainty. All this leads to the conclusion that FV is a random variable.

The reference point for appraising the financial asset is its present value (PV), defined as a present equivalent of a payment available in a given time in the future. It is commonly accepted that the PV of a future cash flows can be an approximate value. The natural consequence of this approach is estimating PV with fuzzy numbers. This was reflected in defining a fuzzy PV as a discounted fuzzy forecast of a future cash flow's value (Ward 1985). The concept of using fuzzy numbers in financial arithmetic comes from Buckley (1987). The Ward's definition is generalized in (Chiu and Park 1994; Greenhut et al. 1995) to the case of imprecisely assessed postponement. Sheen (2005) expands the Ward's definition to the case of fuzzy nominal interest rate. Buckley (1987), Gutierrez (1989), Kuchta (2000) and Lesage (2001) discuss the problems connected with applying the fuzzy arithmetic to calculating fuzzy PV. Huang (2007) expand the Ward's definition even further, to the case of future cash flow given as a fuzzy variable. More general definition of fuzzy PV was proposed by Tsao (2005), who assumes that future cash flow can be treated as a fuzzy probabilistic set. All those authors depict PV as a discount of a imprecisely estimated future cash flow value. A different approach was introduced by Piasecki (2011a, c, 2014), where the fuzzy PV was estimated based on the current market value of a financial asset.

The basic tool for apprising the financial asset is a return rate, defined as a decreasing function of PV and, simultaneously, as an increasing function of FV.

In Piasecki (2011b) it was shown that if PV is a fuzzy real number then the return rate is a fuzzy probabilistic set (Hiroto 1981) representing epistemic random variable (Couso and Dubois 2014). In Siwek (2015) a simple return rate case was researched, where the PV was modelled by a triangular fuzzy number and FV was given as a variable with normal probability distribution. In this way a starting point for this analysis was the assumption that simple return rates have normal distribution, corresponding to classical works of Markowitz (1952). Describing the PV in terms of triangular fuzzy number is proven sensible by research results of Buckley (1987), Gutierrez (1989), Kuchta (2000) and Lesage (2001). In Siwek (2015), the tool used for appraising the financial asset was fuzzy expected return rate. The main purpose of mentioned article was to compare the appraisal of a two-asset portfolio with the appraisal of each component asset. As a result the author obtained a highly complicated relations. This made it difficult to continue the further formal analysis of portfolio characteristics. Thus, only a case study was performed.

The main purpose of the following article is to propose an alternative approach to solve the problem researched in Siwek (2015). For appraising the financial instrument we will use a fuzzy discount factor. We will also refer to the fact that each triangular fuzzy number has a bounded support. Thanks to this, the normal measure used in Siwek (2015) can be substituted by the measure proposed by Khalili (1979).

## 2 Elements of Fuzzy Number Theory

By the symbol $\mathcal{F}(\mathbb{R})$ we denote the family of all fuzzy subsets of a real line $\mathbb{R}$. Dubois and Prade (1979) define the fuzzy number as a fuzzy subset $L \in \mathcal{F}(\mathbb{R})$, represented by its membership function $\mu_L \in [0;1]^{\mathbb{R}}$ satisfying the conditions:

$$\exists_{x\in\mathbb{R}}\, \mu_L(x) = 1; \tag{1}$$

$$\forall_{(x,y,z)\in\mathbb{R}^3} : x \le y \le z \Rightarrow \mu_L(y) \ge \min\{\mu_L(x), \mu_L(z)\}. \tag{2}$$

The membership function value $\mu_L(x)$ is interpreter as a degree, in which described number $L$ is similar to precise real number $x \in \mathbb{R}$ (compare with Dubois and Prade 1997).

Arithmetic operations on fuzzy numbers were defined in Dubois and Prade (1978). According to the Zadeh's Extension Principle (Zadeh 1965), the sum of fuzzy numbers $\mathrm{K}, \mathrm{L} \in \mathcal{F}(\mathbb{R})$ represented by their corresponding membership functions $\mu_{\mathrm{K}}, \mu_{\mathrm{L}} \in [0;1]^{\mathbb{R}}$ is a fuzzy subset:

$$G = K \oplus L \tag{3}$$

described by its membership function $\mu_G \in [0;1]^{\mathbb{R}}$ by the formula:

$$\mu_G(z) = \sup\{\mu_K(x) \wedge \mu_L(z-x) : x \in \mathbb{R}\}. \tag{4}$$

Analogously, the multiplication of a real number $\gamma \in \mathbb{R}^+$ and a fuzzy number $L \in \mathcal{F}(\mathbb{R})$ represented by its membership function $\mu_L \in [0;1]^{\mathbb{R}}$ is a fuzzy subset:

$$H = \gamma \odot L \tag{5}$$

described by its membership function $\mu_H \in [0;1]^{\mathbb{R}}$ given by the formula:

$$\mu_H(z) = \mu_L\left(\frac{z}{\gamma}\right). \tag{6}$$

Moreover, if $\gamma = 0$, then the multiplication (5) is equal to zero. The class of fuzzy real numbers is closed under the operations (3) and (5). Our further analysis will be limited to the case of fuzzy numbers with bounded support. Our further research will be limited to the case of fuzzy numbers with bounded support.

Each fuzzy number is an information about imprecise estimation of a given parameter. Considering the term "imprecision", we can distinguish the ambiguity and indistinctness of information (Klir 1993). The ambiguity is interpreted as a lack of clear recommendation one alternative between the various given alternatives. The indistinctness is interpreted as a lack of explicit distinction between

recommended and unrecommended alternatives. The increase in information imprecision makes it less useful. Thus, there arise the problem of imprecision assessment.

The proper tool for measuring the ambiguity of a fuzzy number is an energy measure proposed by de Luca and Termini (1979). Due to the assumption of a bounded support of a fuzzy number, we can resign from using the normalized measure suggested in (Piasecki 2011c). In this article, the energy measure $d : \mathcal{F}(\mathbb{R}) \to \mathbb{R}_0^+$ is given as the Khalili's measure (1979). For an arbitrary fuzzy number $L \in \mathcal{F}(\mathbb{R})$, represented by its membership function $\mu_L \in [0;1]^{\mathbb{R}}$ we have:

$$d(L) = \int_{-\infty}^{+\infty} \mu_L(x)dx. \tag{7}$$

The right tool for measuring the indistinctness is the entropy measure, proposed also by de Luca and Termini (1972). In this article, the energy measure $e : \mathcal{F}(\mathbb{R}) \to \mathbb{R}_0^+$ will be described like in Kosko (1986). For an arbitrary fuzzy number $L \in \mathcal{F}(\mathbb{R})$ we have:

$$e(L) = \frac{d(L \cap L^C)}{d(L \cup L^C)}. \tag{8}$$

Due to a good synthetic substantiation and universalism of the above-mentioned formula, the entropy measure proposed by Kosko is now widely used.

In this paper we will pay special attention to triangular fuzzy numbers. The fuzzy number $T(r,s,u)$ given for a non-decreasing sequence $\{r,s,u\} \subset \mathbb{R}$ by its membership function $\mu(\cdot|r,s,u) \in [0,1]^{\mathbb{R}}$ by the formula:

$$\mu(x|r,s,u) = \begin{cases} 0 & x < r \\ \frac{1}{s-r} \cdot (x-r) & r \le x < s \\ 1 & x = s \\ \frac{1}{s-u} \cdot (x-u) & s < x \le u \\ 0 & x > u \end{cases}, \tag{9}$$

is a triangular fuzzy number. The main advantage of the triangular fuzzy numbers is the simplicity of their addition and multiplication by a non-negative scalar and the easiness of measuring their imprecision. For an arbitrary pair or triangular fuzzy numbers, say $T(r_1,s_1,u_1)$ and $T(r_2,s_2,u_2)$ as well as $a,b \in \mathbb{R}_0^+$ we have:

$$\begin{aligned} &T(a \cdot r_1 + b \cdot r_2, a \cdot s_1 + b \cdot s_2, a \cdot u_1 + b \cdot u_2) \\ &\quad = (a \odot T(r_1,s_1,u_1)) \oplus (b \odot T(r_2,s_2,u_2)), \end{aligned} \tag{10}$$

$$d(T(r_1, s_1, u_1)) = \frac{1}{2} \cdot (u_1 - r_1), \tag{11}$$

$$e(T(r_1, s_1, u_1)) = \frac{1}{3}. \tag{12}$$

## 3 Return Rate from a Financial Asset

All considerations in this and the following chapter will be performed for a fixed time $t > 0$. We will use a simple return rate $r_t$ defined by the equation:

$$r_t = \frac{V_t - V_0}{V_0}, \tag{13}$$

where:

- $V_t$ is a FV described by random variable $\tilde{V}_t : \Omega = \{\omega\} \to \mathbb{R}$;
- $V_0$ is a PV assessed precisely or approximately.

The variable FV is described by the relationship

$$\tilde{V}_t(\omega) = \check{C} \cdot (1 + \tilde{r}_t(\omega)) \tag{14}$$

where the simple return rate $\tilde{r}_t : \Omega = \{\omega\} \to \mathbb{R}$ is determined for the PV equal to the market price $\check{C}$. Behind Markowitz (1952) we assume that $\tilde{r}$ rate has a normal probability distribution $N(\bar{r}, \sigma)$.

In this paper we additionally assume that the PV is estimated by the triangular fuzzy number $T(a, \check{C}, b)$ determined by its membership function $\mu(\cdot|a, \check{C}, b) \in [0, 1]^{\mathbb{R}}$ described by (9). This condition was initially introduced by Kuchta (2000) and was applied in Siwek (2015). The parameters of a triangular fuzzy number $T(a, \check{C}, b)$ were interpreted there as follows:

- $a$ is the maximal lower bound of PV,
- $b$ is the minimal upper bound of PV.

An example of appointing the parameters $a$, $b$ was presented in Piasecki and Siwek (2015). The parameters $a$, $\check{C}$, $b$ are always non-negative.

According to the Zadeh's Extension Principle, the simple return rate calculated for the PV assessed by this method is a fuzzy probabilistic set represented by its membership function $\tilde{\rho} \in [0; 1]^{\mathbb{R} \times \Omega}$ given by:

$$\begin{aligned}\tilde{\rho}(r,\omega) &= \sup\left\{\mu\big(x|a,\check{C},b\big) : x = \frac{\tilde{V}_t(\omega)}{1+r}, x \in \mathbb{R}\right\} = \mu\left(\frac{\tilde{V}_t(\omega)}{1+r}|a,\check{C},b\right) \\ &= \mu\left(\check{C}\cdot\frac{1+\tilde{r}_t(\omega)}{1+r}|a,\check{C},b\right)\end{aligned} \tag{15}$$

According to (9) the above formula can be rewritten as:

$$\rho(r,\omega) = \begin{cases} \frac{\check{C}\cdot\frac{1+\tilde{r}_t(\omega)}{1+r}-a}{\check{C}-a}, & for \quad a \le \check{C}\cdot\frac{1+\tilde{r}_t(\omega)}{1+r} < \check{C} \\ 1, & for \quad \check{C}\cdot\frac{1+\tilde{r}_t(\omega)}{1+r} = \check{C} \\ \frac{\check{C}\cdot\frac{1+\tilde{r}_t(\omega)}{1+r}-b}{\check{C}-b}, & for \quad \check{C} < \check{C}\cdot\frac{1+\tilde{r}_t(\omega)}{1+r} \le b \end{cases}, \tag{16}$$

what can be further transformed to:

$$\rho(r,\omega) = \begin{cases} \frac{\frac{1+\tilde{r}_t(\omega)}{1+r}-\frac{a}{\check{C}}}{1-\frac{a}{\check{C}}}, & for \quad \frac{a}{\check{C}} \le \frac{1+\tilde{r}_t(\omega)}{1+r} < 1 \\ 1, & for \quad \frac{1+\tilde{r}_t(\omega)}{1+r} = 1 \\ \frac{\frac{1+\tilde{r}_t(\omega)}{1+r}-\frac{b}{\check{C}}}{1-\frac{b}{\check{C}}}, & for \quad 1 < \frac{1+\tilde{r}_t(\omega)}{1+r} \le \frac{b}{\check{C}} \end{cases}, \tag{17}$$

In this case, the expected return rate $R \in \mathcal{F}(\mathbb{R})$ is a fuzzy number given by its membership function $\rho \in [0,1]^{\mathbb{R}}$ as:

$$\rho(r) = \begin{cases} \frac{\frac{1+\bar{r}}{1+r}-\frac{a}{\check{C}}}{1-\frac{a}{\check{C}}}, & for \quad \frac{a}{\check{C}} \le \frac{1+\bar{r}}{1+r} < 1 \\ 1, & for \quad \frac{1+\bar{r}}{1+r} = 1 \\ \frac{\frac{1+\bar{r}}{1+r}-\frac{b}{\check{C}}}{1-\frac{b}{\check{C}}}, & for \quad 1 < \frac{1+\bar{r}}{1+r} \le \frac{b}{\check{C}} \end{cases}, \tag{18}$$

The discount factor $v_t$ calculated using the return rate $r_t$ is given by the equation:

$$v_t = \frac{1}{1+r_t}. \tag{19}$$

Thus, the function $\delta \in [0;1]^{\mathbb{R}}$ described by:

$$\delta(v) = \delta\left(\frac{1}{1+r}\right) = \rho(r) \tag{20}$$

is a membership function of the discount factor $D \in \mathcal{F}(\mathbb{R})$ calculated using the expected return rate $R \in \mathcal{F}(\mathbb{R})$. The above-mentioned discount factor will be further called as the expected discount factor. Combining both (18) and (20) we get:

$$\delta(v) = \begin{cases} \frac{\bar{v}^{-1} \cdot v - \frac{a}{C}}{1 - \frac{a}{C}}, & for \quad \frac{a}{C} \leq \bar{v}^{-1} \cdot v < 1 \\ 1, & for \quad \bar{v}^{-1} \cdot v = 1 \\ \frac{\bar{v}^{-1} \cdot v - \frac{b}{C}}{1 - \frac{b}{C}}, & for \quad 1 < \bar{v}^{-1} \cdot v \leq \frac{b}{C} \end{cases}, \tag{21}$$

where $\bar{v}$ is the discount factor appointed using the expected return rate $\bar{r}$. By applying elementary transformations, the membership function $\delta \in [0; 1]^{\mathbb{R}}$ can be written as:

$$\delta(v) = \begin{cases} \frac{v - \bar{v} \cdot \frac{a}{C}}{\bar{v} - \bar{v} \cdot \frac{a}{C}}, & for \quad \bar{v} \cdot \frac{a}{C} \leq v < \bar{v} \\ 1, & for \quad v = \bar{v} \\ \frac{v - \bar{v} \cdot \frac{b}{C}}{\bar{v} - \bar{v} \cdot \frac{b}{C}}, & for \quad \bar{v} < v \leq \bar{v} \cdot \frac{b}{C} \end{cases}. \tag{22}$$

It is easy to see that the discounting factor appointed above is a triangular fuzzy number $T\left(\bar{v} \cdot \frac{a}{C}, \bar{v}, \bar{v} \cdot \frac{b}{C}\right)$.

The increase in the ambiguity of the expected discount factor $D \in \mathcal{F}(\mathbb{R})$ means that there will be an increase in the number of alternative investment recommendations. It implies an increase in a risk of choice such financial decision, which will be burdened *ex post* by the lost profit. This kind of risk is called an ambiguity risk. The ambiguity risk burdening the expected discount factor $D$ is evaluated by the energy measure $d(D)$. According to (11), it equals:

$$d(D) = \frac{\bar{v}}{2 \cdot \check{C}} \cdot (b - a). \tag{23}$$

An increase in the indistinctness of the factor $D$ means that the boundaries distinguishing recommended decision alternatives are getting blurred. This results in an increase in the risk of choice not recommended decision. This kind of risk is called the indistinctness risk. The indistinctness risk burdening the expected discount factor $D$ is evaluated by the entropy measure $e(D)$. According to (12), the indistinctness risk burdening the expected discount factor is constant.

The ambiguity risk and indistinctness risk combined together will be called an imprecision risk.

In each of the considered cases, the return rate is a function of FV, which is uncertain by its nature, as mentioned in Chap. 1. This uncertainty follows from an investor's lack of knowledge about future state of affairs. This lack of this knowledge implies that no investor is sure of future profits or losses. An increase of uncertainty can result in an increase in the risk of choice a wrong financial decision. This type of risk is called an uncertainty risk. The properties of such risk are discussed in a rich body of literature. In this paper, we evaluate the uncertainty risk using the variance $\sigma^2$ of the return rate.

The formal simplicity of obtained description of an expected discount factor encourages for its further application as a portfolio analysis tool. The maximization criterion of expected return rate can then be substituted by minimization criterion of the expected discount factor. In case of not-fuzzy values of both parameters, the criteria are equivalent.

## 4 Two-Asset Portfolio

By a financial portfolio we will understand an arbitrary, finite element set of financial assets. Each of this assets is characterized by its assessed PV and anticipated return rate.

Let's now consider the case of a two-asset portfolio $\pi$, consisting of financial securities $Y_1$ and $Y_2$. The symbol $\check{C}_i$ denotes the market price of the security $Y_i (i = 1; 2)$. Then

$$\check{C} = \check{C}_1 + \check{C}_2 \tag{24}$$

is the market value of portfolio $\pi$. We assume that for each security $Y_i (i = 1; 2)$ we know the simple return rate $\tilde{r}_t^i : \Omega = \{\omega\} \to \mathbb{R}$ appointed by (13) for the PV equal to the market price $\check{C}_i$ of. Behind Markowitz (1952) we assume that the two-dimensional variable $(\tilde{r}_t^1, \tilde{r}_t^2)^T$ has a cumulative normal distribution $N\left((\bar{r}_1, \bar{r}_2)^{\mathrm{T}}, \sum\right)$, where the covariance matrix take s the form of:

$$\sum = \begin{pmatrix} \sigma_1^2 & cov_{12} \\ cov_{12} & \sigma_2^2 \end{pmatrix}. \tag{25}$$

For each asset $Y_i$ we appoint a FV given by the relation:

$$\tilde{V}_t^i(\omega) = \check{C}_i \cdot \left(1 + \tilde{r}_t^i(\omega)\right). \tag{26}$$

Contribution $p_i$ of an instrument $Y_i$ in the portfolio $\pi$ is given by:

$$p_i = \frac{\check{C}_i}{\check{C}}. \tag{27}$$

Then FV for a portfolio $\pi$ equals:

$$\begin{aligned} \tilde{V}_t(\omega) &= \tilde{V}_t^i(\omega) + \tilde{V}_t^i(\omega) = \check{C}_1 \cdot \left(1 + \tilde{r}_t^1(\omega)\right) + \check{C}_2 \cdot \left(1 + \tilde{r}_t^2(\omega)\right) \\ &= \check{C} \cdot (1 + \tilde{r}_t(\omega)), \end{aligned} \tag{28}$$

where:

$$\tilde{r}_t(\omega) = p_1 \cdot \tilde{r}_t^1(\omega) + p_2 \cdot \tilde{r}_t^2(\omega) \tag{29}$$

is a return rate form a portfolio $\pi$. An expected return rate $\bar{r}$ from a portfolio is then equal:

$$\bar{r} = p_1 \cdot \bar{r}_1 + p_2 \cdot \bar{r}_2. \tag{30}$$

Let assume that for $i = 1, 2$, PV of an asset $Y_i$ is given as a triangular fuzzy number $T\left(a_i, \check{C}_i, b_i\right)$ described in the previous chapter. Thanks to (22), all data allows for appointing an expected discount factor to the security $Y_i$:

$$D_i = T\left(\bar{v}_i \cdot \frac{a_i}{\check{C}_i}, \bar{v}_i, \bar{v}_i \cdot \frac{b_i}{\check{C}_i}\right), \tag{31}$$

where $\bar{v}_i$ is a discounting factor appointed using the expected return rate $\bar{r}_i$. According to (23), the energy measure of this fuzzy number can be calculated as:

$$d(D_i) = \frac{\bar{v}_i}{2 \cdot \check{C}_i} \cdot (b_i - a_i), \tag{32}$$

Using (10) we can show that the portfolio PV is described as a triangular fuzzy number:

$$T\left(a, \check{C}, b\right) = T\left(a_1 + a_2, \check{C}_1 + \check{C}_2, b_1 + b_2\right) \tag{33}$$

Furthermore, using (22), we can appoint an expected discount factor to the portfolio $\pi$:

$$D = T\left(\bar{v} \cdot \frac{a}{\check{C}}, \bar{v}, \bar{v} \cdot \frac{b}{\check{C}}\right), \tag{34}$$

where $\bar{v}$ is a discounting factor calculated using expected return rate $\bar{r}$. Directly form (30) we have a condition:

$$\frac{1}{\bar{v}} = \frac{p_1}{\bar{v}_1} + \frac{p_2}{\bar{v}_2}, \tag{35}$$

from which we have:

$$\begin{aligned}\bar{v} &= \left(\frac{p_1}{\bar{v}_1}+\frac{p_2}{\bar{v}_2}\right)^{-1} = \left(\frac{p_1}{\bar{v}_1}+\frac{p_2}{\bar{v}_2}\right)^{-1}\cdot(p_1+p_2)\\ &= \left(\frac{p_1}{\bar{v}_1}+\frac{p_2}{\bar{v}_2}\right)^{-1}\cdot\left(\frac{p_1}{\bar{v}_1}\cdot\bar{v}_1+\frac{p_2}{\bar{v}_2}\cdot\bar{v}_2\right),\end{aligned} \tag{36}$$

$$\begin{aligned}\frac{\bar{v}}{\check{C}}\cdot b &= \frac{\bar{v}}{\check{C}}\cdot(b_1+b_2) = \bar{v}\cdot\left(p_1\cdot\frac{b_1}{\check{C}_1}+p_2\cdot\frac{b_2}{\check{C}_2}\right)\\ &= \left(\frac{p_1}{\bar{v}_1}+\frac{p_2}{\bar{v}_2}\right)^{-1}\cdot\left(\frac{p_1}{\bar{v}_1}\cdot\left(\bar{v}_1\cdot\frac{b_1}{\check{C}_1}\right)+\frac{p_2}{\bar{v}_2}\cdot\left(\bar{v}_2\cdot\frac{b_2}{\check{C}_2}\right)\right),\end{aligned} \tag{37}$$

$$\begin{aligned}\frac{\bar{v}}{\check{C}}\cdot a &= \frac{\bar{v}}{\check{C}}\cdot(a_1+a_2) = \bar{v}\cdot\left(p_1\cdot\frac{a_1}{\check{C}_1}+p_2\cdot\frac{a_2}{\check{C}_2}\right)\\ &= \left(\frac{p_1}{\bar{v}_1}+\frac{p_2}{\bar{v}_2}\right)^{-1}\cdot\left(\frac{p_1}{\bar{v}_1}\cdot\left(\bar{v}_1\cdot\frac{a_1}{\check{C}_1}\right)+\frac{p_2}{\bar{v}_2}\cdot\left(\bar{v}_2\cdot\frac{a_2}{\check{C}_2}\right)\right).\end{aligned} \tag{38}$$

Next, by combining together (10), (22) and (34)–(38) we can conclude that:

$$D = \left(\frac{p_1}{\bar{v}_1}+\frac{p_2}{\bar{v}_2}\right)^{-1}\odot\left(\left(\frac{p_1}{\bar{v}_1}\odot D_1\right)\oplus\left(\frac{p_2}{\bar{v}_2}\odot D_2\right)\right). \tag{39}$$

Taking into account the above relationship and (10) and (11), we obtain that the energy measure of an expected discounting factor $D \in \mathcal{F}(\mathbb{R})$ meets the condition:

$$d(D) = \left(\frac{p_1}{\bar{v}_1}+\frac{p_2}{\bar{v}_2}\right)^{-1}\cdot\left(\frac{p_1}{\bar{v}_1}\cdot d(D_1)+\frac{p_2}{\bar{v}_2}\cdot d(D_2)\right) \tag{40}$$

Therefore, the energy measure of an expected discount factor of portfolio $\pi$ is an weighted average of energy measures calculated respectively for each component asset $Y_i$. The weights appointed to the assets $Y_i$ are directly proportional to their contribution $p_i$ in the portfolio and inversely proportional to their discount factor $\bar{v}_i$. This means that by minimizing the ambiguity risk of a portfolio we should focus of minimizing the ambiguity of those components which are characterized by the highest expected return rates. According to the rules of financial arithmetic, the contributions $p_i$ are appointed *post factum*, after collecting available data on the component portfolio assets. The condition (40) shows that in the researched case the portfolio diversification only "averages" the risk of ambiguity.

According to (12), the entropy measure of expected discount factor is constant. Thus, the portfolio diversification does not change the indistinctness risk.

The portfolio return rate variance equals:

$$\sigma^2 = p_1^2 \cdot \sigma_1^2 + 2 \cdot p_1 \cdot p_2 \cdot cov_{12} + p_2^2 \cdot \sigma_2^2. \tag{41}$$

Using this commonly known relation, Markowitz showed that there exists a possibility of constructing such a portfolio, that the variance of a portfolio return rate is lower than each variance of the component assets. This way Markowitz proved that portfolio diversification can "minimize" the uncertainty risk.

## 5 Case Study

The portfolio $\pi$ consists of financial assets $Y_1$ and $Y_2$. PV for $Y_1$ is given by a triangular fuzzy number $T(50; 90; 110)$. The membership function plot $\mu(\cdot|50; 90; 110) \in [0, 1]^{\mathbb{R}}$ is presented in the Fig. 1.

Anticipated return rate $\tilde{r}_t^1 : \Omega \to \mathbb{R}$ from the asset $Y_1$ is a random variable with a normal distribution $N(0.25; 0.5)$. Then, corresponding to (18), the expected return rate from $Y_1$ is a fuzzy number $R_1 \in \mathcal{F}(\mathbb{R})$ given by its membership function $\rho_1 \in [0, 1]^{\mathbb{R}}$ by the formula:

$$\rho_1(r) = \begin{cases} \frac{2.25}{1+r} - 1, & for \quad 1.25 \geq r > 0.25 \\ 1, & for \quad r = 0.25 \\ \frac{-5.625}{1+r} + 5.5 & for \quad 0.25 > r \geq 0.0227, \end{cases} \tag{42}$$

and presented in Fig. 2. It is easy to see that the expected return rate appointed this way is not a triangular fuzzy number.

Next we indicate the expected discount factor $D_1 \in \mathcal{F}(\mathbb{R})$ calculated using the expected return rate $R_1$. According to (19) and (22), we have:

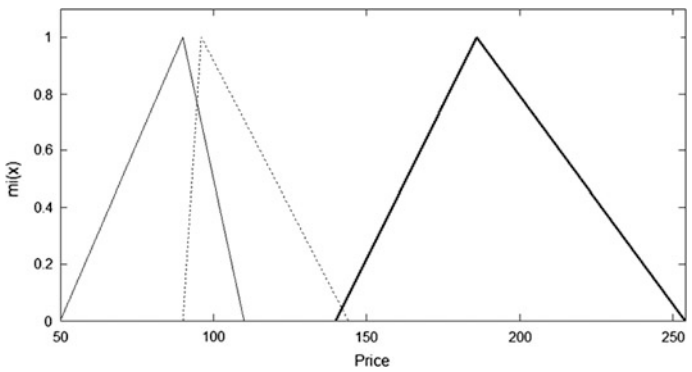


**Fig. 1** Membership functions for PV of assets $Y_1$ (*solid line*) and $Y_2$ (*dotted line*) and the portfolio $\pi$ (*bold line*). *Source* Own study

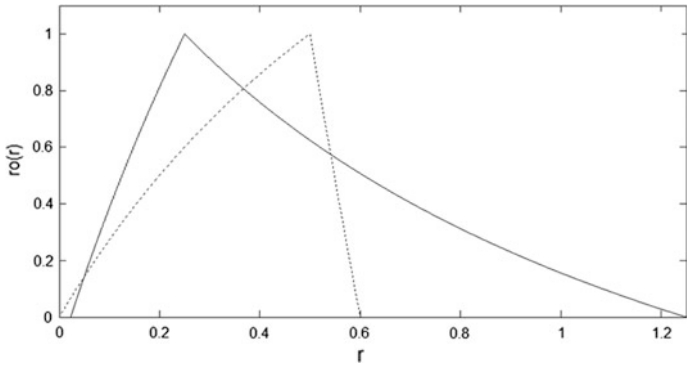


**Fig. 2** Membership functions for expected return rates $R_1$(*solid line*) and $R_2$ (*dotted line*). *Source* Own study

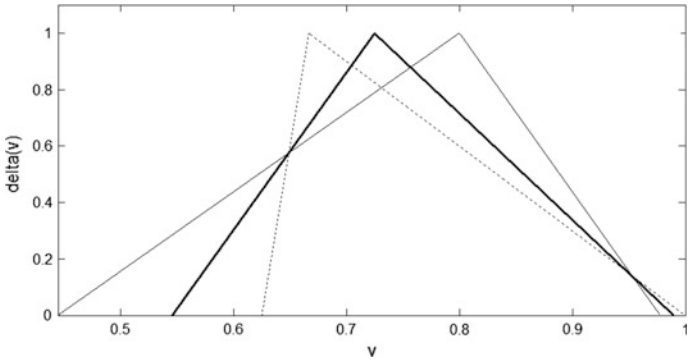


**Fig. 3** Membership functions for expected discount factors $D_1$ (*solid line*), $D_2$ (*dotted line*), and $D$ (*bold line*). *Source* Own study

$$D_1 = T\left(\frac{1}{1+0.25}\cdot\frac{50}{90};\frac{1}{1+0.25};\frac{1}{1+0.25}\cdot\frac{110}{90}\right) = T(0.4444;0.8;0.9778). \tag{43}$$

The membership function plot $\delta_1 \in [0;1]^{\mathbb{R}}$ for an expected discount factor $D_1$ was presented in Fig. 3. Using (23) we can calculate the energy measure of this factor:

$$d(D_1) = \frac{0.8}{2\cdot 90}\cdot(110-50) = 0.2667 \tag{44}$$

The PV of an asset $Y_2$ is given by a triangular fuzzy number $T(90;96;144)$. The membership function plot for $\mu(\cdot|90;96;146) \in [0,1]^{\mathbb{R}}$ is presented in Fig. 1.

The anticipated return rate $\tilde{r}_t^2 : \Omega \to \mathbb{R}$ from $Y_2$ is a random variable with a normal distribution $N(0,5; 0,4)$. Then, corresponding to (18), the expected return rate from $Y_2$ is a fuzzy number $R_2 \in \mathcal{F}(\mathbb{R})$ given by its membership function $\rho_2 \in [0,1]^{\mathbb{R}}$ by the formula:

$$\rho_2(r) = \begin{cases} \frac{24}{1+r} - 15, & for \quad 0.6 \geq r > 0.5 \\ 1, & for \quad r = 0.5 \\ \frac{-3}{1+r} + 3 & for \quad 0.5 > r \geq 0, \end{cases} \tag{45}$$

and presented in the Fig. 2. It is easy to see that here also the expected return rate is not a triangular fuzzy number. Next, we find the expected discount factor $D_2 \in \mathcal{F}(\mathbb{R})$ calculated using the expected return rate $R_2$. According to (19) and (22), we have:

$$D_2 = T\left(\frac{1}{1+0.5} \cdot \frac{90}{96}; \frac{1}{1+0.5}; \frac{1}{1+0.5} \cdot \frac{144}{96}\right) = T(0.6250; 0.6667; 1). \tag{46}$$

The membership function plot $\delta_2 \in [0;1]^{\mathbb{R}}$ for an expected discount factor $D_2$ was presented in the Fig. 3. Using (23) we can calculate the energy measure of this factor:

$$d(D_2) = \frac{0.6667}{2 \cdot 96} \cdot (144 - 90) = 0.1875. \tag{47}$$

According to (10), PV for the portfolio $\pi$ is a triangular fuzzy number:

$$PV = T(50+90; 90+96; 110+144) = T(140; 186; 254) \tag{48}$$

This value is calculated only for illustrative purposes. The membership function plot for $\mu(\cdot|140; 186; 256) \in [0,1]^{\mathbb{R}}$ is presented in the Fig. 1, in order to compare it with PV of $Y_1$ and $Y_2$.

Corresponding to (26), shares $p_1$ and $p_2$ for instruments $Y_1$ i $Y_2$ in portfolio $\pi$ are equal:

$$p_1 = \frac{90}{186} = \frac{15}{31}, \quad p_2 = \frac{96}{186} = \frac{16}{31}. \tag{49}$$

We calculate the expected discount factor $D \in \mathcal{F}(\mathbb{R})$ for the portfolio $\pi$. According to (38), it is a following fuzzy number:

$$
\begin{aligned}
D = &\left(\left(\left(\frac{\frac{15}{31}}{0.8}+\frac{\frac{16}{31}}{0.6667}\right)^{-1}\cdot\frac{\frac{15}{31}}{0.8}\right)\odot D_1\right)\oplus\\
&\oplus\left(\left(\left(\frac{\frac{15}{31}}{0.8}+\frac{\frac{16}{31}}{0.6667}\right)^{-1}\cdot\frac{\frac{16}{31}}{0.6667}\right)\odot D_2\right)=\\
&=(0.4386\odot T(0.4444;0.8;0.9778))\oplus\oplus(0.5614\odot T(0.6250;0.6667;1))\\
&=T(0.5458;0.7252;0.9923).
\end{aligned}
\tag{50}
$$

The membership function plot $\delta\in[0;1]^{\mathbb{R}}$ for an expected discount factor $D$ was presented in the Fig. 3. Energy measure for this factor can be calculated by (39) as follows:

$$
\begin{aligned}
d(D) &= 0.4386\cdot d(D_1)+0.5614\cdot d(D_2)\\
&= 0.4386\cdot 0.2667+0.5614\cdot 0.1875=0.2222.
\end{aligned}
\tag{51}
$$

According to the theory stated in Chap. 4:

$$
d(D_1)>d(D)>d(D_2). \tag{52}
$$

Thus, creating a portfolio $\pi$ resulted in averaging the ambiguity risk. The cumulative distribution of the portfolio component asset return rate vector $(\tilde{r}_t^1,\tilde{r}_t^2)^T$ is a normal distribution $N\big((0.25;0.5)^T,\sum\big)$, where the covariance matrix takes the form of:

$$
\sum=\begin{pmatrix}0.25 & 0.20\\ 0.20 & 0.16\end{pmatrix}. \tag{53}
$$

Using (40) we calculate the variance of a return rate:

$$
\sigma^2=0.0020<\min\{\sigma_1^2,\sigma_2^2\}. \tag{54}
$$

This means that creating the portfolio $\pi$ resulted in minimizing the uncertainty risk. According to (12), the risk of indistinctness did not change.

## 6 Summary

The preformed research indicates that there exist effective methods of portfolio imprecision risk management, which has its source in the approximate appointment of PV for the portfolio component assets. The object of research in this article was

the two-asset portfolio consisting of instruments with PV assessed as a triangular fuzzy number. For this case we obtained the following results:

- The portfolio diversification can lead to a lower uncertainty risk,
- The portfolio diversification averages the ambiguity risk,
- The portfolio diversification has no influence on the indistinctness risk.

This suggests that there exist portfolios burdened with risk that cannot be lowered by diversifying the portfolio in the researched case it was also proven that the portfolio diversification does not increase the imprecision risk. This means that a decrease in the uncertainty does not increase the risk of imprecision.

In this paper as well as in Siwek (2015) an identical case of imprecision risk management was considered. Still, both articles differ greatly in the approach to the subject. In Siwek (2015), the conclusions stated above were achieved only for a single case study. Here, by using the alternative approach, the conclusions were obtained by formal deduction and for an arbitrary two-asset portfolio consisting of instruments with PV given as a triangular fuzzy number. It allows for pointing out a cognitive advantage of the stated alternate approach as opposed to the approach presented in Siwek (2015).

The results obtained above encourage to their continuation. The suggested further research can take the form of generalizing the representation of PV to the case of trapezoidal fuzzy number. By using the mathematical induction, all results obtained this way can be generalized to the case of a multi-asset portfolio.

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# Stock Market Liquidity and Company Decisions to Pay Dividends: Evidence from the Warsaw Stock Exchange


**Szymon Stereńczak**

**Abstract** Studies on the effects of stock liquidity on corporate financial decisions have been made only recently. The first work in this field was the paper by Banerjee et al. (J Financ Quant Anal 42(3):369–397, 2005), in which they investigated the impact of stock market liquidity on companies' dividend policies. In developed markets, the effect of liquidity on companies' dividend payout is well documented, and the findings are not ambiguous: the more liquid shares on capital markets are, the fewer companies are willing to pay dividends, and so they maintain a lower level of payments. Although most studies made on emerging markets support these results, there is still lack of a comprehensive analysis made on the Polish capital market. The goal of this paper is to investigate the relationship between stock liquidity and both companies' propensities to pay dividends, and the level of dividend payments. The research results presented here also support the effects of previous studies: companies with less liquid shares are more willing to pay dividends, and pay them at a higher amount. The paper is a contribution to further research in this field, using data on more companies and from a longer period.

**Keywords** Stock liquidity · Warsaw stock exchange · Dividend Payout

## 1 Introduction

Studies on corporate dividend policy still gives ambiguous results in its determinants. Only recently, since the seminal paper by Banerjee et al. (2005), stock market liquidity has been considered as one of the possible dividend factors. Most studies done in this field indicate that there exists a negative relationship between stock market liquidity and companies' propensity to pay dividends, and the level of payouts (which consists of dividends and share repurchases). The goal of the paper

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is to investigate the impact of stock liquidity on companies' dividend policies using data on Polish public companies.

One of the possible, and plausibly the most important link between liquidity of shares on the stock market is the denial of Miller's and Modigliani's (1961) assumption of perfect capital markets, which resulted in dividend irrelevance theory. Miller's and Modigliani's assumption of perfect capital markets indicates that, if necessary, investors are able to sell a part of their shares at no cost, receiving a so-called homemade dividend. This assumption is not met in markets that are not perfect, especially not perfectly liquid. It can be predicted that the more imperfect is the market, the lower is investors' ability to receive a costless homemade dividend. Hence, the lower share liquidity is, the more difficult it is to get a homemade dividend at no cost, and so the higher is the demand for dividends paid by the company. That indicates the theoretical existence of a negative relationship between stock liquidity and the frequency and level of a company's payouts.

The study by Banerjee et al. (2005) covered NYSE and AMEX companies for the years from 1963 to 2003. They pointed out the existence of a cross-sectional negative impact of stock liquidity and companies' propensity to pay dividends using logit regression. A similar analysis has been conducted by Brockman et al. (2008), however, they expanded their studies to include share repurchases. They showed that liquidity plays a significant role in managers' payout decisions. Similar effects have been shown for other, both developed and emerging, capital markets: Tunisia (Ben Naceur et al. 2006), Japan (Hoda and Uno 2011), Iran (Ghodrati and Fini 2014) and China (Pan et al. 2015, Michaely and Qian 2016), as well as in studies covering several capital markets (Griffin 2010; Gul et al. 2014).

Due to the theoretical indications and results of other studies made both on the developed and emerging stock markets, two hypothesis have been posed in the study. The first one refers to the companies propensities to pay dividends, and the second is associated with the relationship between the level of stock liquidity and the level of dividend paid.

Similarly to Banerjee et al. (2005), Brockman et al. (2008) and Gul et al. (2014), in this study, models have been created in which the dependent variables were a company's propensity to pay dividends and the level of the dividend payout. The explanatory variable was stock liquidity. The models relating stock liquidity and propensity to pay dividends have been created as logit and probit models. To model the impact of liquidity on the payout level, tobit models have been used.

The study covers companies listed on the Warsaw Stock Exchange for the years from 2011 to 2016. Banks and insurance companies have been excluded from the sample due to their unique financial statements. Companies' financial data have been gathered from the Notoria Serwis database. Quotation data, needed primarily to compute the Amihud illiquidity ratio, come from the GPWInfoStrefa database. Share prices have been adjusted for corporate action (i.e. dividend payouts, subscription rights, splits and reverse-splits). Model parameters have been estimated using Gretl.

Controlling for profitability, solvency, company size and growth opportunities, lowering share liquidity implies a company's higher propensity to pay dividends. In the logit and probit models, the variable for stock liquidity is statistically

significant at a level lower than 0.05. Stock market liquidity also affects the dividend yield, and its impact is significant at a level 0.01.

The rest of the paper is organized as follows: Section 2 is devoted to a literature overview; the research sample, variables and methodology of the study is described in the Sect. 3; empirical findings are presented in Sect. 4 and Sect. 5 contains a robustness check; Sect. 6 provides the conclusions. The study was financed by the National Science Centre, Poland as a research project (2015/19/D/HS4/01950).

## 2 Literature Overview

### *2.1 Theoretical Background*

The studies on companies' dividend policy started nearly 60 years ago. One of the most important works in this field remains the paper by Miller and Modigliani (1961). In their study they made an assumption of a perfect capital market, i.e. that (Miller and Modigliani 1961): (1) no single trader is large enough for its transactions to have an impact on the ruling price, (2) all traders have equal and costless access to information about shares, (3) there are no transaction costs. In addition, they assumed the rational behaviour of investors and perfect certainty about the future. Due to the costless trading and no impact of dividend policy on a company's value, an investor in need of cash is able to receive a homemade dividend at no cost, selling a part of the shares he or she owns.

In Miller's and Modigliani's world of perfect capital markets, getting a dividend directly from the company gives the same amount of money as selling a part of the shares. Thus, the choice of the form of raising money does not affect the investor's wealth. In practice, however, capital markets are not perfect, especially not perfectly liquid. Lack of perfect liquidity means that, in addition to the existence of transaction costs, trading a large amount of shares can move the price in an unfavourable direction. Thus, choosing a dividend has an effect on the investor's wealth: the less liquid shares are, the higher are transaction costs and the higher is the price impact of trade, and the smaller the amount of cash the investor obtains from the homemade dividend.

The other theoretical justification of the existence of the relationship between share liquidity and a company's dividend policy comes from studies on the effects of liquidity on the rates of return expected by investors (company's cost of equity). Trading on perfectly liquid markets, investors should be able to trade securities immediately and at no cost. In practice, investors face illiquidity, i.e. lack of perfect liquidity. Hence, an agent willing to trade faces a trade-off: trade immediately, incurring high transaction costs (especially brokerage fees, taxes) and price impact, or trade patiently, splitting the order into small pieces and incurring an opportunity cost (Amihud and Mendelson 1986; Huberman and Stanzl 2005). Investors wish to be compensated for those costs, hence less liquid stocks should yield higher returns.

The effects of illiquidity on stock returns has been broadly investigated since Amihud and Mendelson's (1986) seminal paper. The most important studies in this field, in addition to the paper by Amihud and Mendelson (1986), were studies done by: Brennan and Subrahmanyam (1996), Datar et al. (1998), Amihud (2002), Pastor and Stambaugh (2003) and Acharya and Pedersen (2005). Most of the studies done so far were conducted using data from US stock markets, and most of them demonstrated the existence of the link between the liquidity and returns expected by investors: the lower stock liquidity is, the higher are the returns demanded by investors (the higher is the company's cost of equity). Thus, the less liquid a company's shares are, the higher is a company's equity cost of capital, and the lower should be the company's preference for equity financing. To reduce the value of equity, companies with less liquid shares should pay higher dividends than companies with more liquid stock that are more willing to use equity financing.

Besides the abovementioned theoretical links between stock liquidity and a company's dividend policy, it should be mentioned that dividend payments are potentially a way to increase the liquidity of shares. Igan et al. (2006) and Farooq and Seffar (2012) demonstrated that companies that pay dividends have more liquid shares. One possible explanation of this phenomenon is that by paying dividends, companies reduce their agency and adverse selection problems for uninformed investors, thereby leading to more liquidity for the company's stock. Companies with the least liquid shares should pay dividends more often and at higher amounts, in order to increase their stock liquidity.

## *2.2 Empirical Studies*

The first empirical study on the link between stock liquidity and companies' dividend policies (known to the author) is the study by Banerjee et al. (2005). Their study covered NYSE and AMEX companies for the years from 1963 to 2003. They investigated the effects of stock liquidity on companies' dividends payouts in cross-section and over time. They pointed out that owners of less (more) liquid stocks are more (less) willing to receive dividends. Further, Banerjee et al. (2005) demonstrated that an increase in US market liquidity resulted in a decline in companies' propensity to pay dividends. According to their research, stock liquidity has a predictive power about dividend initiations and omissions for individual companies.

A similar analysis was carried out by Brockman et al. (2008). However, they examined the impact of share liquidity on managerial payout decisions (i.e. dividends and stock repurchases). They showed that managers compare the tax and flexibility advantages and liquidity costs disadvantage of repurchase, and found that liquidity plays a significant role in managers' payout decisions: higher stock liquidity results in greater preference of buyout instead of dividends.

Brockman et al. (2008) showed that companies' propensities to share repurchase and the buyout volume are positively correlated to stock liquidity. Conversely, the

amount of dividends paid by a company lowers with the increase in equity market liquidity. The same goes for the impact of stock liquidity on a company's propensity to pay dividends. Similarly to Banerjee et al. (2005), Brockman et al. (2008) demonstrated that the growing popularity of stock repurchases (as a method of payout) is due to the increase in US capital market liquidity.

The effects of share liquidity on a company's dividend policy have been studied on other markets, including both developed and emerging stock exchanges. The negative relationship between stock liquidity and the dividend level has been demonstrated for the Tunisian (Ben Naceur et al. 2006), Japanese (Hoda and Uno 2011) and Chinese (Pan et al. 2015) stock markets. The results of the study made on Iranian capital market (Ghodrati and Fini 2014) are ambiguous, and the direction of the relationship between stock liquidity and companies' propensities to pay dividends depends on the proxy for liquidity used.

In this field, some international analyses have been done. Two of them are studies by Griffin (2010) and Gul et al. (2014). The results of those studies support the results obtained in other research: companies with less liquid shares are more willing to pay dividends than companies with more liquid stock.

## 3 Data Description

### *3.1 Variables*

There are a lot of liquidity measures that can be used in studying the effects of liquidity on corporate dividend policy. Probably the most common proxy for liquidity in early studies on US markets was the bid-ask spread and its various estimates, e.g. Roll's (1984) effective spread estimate, based on the covariance of price changes, zero-return-days measure developed by Lesmond et al. (1999) and the "effective tick" measure by Holden (2006). The other commonly used measure of liquidity is trading volume and turnover. Those simple liquidity proxies capture the investors' trading activity and do not take into account the costs of trading. The price impact of trade is captured by Amihud's (2002) illiquidity ratio and Pastor and Stambaugh's (2003) $\gamma$.

As a proxy for liquidity Amihud's illiquidity ratio has been used. This measure captures the price impact of trade, hence it helps to explain the cost of obtaining the homemade dividend. It has been computed as an annual average of the absolute value of daily price change divided by daily turnover for companies with data available for at least than 185 days per year. Companies with data available for less than 185 days per year have been excluded from the sample to avoid biases in the computed value of illiquidity ratio. To ensure the normal distribution of liquidity measure, computed values have been multiplied by $10^3$ and logarithmized, similarly as Amihud (2002) did.

The set of control variables includes profitability, solvency, company size and growth perspectives. All of those variables have been computed annually. Profitability is measured at operating level and is computed as the operating profit in year *t* divided by the averaged value of total assets in year *t*. Calculating the profitability at operational level is done to avoid the impact of differences in the level of debt. In addition, another proxy for profitability has been used, i.e. return on equity (hereafter ROE) computed as the ratio of net profit in year *t* to averaged book value of equity in the year *t*. ROE was included with one period lag. Solvency was calculated as a ratio of operating cash flow in the year *t* to the averaged value of total assets at the end of the year *t*. Company size is a natural logarithm of average market value in the year *t*, and market-to-book value in the year *t* was used as a proxy for growth perspectives. It can be expected that more profitable, solvent, bigger and value companies will be more willing to pay dividends and will pay them in higher amounts.

Companies' propensities to pay dividends is a latent variable and will be proxied by a dummy variable that equals 1 if a company is defined as a dividend payer in year *t*, and 0 otherwise. The company is defined as a dividend payer in year *t* whenever that company's cash flow statement reports a dividend payment in year *t*. The variables for dividend level is the dividend yield, calculated as dividend per share paid in year *t* divided by averaged share price in year *t*. Definitions of all used variables are described in Table 1.

Companies' financial data have been collected from the Notoria Serwis database. Quotation data, needed primarily to compute Amihud's illiquidity ratio, come from the GPWInfoStrefa database. Rates of return are computed daily as simple rates of return. In order to calculate the rates of return needed to estimate the level of liquidity, the prices of shares have first been adjusted for corporate actions, i.e. dividends, splits, reverse-splits and subscription rights.

## *3.2 Research Sample*

The study covers companies listed on the Warsaw Stock Exchange for the years from 2011 to 2016. Banks and insurance companies have been excluded from the sample due to their unique financial statements. Only companies capable of paying a dividend (e.g. with positive book value of equity) were included in the sample. This gives a sample of 2186 company-year observations in an unbalanced panel. 49.5% of observations are dividend payers. Descriptive statistics of the research sample are presented in Table 2.

The asymmetry and skewness of distribution of dividend yield is possibly an effect of the high number of zeros (about half the observations). Thus, to avoid low quality of the models, the impact of stock liquidity on the level of dividends is verified using tobit models of regression. Dividend yield, solvency, size and book-to-market value are right-sided asymmetrically distributed and profitability, ROE and illiquidity are variables with left-sided asymmetric distribution. All the variables, except liquidity, have leptokurtotic distribution and liquidity has platykurtotic distribution.

**Table 1** Definitions of variables

| Variable | Symbol | Definition |
|---|---|---|
| Company's propensity to pay dividend | P (Div = 1) | The proxy for propensity to pay dividends is a dummy variable that equals 1 if a company's cash flow statement reports a dividend payment in year *t*, and 0 otherwise, |
| Dividend yield | DY | Value of dividend per share paid in the year *t* divided by average stock price in the year *t*, |
| Operating profitability | Prof | Gross operating profit in year *t* divided by average value of total assets in year t, |
| Lagged return on equity | $ROE_{t-1}$ | Net profit in year $t-1$ divided by average book value of equity in year $t-1$, |
| Solvency | Solv | Value of operating cash flow generated in year *t* divided by average value of total assets in year *t*, |
| Size | Size | Natural logarithm of the average market value of equity (in '000 PLN) in year *t*, |
| Market-to-book value | M-BV | Average company capitalization in year *t* divided by average book value of equity in year *t*, |
| Liquidity | ln*ILLIQ* | Amihud's illiquidity ratio in year *t*, multiplied by $10^3$ and logarithmized, Amihud's illiquidity ratio is computed using the following formula: $ILLIQ_{it} = \frac{1}{D_{it}} \sum_{y=1}^{D_{it}} \frac{\lvert r_{ity} \rvert}{VOL_{ity}}$ where: $D_{it}$ denotes the number of days with available data for company *i* in year *t*, $r_{ity}$ denotes the rate of return of stock *i* in day *y* of year *t*, and $VOL_{ity}$ is the corresponding trading volume |

**Table 2** Descriptive statistics of the research sample

| Variable | Mean | Std. Dev. | Skewness | Kurtosis | Quartile 1 | Median | Quartile 3 |
|---|---|---|---|---|---|---|---|
| DY | 4.452% | 27.146% | 16.314 | 330.664 | 0% | 0% | 3.246% |
| Prof | 4.545% | 11.888% | −0.495 | 23.035 | 0.917% | 4.735% | 8.725% |
| $ROE_{t-1}$ | 2.857% | 34.435% | −7.105 | 107.542 | 0.388% | 6.533% | 13.806% |
| Solv | 6.047% | 11.415% | 0.064 | 8.572 | 0.946% | 6.174% | 11.356% |
| Size | 11.960 | 2.064 | 0.239 | 0.632 | 10.690 | 11.904 | 13.153 |
| M-BV | 5.981 | 55.551 | 17.807 | 65.452 | 0.576 | 1.014 | 1.845 |
| ln*ILLIQ* | −6.273 | 3.096 | −0.631 | −0.214 | −8.461 | −5.664 | −3.780 |

# 4 Empirical Findings

## *4.1 Development of Hypotheses*

Let us assume that each investor in the market works as an agent (e.g. investment fund) which in each period has certain liquidity needs (in terms of the amount of

money needed to pay liabilities). If the portfolio of each agent is made up entirely of shares, an investor has only two ways to obtain the cash needed: get a dividend directly from the company or sell a part of the shares he or she owns (obtain a homemade dividend). In Miller's and Modigliani's (1961) world of perfect capital markets those two ways are equal, and give the same amount of money to the investor, having no impact on wealth.

Nevertheless, capital markets, especially emerging stock markets, are far from perfect. Thus, due to the lack of perfect liquidity and accompanying occurrence of liquidity costs (which arise only in the moment of sale of shares), those two ways are not equal. Obtaining a homemade dividend is not costless, hence getting a dividend directly from a company is more valuable than a homemade dividend. Thereby, in a not perfectly liquid market, selling a part of the shares to satisfy the agent's liquidity needs is going to reduce the value of that agent's wealth.

Assuming that the main purpose of a corporation is to maximize investor wealth, companies should avoid situations where a shareholder bears high transaction costs due to obtaining a homemade dividend from selling illiquid shares. Thus, managers of companies with less liquid shares, conscious of the role of dividends (received directly from the company) should decide for investor wealth to make payments more often and in higher amounts. Thus, it is reasonable to assume the following two hypotheses in the study:

*H1. Companies with less liquid shares are more willing to pay dividends than companies with more liquid shares.*
*H2. Companies with less liquid shares pay higher dividends than companies with more liquid shares.*

To verify the hypotheses, the regression analysis was applied. Similarly to Banerjee et al. (2005), Brockman et al. (2008) and Gul et al. (2014), to verify the hypothesis *H1*, logit and probit models were created, explaining the impact of stock liquidity on a company's propensity to pay dividends. The relationship described in hypothesis *H2* was verified by applying a tobit regression to dividend yield (DY) as a dependent variable, and liquidity of shares as an explanatory variable. For summary statistics, Statistica was used, and model parameters were estimated using Gretl.

## *4.2 Summary Statistics*

First, it is worth starting by presenting some summary statistics for the subsample of companies that paid dividends and the subsample of companies that did not pay dividends. It can be expected that dividend-paying companies have different financial characteristics to non-dividend-paying companies. The compared characteristics are: profitability, solvency, size, growth opportunities and level of liquidity. Summary statistics are given in Table 3 and the correlation matrix is presented in Table 4.

**Table 3** Summary statistics for dividend-payers and non-dividend-payers

| Characteristic | Prof | $ROE_{t-1}$ | Solv | Size | M-BV | ln*ILLIQ* |
|---|---|---|---|---|---|---|
| Dividend-paying companies—mean | 7.012% | 9.938% | 8.786% | 12.639 | 3.409 | −6.738 |
| Dividend-paying companies—Std. Dev. | 9.971% | 18.657% | 10.232% | 1.916 | 23.163 | 3.249 |
| Non-dividend-paying companies—mean | 2.108% | −4.249% | 3.343% | 11.295 | 8.522 | −5.797 |
| Non-dividend-paying companies—Std. Dev. | 13.072% | 43.898% | 11.874% | 1.986 | 74.791 | 2.854 |
| Difference in means | 4.904% | 14.187% | 5.443% | 1.343 | −5.114 | −0.941 |
| *p*-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.035 | 0.000 |

**Table 4** Correlation matrix of variables

| Variable | DY | Prof | ROE | Solv | Size | M-BV | ln*ILLIQ* |
|---|---|---|---|---|---|---|---|
| P (Div = 1) | 0.1610 | 0.2025 | 0.1441 | 0.2333 | 0.3267 | −0.0403 | −0.1536 |
| DY | | −0.0195 | 0.0054 | 0.0208 | −0.0211 | −0.0144 | 0.0415 |
| Prof | | | 0.4524 | 0.4619 | 0.2206 | −0.0058 | −0.0959 |
| ROE | | | | 0.2046 | 0.1522 | −0.0301 | −0.0752 |
| Solv | | | | | 0.2287 | 0.0113 | −0.1034 |
| Size | | | | | | 0.2413 | −0.6177 |
| M-BV | | | | | | | −0.0061 |

It should be noted that only about half of companies in the research sample paid a dividend in the years 2011–2016. Those numbers may seem surprising, taking into account that the Warsaw Stock Exchange is considered quite an illiquid stock market.

Consistent with the expectations, on the Polish capital market dividend payers are more profitable, more solvent, bigger and have lower market-to-book value. Contrary to the expectations, dividend payers are more liquid (have lower values of Amihud's illiquidity ratio). Companies that pay dividends have about 5 p.p. higher average operational profitability than non-dividend-paying companies and the ROE of dividend-payers is about 14 pp. higher than the ROE of non-dividend-payers. Both the higher operating profitability and net profitability allow the company to pay dividends more often and at higher amounts.

On average, dividend-paying companies are larger than companies that do not pay dividends and have smaller growth opportunities (the difference in means of M-BV is 5.114). It is plausible that larger companies with smaller prospects for growth have lower capital needs and, to avoid agency costs due to maintaining a high level of cash, pay dividends more often than smaller companies with more

growth opportunities that have higher capital needs. Surprisingly, dividend-paying companies have more liquid shares than non-dividend-payers. The value of difference in means of illiquidity ratio between non-payers and payers equals 0.94, which indicates that there is a plausibility that the relationship between shares' liquidity and a company's dividend policy has the opposite direction than that expected (i.e. a company's dividend policy affects stock liquidity). All of the differences in means are statistically significant at the 0.05 level.

As shown in Table 4, the variables are rather not correlated, except for illiquidity and size. There is a strong and significant relationship between those two variables, nevertheless, both should be taken into account when constructing regression models. This makes it possible to distinguish the effect of company size and stock illiquidity on the company's dividend policy. The correlation between illiquidity and variable corresponding to being a dividend payer is negative, but this is not surprising in the context of the summary statistics presented in Table 3.

## *4.3 Regression Analysis of Stock Liquidity Effects on Companies' Dividend Policies*

In order to investigate the effect of company characteristics potentially influencing the decision on dividend payment, a regression analysis was applied. Six models of various forms were estimated. The first two models (M1)-(M2) are logit models with the company's propensity to pay dividends (measured as a possibility) as a dependent variable. Models (M3)-(M4) have the same dependent variable, but are estimated as a probit model. Model (M5) and (M6) explain the value of dividends paid measured as dividend yield. Due to the fact that the values of dependent variables are censored, it is necessary to estimate those models as tobit models. The set of explanatory variables is the same in each of the estimated models and consists of: profitability, lagged ROE, solvency, size, market-to-book value, liquidity and value of dependent variable lagged by one period. Table 5 consists of estimated model parameters, and standard errors of coefficients are given in the parentheses below the value of coefficient.

Controlling for profitability, solvency, company size and growth opportunities, lowering share liquidity implies a company's higher propensity to pay dividends. The signs of all control variables are consistent with the expectations, i.e. higher profitability, higher solvency, bigger size and lower market-to-book value also increases the possibility of being dividend-payer. The abovementioned characteristics have an impact on the amount of dividend paid by the company.

In all estimated models variable for stock liquidity is statistically significant at a level of 0.05 and the values of the parameters are positive, as expected. That means that the liquidity of a company's shares has an effect on the company's propensity to pay dividends, as well as on the size of dividend paid by the company. The lower stock liquidity is (i.e. the higher the values of Amihud's illiquidity measure), the higher is the company's propensity to pay dividends and dividends are paid at higher amounts.

**Table 5** Stock market liquidity and dividend policy: panel regression

| Model | (M1) | (M2) | (M3) | (M4) | (M5) | (M6) |
|---|---|---|---|---|---|---|
| Dependent variable | P (Div = 1) | P (Div = 1) | P (Div = 1) | P (Div = 1) | DY | DY |
| Constant | −4.377*** (0.5127) | −4.391*** (0.5506) | −2.552*** (0.2848) | −2.572*** (0.3078) | −0.679*** (0.0781) | −0.671*** (0.0830) |
| Prof | 1.794** (0.8257) | 1.774** (0.8292) | 0.976** (0.4522) | 0.959** (0.4534) | 0.313** (0.1231) | 0.301** (0.1230) |
| $ROE_{t-1}$ | 0.698** (0.3045) | 0.687** (0.3042) | 0.395** (0.1681) | 0.392** (0.1690) | −0.020 (0.0366) | −0.022 (0.0366) |
| Solv | 1.650** (0.7650) | 1.747** (0.7696) | 0.873** (0.4269) | 0.915** (0.4292) | 0.278** (0.1197) | 0.305** (0.1204) |
| Size | 0.272*** (0.0509) | 0.270*** (0.0515) | 0.156*** (0.0284) | 0.155*** (0.0288) | 0.048*** (0.0077) | 0.048*** (0.0077) |
| M-BV | −0.005* (0.0028) | −0.005* (0.0028) | −0.003** (0.0015) | −0.003** (0.0015) | −0.001*** (0.0004) | −0.001*** (0.0004) |
| ln*ILLIQ* | 0.076** (0.0298) | 0.075** (0.0301) | 0.042** (0.0165) | 0.041** (0.0167) | 0.013*** (0.0045) | 0.013*** (0.0045) |
| $Div_{t-1}$ | 2.927*** (0.1409) | 2.943*** (0.1419) | 1.753*** (0.0793) | 1.760*** (0.0797) | – | – |
| $DY_{t-1}$ | – | – | – | – | 0.526*** (0.0310) | 0.527*** (0.0310) |
| Year dummies | NO | YES | NO | YES | NO | YES |
| Number of observations | 1559 | 1559 | 1559 | 1559 | 1559 | 1559 |
| McFadden *R*-squared | 0.387 | 0.388 | 0.387 | 0.389 | – | – |
| AIC | 1341.231 | 1346.346 | 1339.687 | 1344.861 | – | – |
| Correct predictions | 82.7% | 82.7% | 82.7% | 82.7% | – | – |

*Notes* *, ** and *** represent significance at level 10, 5 and 1% respectively

It is worth paying attention to the slopes for the two variables, i.e. the lagged dividend yield and dummy variable, that equals 1 if a company paid a dividend in the previous year ($Div_{t-1}$). The slope coefficients for both those variables are positive, which indicates that companies are rather unwilling to stop paying dividends as well as to decrease their value. Due to the fact of including lagged variables, the number of observations used to estimate the model is lower than the general number of observations. Including lagged variables may cause survivorship bias, which may weaken the results and conclusions.

The marginal effects at the mean (MEM) for increase in liquidity measure ranges from 0.0164 to 0.0189. This means that, assuming that the values of other variables (i.e. profitability, solvency, size and market-to-book value) are equal to the averages, an increase in the value of liquidity measure (ln*ILLIQ*) by 1 increases a

company's propensity to pay dividends roughly by approximately 1.75 p.p. As the computed measure for each stock is logarithmized, the impact of an increase in liquidity on the companies' propensity to pay dividends is not linear. To increase the possibility of becoming a dividend-payer by 1.75 p.p. the value of unlogarithmized illiquidity ratio should increase about 2.7183 times. Assuming everything else is equal to the mean values, an increase in illiquidity from 1st quartile ($\ln ILLIQ = -8.461$) to 3rd quartile ($\ln ILLIQ = -3.780$) results in an increase in propensity to pay dividends ranging from 6.14 to 9.79%.

Summarizing, a regression analysis using logit, probit and tobit models gives support for hypotheses *H1* and *H2*. The estimated logit and probit models demonstrated the existence of the link between the level of share liquidity and a company's propensity to pay dividends. Moreover, the estimated slopes of tobit models show that illiquidity has a positive effect on dividend yield. Thus, due to the results of the regression analysis, both hypotheses assumed in the study may be verified as true.

## 5 Robustness Check

In order to confirm the robustness of results obtained in the regression analysis, two robustness checks were done. First, to analyse whether the conclusions from the panel regression described in the previous section were robust to the change of liquidity measure, the natural logarithm of Amihud's illiquidity ratio was replaced by the number of quartile of liquidity to which the company belongs. The estimated values of coefficients are presented in Table 6. In the second stage, as a variable for liquidity, a dummy variable, that equals 1 if the value of illiquidity ratio is higher than median and 0 otherwise, was used. The results of the regressions are presented in Table 7. In both situations the signs of the parameters are expected to be positive.

Replacing the value of the natural logarithm of Amihud's illiquidity ratio (multiplied by $10^3$) by the number of quartile of liquidity to which the company belongs does not change the conclusions from the panel regression presented in Sect. 4.3. Similar conclusions come from the panel regression with dummy variable that equals 1 if the value of illiquidity ratio is higher than median put in the place of the value of Amihud's illiquidity ratio.

Due to the results obtained in the panel regression described in the previous section and the robustness check, it can be stated that the liquidity of a company's shares has an effect on the corporate dividend policy. This impact is statistically significant, robust and economically relevant. Signs of the parameters of estimated models are consistent with the expectations: more profitable, more solvent, bigger, and value companies, and those with less liquid shares, are more willing to pay dividends and pay them at higher amounts, which confirms the hypotheses stated in the paper.

**Table 6** Stock market liquidity and dividend policy: robustness check (number of quartile of illiquidity)

| Model | (M7) | (M8) | (M9) | (M10) | (M11) | (M12) |
|---|---|---|---|---|---|---|
| Dependent variable | P (Div = 1) | P (Div = 1) | P (Div = 1) | P (Div = 1) | DY | DY |
| Constant | −5.241*** (0.7105) | −5.227*** (0.7473) | −3.027*** (0.3913) | −3.036*** (0.4131) | −0.739*** (0.1071) | −0.726*** (0.1115) |
| Prof | 1.815** (0.8291) | 1.793** (0.8325) | 0.986** (0.4530) | 0.968** (0.4542) | 0.322*** (0.1231) | 0.310** (0.1229) |
| $ROE_{t-1}$ | 0.708** (0.3045) | 0.696** (0.3044) | 0.402** (0.1679) | 0.399** (0.1689) | −0.016 (0.0366) | −0.017 (0.0366) |
| Solv | 1.591** (0.7663) | 1.689** (0.7709) | 0.842** (0.4274) | 0.883** (0.4297) | 0.276** (0.1198) | 0.303** (0.1205) |
| Size | 0.262*** (0.0482) | 0.260*** (0.0488) | 0.150*** (0.0269) | 0.150*** (0.0272) | 0.041*** (0.0070) | 0.041*** (0.0071) |
| M-BV | −0.005* (0.0028) | −0.005* (0.0028) | −0.003** (0.0014) | −0.003* (0.001) | −0.001** (0.0004) | −0.001** (0.0004) |
| No. of quartile of ln*ILLIQ* | 0.198*** (0.0762) | 0.193** (0.0769) | 0.110*** (0.0423) | 0.108** (0.0426) | 0.023** (0.0117) | 0.023** (0.0117) |
| $Div_{t-1}$ | 2.930*** (0.1410) | 2.945*** (0.1420) | 1.754*** (0.0793) | 1.762*** (0.0797) | – | – |
| $DY_{t-1}$ | – | – | – | – | 0.529*** (0.0310) | 0.530*** (0.0310) |
| Year dummies | NO | YES | NO | YES | NO | YES |
| McFadden *R*-squared | 0.387 | 0.388 | 0.387 | 0.389 | – | – |

*Notes* *,** and *** represent significance at level 10, 5 and 1% respectively

## 6 Conclusions

Previous studies made both on developed and emerging capital markets have shown the relationship between stock market liquidity and companies' dividend policies. This paper aimed to investigate this relationship on the Polish capital market. Two hypotheses have been stated that suggest that liquidity has an effect both on the firm's propensity to pay dividends, and the level of dividends paid.

To verify the assumed hypotheses a regression analysis was applied, using pooled cross-sectional time-series data. Six different models were estimated. In the logit and probit models the dependent variable was the company's propensity to pay dividends, in the tobit models—dividend yield. In all models, the explanatory variables were liquidity and the set of control variables, consisting of proxies for profitability, solvency, size, growth opportunities and the lagged dependent variable.

**Table 7** Stock market liquidity and dividend policy: robustness check (company's shares are illiquid)

| Model | (M13) | (M14) | (M15) | (M16) | (M17) | (M18) |
|---|---|---|---|---|---|---|
| Dependent variable | P (Div = 1) | P (Div = 1) | P (Div = 1) | P (Div = 1) | DY | DY |
| Constant | −4.656*** (0.5956) | −4.643*** (0.6320) | −2.715*** (0.3297) | −2.721*** (0.3514) | −0.660*** (0.0888) | −0.647*** (0.0934) |
| Prof | 1.824** (0.8240) | 1.801** (0.8277) | 0.987** (0.4507) | 0.970** (0.4519) | 0.323*** (0.1228) | 0.311** (0.1226) |
| $ROE_{t-1}$ | 0.709** (0.3030) | 0.697** (0.3031) | 0.402** (0.1678) | 0.399** (0.1688) | −0.015 (0.0365) | −0.016 (0.0365) |
| Solv | 1.569** (0.7655) | 1.670** (0.7702) | 0.834* (0.4263) | 0.875** (0.4287) | 0.275** (0.1198) | 0.302** (0.1205) |
| Size | 0.240*** (0.0457) | 0.238*** (0.0461) | 0.13*** (0.0256) | 0.138*** (0.0259) | 0.038*** (0.0066) | 0.037*** (0.0066) |
| M-BV | −0.005* (0.0027) | −0.005* (0.0027) | −0.003* (0.0014) | −0.003* (0.0014) | −0.001** (0.0004) | −0.001** (0.0004) |
| Company's shares are illiquid | 0.351** (0.1635) | 0.342** (0.1647) | 0.198** (0.0906) | 0.194** (0.0911) | 0.037 (0.0247) | 0.037 (0.0248) |
| $Div_{t-1}$ | 2.929*** (0.1408) | 2.944*** (0.1418) | 1.754*** (0.0793) | 1.762*** (0.0796) | – | – |
| $DY_{t-1}$ | – | – | – | – | 0.530*** (0.0310) | 0.532*** (0.0310) |
| Year dummies | NO | YES | NO | YES | NO | YES |
| McFadden *R*-squared | 0.386 | 0.387 | 0.387 | 0.388 | – | – |

*Notes* *,** and *** represent significance at level 10, 5 and 1% respectively

Regression analysis gives support for the hypotheses stated in the study. The level of stock liquidity has an effect on companies' propensity to pay dividends and the dividend yield. The lower a company's shares on the capital market are, the more willing the company is to pay dividends and the amount of dividends paid is higher. Those results are statistically significant and robust. Taking into account an increase in propensity to pay dividends resulting from an increase in value of illiquidity measure from 1st quartile ($\ln ILLIQ = -8.461$) to 3rd quartile ($\ln ILLIQ = -3.780$), the results should be assumed as economically relevant.

The author is conscious that the study, and its results as well, has numerous limitations. It covers a relatively short period of time, and not all of the companies listed on the Warsaw Stock Exchange. Only one measure of stock liquidity has been applied, and the set of control variables may seem arbitrary, but the author believes that it covers the most important factors driving company dividend policy. Hopefully, this paper will contribute to furthering research in this field on the Warsaw Stock Exchange.

First, it should be noted that the study could be repeated using data covering more companies and a longer period of time. It is plausible that the set of control variables could be constructed in a different way, and the stock liquidity could be measured in a different manner. One possible development of this study would be to explain the link between stock liquidity and companies' dividend policy on the market or portfolio level (and not on the single company level). One could use innovations in stock liquidity as an additional explanatory variable. The other possibility is to investigate the effect of stock liquidity on stock repurchases—an alternative for dividend payments. There is also a possibility to investigate the reverse causality in the relationship between stock liquidity and a company's dividend policy.

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# Managing of Financial Flexibility


**Józefa Gryko**

**Abstract** Article focuses on showing the importance of financial management in creating the flexibility of the company and identifying conditions affecting the decision on the company's financial flexibility. This paper reviews existing literature and provides a definition of financial flexibility which emphasizes its multidimensionality. The article discusses the potential benefits of maintaining financial flexibility and choice of factors shaping it. The article presents a decision on the financial flexibility formation as a result of two groups of factors—the company's need for flexibility and the capability of its creation.

**Keywords** Financial flexibility · Financial management

## 1 Theoretical Basis

Flexibility is a very complex concept which is difficult to define satisfactorily. It is company's answer for change in its environment. Managers identify the need for financial flexibility as the main driver of their financing decisions (Brounen et al. 2006; Bancel and Mittoo 2004).

The concept of financial flexibility as a factor influencing financial decisions was identified by Modigliani and Miller (1963) by indicating that firms do not have a tendency "to use the maximum possible amount of debt in their capital structure" due to limitations by lenders leading to "the need for preserving flexibility."

Myers and Majluf (1984) drew attention to the impact of asymmetry of information on managers' decisions about the capital structure and on the reaction of investors to information about firm's investment opportunities. According to Myers

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and Majluf, at least for some companies, maintaining financial slack is beneficial to the shareholders. They also pointed to the ways of ensuring this financial slack—by limiting dividend payments, keeping large holdings of cash or marketable securities, and by maintaining spare debt capacity.

Gamba and Triantis (2008) also proposed the definition of financial flexibility as a company's ability to raise or restructure its financing at a low cost. They pointed out that financially flexible firms are able to avoid financial distress in the case of negative shocks, and are capable to fund investment when profitable opportunities arise.

Byoun, in turn, defined the company's financial flexibility as the ability to mobilize financial resources in response to uncertain future contingencies. He emphasized the importance of unexpected changes constraining firm from accessing the capital markets that imply financial decisions to be made not only in response to certain conditions or events but also in an attempt to deal with uncertain future contingencies (Byoun 2011).

D. J. Denis defined financial flexibility as the ability of a company to respond in a timely and value-maximizing manner to unexpected changes in cash flows or in a set of investment opportunities (Denis 2011). This definition takes into account the time dimension in response to the change and the intent dimension.

In a number of papers, financial flexibility is not precisely defined. Research focuses on how financial flexibility is attained and also on identifying firms maintaining financial flexibility. There are several identified ways to provide financial flexibility. Most commonly indicated in financial literature are connected to shaping firm's capital structure, cash management or payout policies. Regarding the capital structure decision, maintaining a relatively low leverage, which by some researchers is associated with a conservative leverage policy provides a spare debt capacity that can be used if a need arises. Thus firms with preserve debt capacity and/or large cash holdings are identified as having financial flexibility. Financial flexibility can be achieved by large cash holdings (Almeida et al. 2004; Denis and Sibilkov 2010; Faulkender and Wang 2006; Bates et al. 2009; Gamba and Triantis 2008). Firms can also attain financial flexibility through conservative leverage policies (deAngelo and deAngelo 2007; Sufi 2009; Marchica and Mura 2010; Denis and McKeon 2012; Byoun 2011).

This paper focuses on a more precise definition of financial flexibility and a view of financial flexibility through the prerequisites of financial managers' decisions. This is a retrospective look, by asking the question of what factors should be taken into account by the managers who decide to provide the company with financial flexibility. Such point of view can be valuable from the perspective of better identification of companies with financial flexibility and subsequent measurement of the effects that should be associated with the choice of a specific way to provide financial flexibility. This is also a question of the relationship between financial management and business management. Hence the article is divided into parts. Firstly, it focuses on the flexibility of the company and its relationship to financial

flexibility. It then focuses on the role of financial management in shaping company's flexibility and in the economic account the benefits of maintaining financial flexibility.

## 2 Flexibility as Company Attribute

In discussing the problem of defining financial flexibility, it should be emphasized that in addition to the science of finance, flexibility is defined in terms of management sciences. With the growing dynamics of changes in the environment it was necessary to search on the basis of management science for new rules of managing the organization because existing rules were designed for the relatively stable and relatively slowly changing environment and proved to be unreliable. Flexibility has become an essential feature of the company's strategy. Strategic flexibility is defined as both active and reactive response to changes within and outside the organization, using vital and desirable organizational continuity, core values, culture, key competencies, branding and positioning. The level of strategic flexibility is a predictor of survival and sustainability of a company. Flexibility is both a factor shaping the company's current financial performance and a condition of its long-term performance and development (Sushil 2001).

From the point of view of shaping the flexibility of the organization it stresses that it consists of the flexibility of individual resources and of business processes of the firm that can become an element of competitive advantage only if they are properly coordinated and integrated. The flexibility of an organization as a whole is composed of: the flexibility of technology, people, formal and informal organizational structures, and the systems and processes in force in the enterprise (Ahmed et al. 1996).

It should be stressed that the basis for the transfer of partial flexibilities to a sustainable competitive advantage is their integration, because with regard to the flexibility of the organization, there is a synergy between its constituent partial flexibilities. The impact of flexibility on the results and performance of the company is shown in Fig. 1 (source: Dreyer and Grønhaug 2004).

The organization's flexibility is difficult to define due to its multidimensional and polymorphic nature (Suarez et al. 1995; Evans 1991). The most common definition is the ability to adapt.

There may be several types of flexibility and inflexibility in the company at the same time. In particular, four dimensions of flexibility can be identified—first, in terms of time (Eppink 1978; Gustavsson 1984); secondly, with regard to predicted or unforeseen changes (Carlsson 1989), the third dimension is the way of achieving offensive or defensive flexibility (Volberda 1996) and the last one is the degree in which flexibility is created inside and outside the organization (Das and Elango 1995).

Golden and Powell called these dimensions in turn: temporal, range, intention, and focus. Temporal dimension of flexibility is the length of time that it takes a

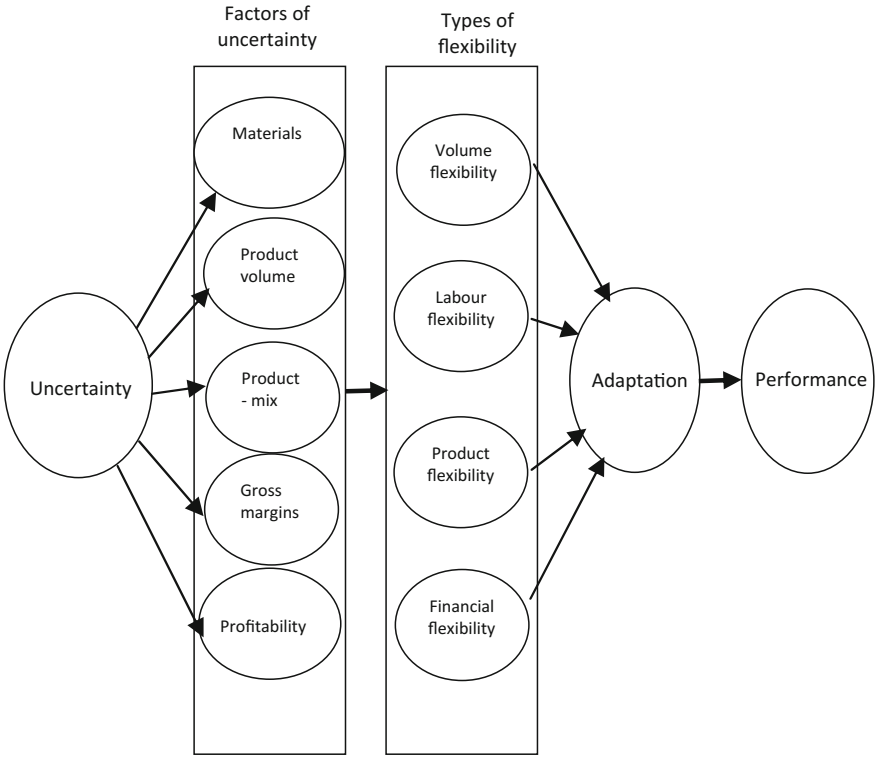


**Fig. 1** The impact of flexibility on performance

company to respond to environmental changes. Range dimension is the extent of the company's ability to implement actions in response to a change, both expected by the company and one that was not anticipated. Dimension of intent is the approach to creating flexibility and the way of change management—it determines whether the company actively seeks to introduce positive changes or passively responds to changes in the environment. At the same time, it is this dimension that shows whether in the event of an unavoidable change the organization will be able to adapt to gain benefits or not. The last dimension is the location of the flexibility that is not always within the organization, because the firm can expand its flexibility by using external relations with its business partners (Golden and Powell 2000).

With regard to short-term decisions, financial flexibility lies primarily in the financial liquidity management of a firm, i.e. the optimization of the value of its current assets and sources of its financing. Investment and financing decisions of the firm are medium and long-term decisions and they are partly irreversible. The capital needs of companies must be determined in advance, necessary to perform the necessary activities related to obtaining sources of financing. Issue of shares, debt securities, or borrowing on a company's terms is time-consuming. It can be

assumed that there is a link between the time of raising funds and the cost of capital—the sooner a firm will want to raise funds, the higher the cost will be.

Minimizing the cost of building financial flexibility requires the creation of an ex ante capital resource or the capability to raise it at a settled cost so that it is the basis for financing adaptation activities to the environment change, such as the use of investment opportunities, the completion of research, etc. Any lack of capital will result in a delay in adaptation, a reduction in the range of activities available, or an increase in the cost of capital, resulting in a reduction in the efficiency of the firm.

The range dimension of financial flexibility should be considered in two ways. First of all, with regard to the availability of financing for the company. The availability of capital for the company changes over time, so with the development of the company, the range of available sources of finance will increase. In addition, this area has a clear relationship with the focus dimension of flexibility—this is more external location, because what sources are available to the enterprise is determined by the level of development of the financial market mechanisms and possible reduction of barriers to access to capital.

In the second place, attention should be paid to the importance of financial flexibility in extending the scope of the possibilities of using the remaining partial flexibilities. It can be argued that the ability to provide sources of financing for a company's activities in the area of resource, production, technology, and human resource development makes financial flexibility an important determinant of shaping the remaining partial flexibilities.

Dimension of intention with respect to the financial flexibility will apply to premises for decision-making by managers, but also to the expectations of the various groups of stakeholders and assessment of demand for flexibility. The most obvious should be the classic financial management goal of maximizing shareholder value, so if taking active action to prepare for a change that will benefit shareholders, then the company should build financial flexibility. However, taking into account the possibility of divergences in objectives between stakeholders, it may be appropriate to consider the intent of providing financial flexibility as the reason for the lack of agreement in the capital structure theory regarding the potential benefits of financial flexibility and how they are divided between contract parties.

The multidimensional nature of flexibility also leads to intertwining of causes with effects both within the dependency between investment and financing decisions making use of the flexibility, and in the area of permeation of flexibility dimensions. It makes studying the determinants of flexibility extremely difficult; it is difficult to clearly outline the boundaries of individual areas of financial flexibility and also to indicate simple cause-effect relations. The multiplicity of areas, which is related to the formation of financial flexibility, is also indicated by Bancel (2012). He distinguished four areas of shaping company's financial flexibility. The first area is company's financing policy and consists of leverage, pay out, equity and cash policies. The second one is about risk management and operational flexibility. The third area is the impact of institutional environment on the company, and the last one is related to corporate governance practices.

Taking into account the definitions outlined, it is possible to agree on the perception of flexibility as the ability of a firm to response to a change. Accepting the view that flexibility is a multidimensional phenomenon, it can be assumed that all authors define flexibility properly, but they include different dimensions of flexibility in their definitions. One can then find a time dimension—taking into account the pace of the company's response to change (e.g. Denis).

Range dimension—referring to the opportunities created by financial flexibility—the ability to react to financial distress (e.g. Byoun), the ability to react to emerging investment opportunities (e.g. Mayers, Majluf), the possibility of restructuring financing sources (e.g. Gamba, Triantis). Taking into account the intention dimension, outlined definition assume the need to shape flexibility, so they are determined rather by the offensive attitude, active on the part of the company, so long as acquiring the financial flexibility is value-enhancing (e.g. Denis).

It can be presumed that the company adopts a passive attitude in the absence of the benefits of flexibility. The consequence of adopting an active attitude in response to change, i.e. looking for benefits or hedging future costs, is to focus on the internal placement of flexibility i.e. the ability to shape it through the company's financial decisions.

In conclusion, we can propose a fuller definition of financial flexibility, taking into account the dimensions of flexibility identified in management science and the complexity of its relationship with the flexibility of the organization. Financial flexibility is the company's ability to respond to change in the environment by providing cost-effective ways of funding its future activities or restructure its financing. Maintaining the ability to finance the response to the change provides the potential for future value creation of the company by exploiting profitable investment opportunities when they arise and by avoiding financial distress in the face of negative shocks. Financial flexibility is a combination of financial, operational and strategic decisions.

## 3 Role of Financial Management in Organizational Flexibility Creation

In response to changes in the environment a new or modified strategy that sets the company's target level of flexibility is defined for the company. Attributes associated with the expected quality, time and scope of the flexibility of the company stem from the specific nature of its operations and are essentially non-financial area.

The purpose of financial management is to make the cost-effectiveness analysis, which creates a feedback whether the pursuit of a target level of flexibility will serve the purpose of increasing the company's value. At the same time the task of the financial manager is to provide a source of funding changes in the company. It is worth noting that the cost of capital associated with financing reaction to change is a component of the discount account of economic efficiency. The ability to finance

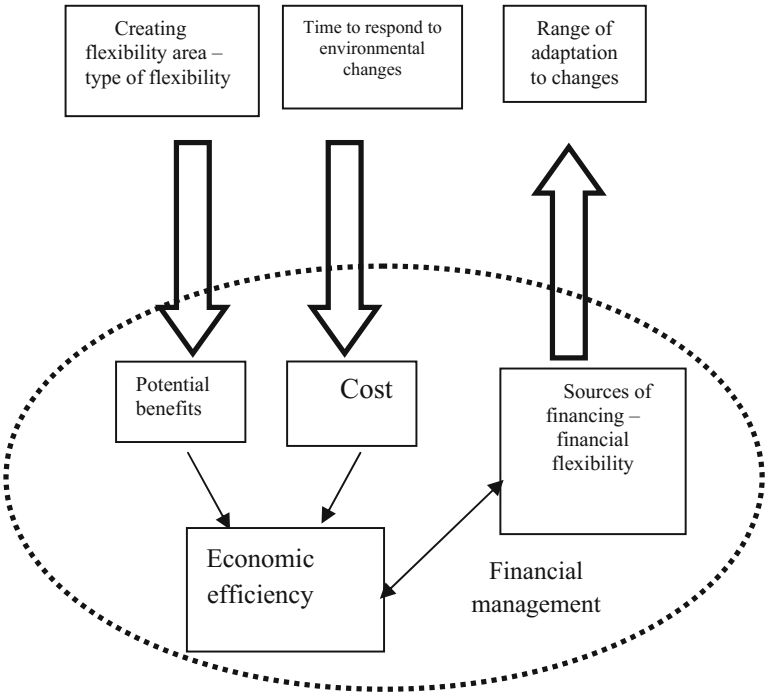


**Fig. 2** Role of financial management in organizational flexibility creation

the cost of reacting to change, in a time that is adequate for the benefit of the firm, is associated with shaping the company's financial flexibility and is the domain of financial management science. In a situation of change in the environment, requiring a specific response, the lack of capability to finance costs undermines the ability to implement a new corporate strategy. Hence, the definition of financial flexibility focuses on the specific way to achieve the ability to react to change, i.e. the ability to finance it (Fig. 2).

An important element of building strategy of financial flexibility is to assess the economic effectiveness of its creation. Taking into account the complexity of the financial flexibility issue, the choice of how to provide it must take into account its individual dimensions and relationships with the creation of flexibility of an enterprise as an organization. It will also be contained in the instantiation of the proposed definition of the condition that is associated with the capacity to respond to change, i.e. "value creation potential".

The potential positive impact of having financial flexibility on the value of an enterprise is related to the benefits of avoiding direct and indirect costs of financial distress and the ability to finance cost-effective future investments. This value is only of a potential nature because it results from the fact that the probability (number of potential states of nature) of maintaining or increasing the value of the company in the future increases. The turbulence of the environment makes the

number of potential future states of nature grow. Companies respond to increasing uncertainty about the environment by making financial decisions using financial planning and implementing risk management methods. Implementing such plans usually depends on providing the company with a certain level of flexibility. The role of finance is to provide financing for changes in the company.

Shaping financial flexibility requires decision about the attitude of the company to future changes. A firm can adopt an active attitude here, that is, to create flexibility and to be able to use positive change or to protect itself from negative change, and passive attitude, i.e. not to build flexibility and accept that any change will not bring benefits to the company or cause financial distress. The decisions will mean a different number of future states of nature (scenarios) in which it will be possible to increase the company value.

The economic effectiveness analysis of the two outlined attitudes will be different. Change is a future phenomenon and its potential consequences for an enterprise are always fraught with uncertainty. Even considering the high probability of change, forecasts are subject to the risk of error at the moment of making a decision. Should there be a change, a company should benefit from being financially flexible. A company that creates flexibility pays a price for an option to benefit from a change in the future in a form of current costs of acquiring and maintaining flexibility. Depending on the method of providing flexibility, these costs may concern costs of holding additional liquid assets or opportunity cost related to unused tax shield on interest. On the other hand, passive attitude is to avoid the current costs of building and maintaining flexibility, and accepting the possible future costs associated with change in the environment.

When discussing the goal of shaping flexibility, it is also worth mentioning the dimension of focus. It is related to the source of change—these may be internal sources, i.e. deterioration of the company's financial performance and rating, and external sources, especially shocks in the financial market, which will affect availability and financing conditions. Only financial flexibility protects against shocks on the financial market.

The company can protect itself from internal changes by creating flexibility in other areas of operation. There is another level of economic comparison resulting from the linkage between the company's partial flexibilities—that is, the decision on which area to achieve the desired change response capability will be associated with cost minimization. Without flexibility in other areas, the effect of financing operational activity can be achieved by financial flexibility. Creating other partial elasticities is not always possible, it can generate running costs, it can also be the source of further changes (change of laws, consequences of financial distress of the trading partners, etc.).

In the case of financial flexibility, a clear analogy can be found with the development of a risk management strategy, i.e., depending on the financial position of the company, the likelihood of expected changes and their potential consequences for the financial result, you may decide to prepare for certain changes or changes in the financial effects.

Benefits of financial flexibility associated with the ability to use options for investment opportunities are important for a company. Preparing to fund future investment opportunities is important both for the stability of the company's financial performance, its ability to stabilize its dividend policy, and its continued value increasing. Financially inflexible companies can lose investment opportunities and fail to build value for shareholders. If a lack of capability to finance the investment coincides with the deterioration of the company's financial performance or a reduction in dividends to the level below shareholders expectations, this will lead to a reduction in the market price of the company's shares and peripheral difficulties in raising funds.

In this respect, financial flexibility should be significant from the point of view of the company's existing shareholders.

The basis for the good results and value of the company is its conjugation with the environment—the real market where the products of the company are being sold. This market creates both opportunities and threats, both in terms of revenues from the company's current operations and its potential investment opportunities. Financial management decisions focus on ensuring efficiency in both the existing business segments and the future potential segments created by the environment. Future financial needs can be generated both by existing business activities and by potential investment opportunities. Proper estimation of these needs is the basis for capital budgeting. Since, however, the estimates relate to future decisions, burdened with uncertainty, there is a likelihood of changes in the environment that will make capital requirements different from those planned. This uncertainty raises the need for financial flexibility.

If the company's capital needs are lower than expected, there will be a need to repay funds to donors or continue to bear the cost of maintaining liquid assets or insufficient use of interest-bearing tax credits. These costs will burden the company's bottom line, lowering its profitability and market valuation. From the perspective of shareholders, there is also a threat of the agency costs, because in the situation where it is impossible to make profitable investments, managers may refuse to return the capital they have already invested and be tempted to use the funds to make ineffective investments but with a higher rate of return than generated by the liquid assets held.

It is also possible to make a short-term use of asymmetry of information, as the realization of expected investment or new investment opportunities (even ineffective) should provide a positive or neutral signal to the market, unlike return of unused capital justified by the lack of effective use. In this context, Jensens's (1986) observation of the negative effects of having excess reserves and depriving managers of financial market pressures are correct. In the situation of a possible surplus of capital over the needs of the firm, it seems profitable to provide financial flexibility through the option of issuing a provisional debt—the cost of such an instrument will be related to the loss of tax shield on interest due to the use of debt to a lesser extent than marked by the static optimum.

If expectations of capital demand turn out to be insufficient, the consequence will be the loss of value of the company. If capital is not sufficient to finance the needs

arising from running an existing business, this may result in costs of financial distress. In situations where the capability of raising capital is too small for the investment needs of a firm, the costs of unused investment opportunities may appear, and in some cases the path of company's development may be impeded. The cost of lost benefits associated with not exploiting investment opportunities, however, is related to the state of the capital market and the ability of the company to raise capital on the market. Investment opportunities cannot be treated as something unstable or volatile. In the situation of emerging investment opportunities, if the market is able to properly value this possibility, the company should be able to raise capital. There are two situations in which the costs of lost investment opportunities will be high. The first occurs when the lack of capital does not allow a firm to take action in adequate time, which prevents or significantly affects investment to take in the future (e.g. by a competitor submitting a patent application significantly reduces the possibility of manufacturing solutions, loss of investment opportunity). The second situation is a periodic lack of access to capital because of market inefficiencies. Such inefficiencies can be a result of general economic conditions (e.g. crisis) or the effect of underestimating the company's value, for example due to information asymmetry. In an efficient capital markets, costs will only be associated with the delay in the return on investment, although in some cases they may also be offset by the value of the delayed investment option.

The demand for financial flexibility is also linked to extreme events. Before such a part of the event the company is unable to protect or build security would be economically inefficient. Therefore, if such an event occurs it will bring the consequence of the bankruptcy of the company. However, there may be extreme events where providing financial resources for continuing operations will significantly increase the company's chances of surviving the crisis, especially assuming potential support from the public authority.

The state of the capital market and its ability to raise capital are subject to fluctuations—which is also a source of demand for flexibility. Changes in the availability of financing sources may be related both to the supply of capital on the market and to the company's demand for capital at a certain cost. The first group of reasons influencing the supply of capital is external factors of a macroeconomic, legal and institutional nature. The second group of conditions is the possibility of changing the market assessment of the company. It is important here that the rating of a firm is affected by the stability of the financial results reported and the payments to the investors. It should be noted that from the point of view of existing owners, only some of the changes in the financial market create an ex ante demand for flexibility. These are changes resulting from underestimation of the company's value or the consequence of an adverse selection caused by information asymmetry. Such changes cause the capital to be offered at an inadequate cost—too high for the company's risk. In such a situation, companies without financial flexibility faces excess cost of capital appears due to the lack of sufficient capital. On the other hand, in a situation of market turmoil leading to the company's over-valuation, the company is beginning to be able to freely build financial flexibility by raising funds

through share issues, thus ensuring future ability to raise debt. In this situation, excessive flexibility may be created and consequently the costs of agency conflicts will increase.

## 4 Financial Flexibility Creation

The company's flexibility is determined by three aspects, the combination of which creates a set of determinants leading to shaping financial flexibility of a company in a particular way. The concept is shown in Fig. 3. Most of the differentiated factors that shape flexibility affect simultaneously several aspects. In addition, the relationship between the various aspects changes over time, which translates into the need to adjust the way of providing flexibility to specific conditions.

The first aspect is related to the uncertainty of the environment, which has a significant impact on the need for a particular method of providing flexibility. The uncertainty of the environment can have different sources—both due to the state of the economy (the conditions apply then to the whole population of enterprises), as well as requirements for the company created in its sector by the competition (which explains the sector differences in the liquidity shaping and debt levels).

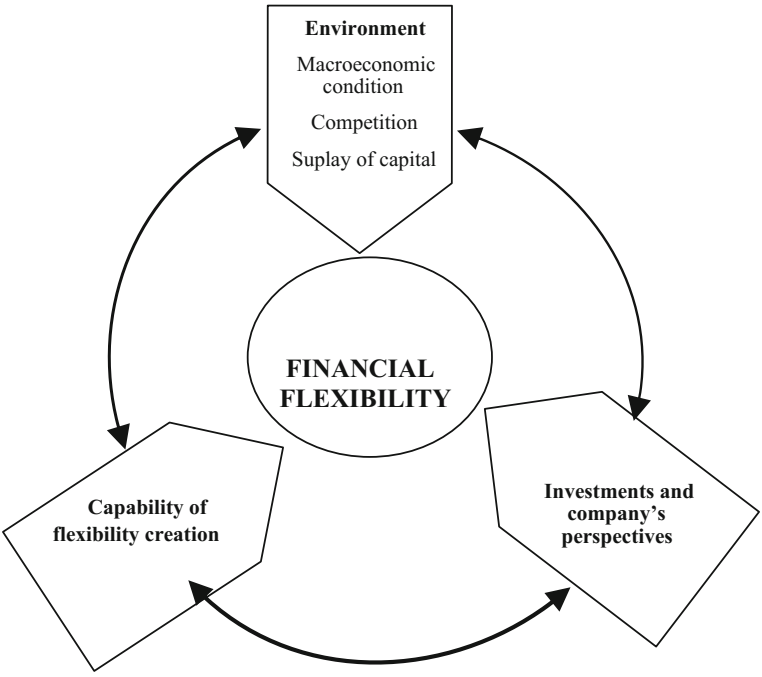


**Fig. 3** Factors shaping financial flexibility

Uncertainty in the environment is also related to changes in the supply of capital and the perception of the company by the environment. Uncertainty of the environment is largely related to the dimension of time, and hence the adequacy of temporal response to change. The more likely is the change in the immediate environment, the greater the tendency to favor the cash flexibility. The cash flexibility seems to be the optimal choice, given the benefits that it provides, i.e. it provides partial independence from the market in the short term, therefore, it allows for respond to worsening economic conditions of the company in adequate time and reduces risk of negative current consequences of the financial distress.

Another aspect influencing the choice of the way to create flexibility is the scope of the current investment activity of the company and its growth opportunities. During the implementation of the investment which causes the dynamic growth of fixed assets, firms are prone to choose the cash flexibility only and at the same time firms using their spare debt capacity, changing the financial leverage from low to high. Maintaining high level of cash allows the company to secure completion of the investments. The proper form of flexibility in the growth prospects of the situation is the debt flexibility.

The last aspect influencing change is the ability to shape it, which is related to the range dimension of financial flexibility. The range of possible ways to implement to provide financial flexibility is dependent on the level of financial constraints the company and its financial condition.

## 5 Conclusions

The main conclusion is that financial flexibility is very complex and multidimensional concept, strongly related with company flexibility. This article is an attempt to locate financial flexibility both in corporate finance management and in the implementation of its strategy.

A new definition of financial flexibility has been proposed, taking into account the dimensions of flexibility identified in management science and the complexity of its relationship with the flexibility of the organization. Further research should concern mutual interwining of the factors that shape flexibility and the fact that relationship between the various aspects changes over time.

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# Financial Constraints and Cash Flow Sensitivity to Investment in Indian Listed Manufacturing Firms


**Sanjeev Kumar and K. S. Ranjani**

**Abstract** The present study is an effort to test the validity of cash flow sensitivity to investment as a measure of financial constraints in Indian manufacturing firms using panel data for 768 listed firms over a period of six years (2010–2016). It also analyses effects of tangibility of assets in alleviating financial constraints. Findings suggest that stand-alone, small and lower debt capacity firms are more cash flow sensitive to investment in comparison to the business group affiliated, large and higher debt capacity firms. Investment for large firms is strongly influenced by capital structure whereas medium-size firms have a mixed effect of financial factors on investment decisions. Further, results for effects of tangibility of assets on easing financial constraint are found significant only in low market capitalization firms.

**Keywords** Financial constraints · Investment determinants
Market capitalization · Tangible net worth · Ownership classification
Panel data · India

## 1 Introduction

There is a long-standing debate over the use of cash flow sensitivity as the measure of financial constraints ever since the inception of the literature for financial constraints due to asymmetry in the availability of external finance. The term cash flow sensitivity of investment emerged since the origin of the literature of financial constraints by Fazzari et al. (1988). Cash flow sensitivity of investment refers to the propensity of the firm to save internal funds to meet out the future investment requirements. It is used to capture the effects of financial constraints (see Fazzari et al. 1988; Hoshi et al. 1990; Almeida and Campello 2007). They reported that

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acceptance of an investment project for the financially constrained firm will not only be the function of positive NPV (net present value) but also depend on the availability of internal funds of the firm. However, some results have shown unconstrained firms to exhibit higher cash flow sensitivity than constrained firms (see Kaplan and Zingales 1997; Cleary 1999; Erickson and Whited 2000). Further, Gilchrist and Himmelberg (1995) reported similar cash flow sensitivity to investment for financially constrained and unconstrained firms. Hence, the present study is motivated by the segregated literature over the interpretation of cash flow sensitivity and the fact that there exists a large inconsistency in the rates at which the external finance is available to the Indian firms depending upon the characteristics of the firm such as business group affiliation, tangibility of assets and market capitalization. Also, financial constraints as the research interest are limited largely to the United States and European countries only. The current study will contribute to the literature by reporting relative dependence on internal funds to the Indian listed manufacturing firms that will bring out perspectives for developing economies. It will also strengthen the segregated literature over the use of a proxy for financial constraints along with capturing the effects of pledgeable assets in alleviating the effects of financial constraints.

## *1.1 Literature Review*

The assumption of perfect capital market claims internal and external finance as undifferentiated substitutes to finance investment opportunities (Modigliani and Miller 1958). Also, investment decisions of the firms are independent of their capital structure with the symmetrical availability of financing sources to all the firms. An alternate perspective to the perfect capital market assumption came from the work of Fazzari et al. (1988) refuting internal and external finance as perfect substitutes for investment decisions. They provided empirical evidence for the same using a sample of 422 U.S. manufacturing firms by distinguishing them on the basis of dividend to income ratios. Firms that had least pay-out efficiency were hypothesized as financially constrained[1] and found to be more cash flow sensitive to investment than unconstrained firms. According to this alternate agenda firm's investment will be the function of its financial factors and characteristics of the firm. A financially constrained firm will find it difficult to fund positive NPV (Net Present Value) due to the scarcity of internal funds and costly external finance. Later studies by Devereux and Schiantarelli (1990), Hoshi et al. (1990), Whited (1992), Wang (2003), Almeida et al. (2004), Denis and Sibilkov (2009), Bhaumik et al. (2012) confirmed the findings of Fazzari et al. (1988).

[1]In an imperfect capital market where characteristics of the firm will influence the acceptance of investment opportunities, firms that fail to fund positive NPV projects due to asymmetry between internal and external funds will be called as financially constrained firms.

However, findings of Fazzari et al. (1988) were soon disputed by Kaplan and Zingales (1995) reporting inverse results and inefficiency in the interpretation of results. They reported financially unconstrained firms more cash flow sensitive to investment and questioned cash flow sensitivity of investment as the measure of financial constraints using the 10-k text[2] of 49 U.S. firms. Further, studies by Kadapakkam et al. (1998), Cleary (1999, 2006), Erickson and Whited (2000), Alti (2003) also supported the results of Kaplan and Zingales (1995).

In search of an alternate perspective as the measure of financial constraints Almeida et al. (2004) propose the 'propensity of firms to save cash out of cash flows' (cash-flow sensitivity of cash) as a proxy for liquidity constraints, because only constrained firms will manage liquidity to maximize their value. They tested whether financially constrained firms exhibit high cash-flow sensitivities, while unconstrained firms do not. They found that financially constrained firms have higher propensity to retain cash following negative macroeconomic shocks, while unconstrained firms do not show any such relation. In extension to above, Almeida and Campello (2007) tested the effect of tangibility of assets on investment of the firms. The study used cash flow and asset tangibility multiplier to find out the marginal effect of asset tangibility on cash flow sensitivity to investment. In Indian context, Bhaduri (2005) reported the effects of liberalization on easing financial constraints of the firms. Later, Bhaumik et al. (2012) highlighted significant influence of financial constraints on Indian manufacturing firms. However, there is a dearth of studies in exploring the role of cash flow sensitivity as the valid proxy for measuring financial constraints in the Indian context. Also, to the best of our knowledge, none of the Indian studies has illustrated the role of tangibility of assets in easing financial constraints. The effect of tangibility of assets on alleviating cash flow problems needs to be studied to define the utility of collateral as an enabling factor to access external finance in Indian manufacturing firms. Hence, the current study empirically investigates cash flow sensitivity to investment and effects of asset tangibility along sales, leverage in Indian manufacturing sector to test the validity of above-discussed measures in the Indian context.

## 2 Model

The amount of external capital required at any time for the financially constrained firm can be given by $\varphi$ can be the function of the debt capacity and other financial factors of the firm.

$$\varphi = F(\tau, \textit{financial factors}) \ldots \tau \text{ is the debt capacity of the firm}$$

[2]Annual financial report of U.S. companies required by Securities and Exchange Commission highlighting financial performance of firms.

An unconstrained firm can have two scenarios-either amount of internal funds available to the firm ($\omega$) is in excess of current demand $\pi$ or the availability of external funds satisfies current demand. Suppose $\pi$ is the funding requirement for the new investment opportunity available.

$\pi < \omega$ *or* $\varphi \notin \tau$ (external funds available irrespective of tangibility of assets)

Borrowing constraints for a financially constrained firm can be given by creditor's liquidation value of the firm ($\tau l$).

$$\pi < \tau l$$

Hence, cash flow sensitivity to investment for financially constrained and unconstrained firms according to Almeida and Campello (2007) can be written as

$$\frac{\partial I}{\partial w}(w, \tau) = \frac{1}{1-\tau} \quad \text{for financially constrained firms}$$
$$\frac{\partial I}{\partial w}(w, \tau) = 0 \quad \text{for financially unconstrained firms}$$

The cash flow sensitivity will decrease with the increase in the tangibility of assets to the firm for the financially constrained firm i.e. tangibility will result in easing the financial constraints to the constrained firms while investment for unconstrained firms will be independent of the fluctuations of cash flows. Thus tangibility will be irrelevant to the investment of the financially unconstrained firm.

## 3 Empirical Estimation Framework

To identify the role of cash flow sensitivity to investment in measuring financial constraints we use sales accelerator model proposed by Abel and Blanchard (1986) which states that increasing firm sales leads to increasing firm investment along with other financial factors. The model is further extended to understand the role of tangibility in influencing cash flow sensitivity to investment in Eq. 1. The interaction term between cash flow and tangibility will highlight the role of tangibility in easing financial constraints for the firms.

$$\left(\frac{I}{K}\right)_{i,t} = \alpha o + \rho\left(\frac{I}{K}\right)_{i,t-1} + \beta_1\left(\frac{\Delta S}{K}\right)_{i,t} + \beta_2\left(\frac{CF}{K}\right)_{i,t} + \beta_3\left(\frac{D}{K}\right)_{i,t} + \beta_4 \text{Ln } tangibility + \beta_5\left(\text{Ln } tangibility_{i,t} \times \left(\frac{CF}{K}\right)_{i,t}\right) + u_{i,t} + e_{i,t} \tag{1}$$

where $I$ represent firm investment (Change in gross fixed assets), $S$ represents a change in firm sales or output as a measure of future profitability and growth opportunities. $CF$ represents the sum of cash flows, net income, depreciation and amortisation, D represents the total borrowings in addition to preference share capital and $u_{i,t}$ represents the idiosyncratic error term. K is the firm's beginning of the period capital stock calculated according to the specification used by Fazzari et al. (1988) highlighted in Eq. 2.

$$K_{i,t} = \frac{P_t}{P_{t-1}}\left[I_{i,t-1} + K_{i,t-1}\left(1 - \frac{1}{L}\right)\right] \tag{2}$$

where $K_{i,t}$ is the capital stock for the firm i at time t, $P_t$ is the GDP deflator at factor cost for the manufacturing firms taken for the base year 2004–2005. $I_{i,t-1}$ is lagged investment and L is average service life of the firm.

## 4 Sample Splitting Criteria

To study the effects of financial constraints we require an appropriate splitting criteria to divide the firms into different regimes. By splitting firms into groups with different level of asymmetric information, we can investigate the asymmetric impact of asymmetric information and agency problems on firms with different characteristics. The selection of relevant splitting criteria is also important because cash flow sensitivity of investment is susceptible to the factors used to split the firms according to the literature. Hence it is required to identify the criteria in Indian context that allows us to interpret the availability of internal funds to the firms. We use three criteria to split the firms into financially constrained and unconstrained firms that are as follows:

- Ownership status of the firms.
- Size of firms.
- Debt Capacity of the firms.

The reason for selecting ownership classification as the criteria for splitting the firms is due to the fact that the firms with the group affiliation have easier access to internal funds in comparison to standalone firms. Business groups are particularly effective in dealing with information and contract enforcement problems within the groups. When a firm needs external finance it can obtain funds at a relatively lower cost. Therefore it is expected that firms who have an affiliation with industrial groups will have lower investment cash flow sensitivities than firms who are not part of an industrial group, because of the reduction in information costs for being part of the group and the access to the internal capital group. Moreover, this sample splitting criterion is particularly desirable, because the status of affiliation to industrial groups tends to be fixed, which avoids the problem of endogeneity.

The evidence of investment cash flow sensitivities tends to be quite robust with the affiliation to the industrial group as a sorting criterion. Hoshi et al. (1990), using a dataset from Japan, find that firms that are part of the industrial groups display lower cash-flow sensitivities. Evidence from other countries such as Korea (Shin and Park 1999), Canada (Schaller 1993); Chirinko and Schaller (1995) also found supporting results for the idea that affiliation to industrial groups helps to reduce information asymmetries and to relax financial constraints.

Market capitalization is used as the splitting criteria by taking reference from Lamont et al. (2001) where it is used as the proxy for size. Market capitalization is also used as the proxy for calculating Tobin Q values of the firm in the Kaplan-Zingales index as described in Lamont et al. (2001). Market capitalization of the firm is very important in the as it reflects the liquidity of the stock and also reflects the awareness among the investors about the firm. Similarly, tangible net worth can be seen as the amount of collateral that a firm can use to borrow external funds. Tangibility of assets and debt capacity are the well-known factors in the literature that enables the firm to have easier access to external funds. In a study conducted by Almeida and Campello (2007) reported that asset tangibility increases cash flow sensitivity for financially constrained Firms. Taking reference from the above, we are using tangible net worth as a proxy for pledgeable assets in the Indian context.

## 5 Data and Methodology

In our study, the data is extracted from CMIE (Centre for Monitoring Indian Economy) Prowess database which is India's largest database for the firm level data of the Indian companies. It constitutes the firm-level data from the annual reports, financial statements and other published reports for the Indian firms. The database has the collection of 26,000 Indian firms across various sectors. Data is extracted for the period of seven years (2009–2015) for all the listed[3] manufacturing firms available in the CMIE database. The final analysis is performed for the period of (2010–2015) as data for 2009 is required only to calculate final variables for the study. The proxy used for the variables have been highlighted in Table 1.

There are a total of 1034 firms across different industries under manufacturing sector. Further, data is cleaned based on various parameters to improve the efficiency and validity of the results. Data is cleaned as under:

1. Firms with missing data for three or more years on investment or capital stock are removed from the analysis.
2. Firms that do not have data on market capitalization or tangible net worth are removed from the analysis. There are two reasons for the above, firstly market capitalization and tangible net worth are used as splitting criteria for the firms

[3]Listed on Bombay stock exchange.

**Table 1** Variables and proxy used

| Variable | Proxy used |
|---|---|
| Investment | Gross fixed assets additions − Gross fixed assets deductions for the year (in millions) |
| Change in sales | $Sales_n - Sales_{n-1}$ (in millions) |
| Cash flow | Profit after tax + Depreciation + Amortisation for the year |
| Debt | Total borrowings + preference share capital |
| Replacement value of capital stock | Gross fixed assets subject to the specification used by Fazzari et al. (1988), Athey and Laumas (1994), Bhaduri (2005) |
| GDP implicit price deflator | RBI data on GDP implicit price deflator for manufacturing firms subject to the base year 2004–2005 |
| Average service life of the firm | 16 years (Bhaduri 2005) |
| Size | Market capitalization |
| Debt capacity | Tangible net worth (Net worth − Intangible net worth) |

**Table 2** Summary of observations

| Variable | Observations | Mean (in millions) | Std. Dev. (in millions) | Min (in millions) | Max (in millions) |
|---|---|---|---|---|---|
| Investment | 4608 | 1736.121 | 9822.773 | −157,600 | 270,749.3 |
| Debt | 4312 | 11,243.2 | 48,965.9 | 0 | 976,200 |
| Change in sales | 4608 | 3265.547 | 32,669.8 | −604,880 | 811,410 |
| Cash flow | 4608 | 2777.313 | 14,533.43 | −58,394 | 365,270 |
| Capital stock | 4608 | 16,023.14 | 85,102.73 | −353.728 | 2,060,185 |
| Tangible net-worth | 4608 | 14,345.93 | 983.3293 | −11,886.6 | 1,813,910 |

into various groups. Secondly, firms without data on market capitalization might be delisted or cease to exist. Also in some cases, CMIE does not drop the firms that cease to exist from the database.

3. Firms with negative tangible net worth are removed from the analysis because of the deficit on the asset side. The firms facing this condition will face negative influence on financing opportunities and will experience shrunken business growth. Hence dropping these firms will remove biasness in the results.
4. Firms that are merged into some other firms are removed from the analysis.

The application of above filters reduced the number of firms to 768 in total for which summary statistics are provided in Table 2. There are total 27,352 observations for five variables calculated for six years. The cleaned data is then bifurcated on the basis of the splitting criteria chosen for the study. Firstly, the firms are divided on the basis of business group affiliation that divides the data into 423 business group associated and 345 standalone firms.

Secondly, firms are divided on the basis of market capitalization which is taken as the proxy for size according to which the firms are divided into three groups in the order of high to low market capitalization viz. HMC (High market capitalization), MMC (Medium market capitalization) and LMC (low market capitalization) with 256 firms in each of the groups. Finally, third criteria for the division of firms is on the basis of tangible net worth taken as the proxy for debt capacity. Firms are divided into three groups in the order of high to low tangible net worth viz. HTNW (High tangible net worth), MTNW (Medium tangible net worth) and LTNW (Low tangible net worth) with 256 firms in each of the groups. Tangible net worth is taken as the criteria for splitting the firms according to debt capacity as well as a proxy for tangibility of assets in the analysis. Another important restriction that we applied to the data is prohibiting the firms to change the group to which they belong over the period of analysis i.e. firm belonging to LMC group will not be changed to MMC or HMC with time. Similarly, for other two criteria firms will not be allowed to shift the group. The study is confined to the period of only six years which lowers the chance for the firms to change regimes. Hence, to this particular study, we did not find significant need of applying sample selection model to enable firms to change the regime from financially constrained or unconstrained firms or vice versa.

Finally, each group is analysed using the GMM (Generalized Method of Moments) for the first order[4] and second order[5] as specified by Arellano and Bond (1991) using dynamic panel data model. The proposed sales accelerator model can be considered as a dynamic panel data equation where a lag of dependent variable along with other variables is taken as an independent variable to check out cash flow sensitivity of investment. The advantage of using GMM is the efficient results which it brings by taking the unobserved heterogeneity into account by estimating first order equation. Further second order GMM can be used to better the result of first order estimates due to the asymptotic efficient estimates. Also, endogeneity problems are taken care of by using a lag of dependent variable as instruments. We allowed maximum one lag of dependent variable to be used as instruments in most of the groups except few which used more instruments for the analysis. The autoregression of order AR (2) is used in the analysis. To find out that model is appropriate robustness checks are performed using Arellano and Bond (1991) test for autocorrelation ($H_0$-no autocorrelation) and Sargan test (1958) for the validity of over identifying restrictions ($H_0$-over identifying restrictions are valid). The results are reported after checking for any lacunas in the model. The final results are reported according to GMM second order considering the efficiency that it brings to the estimates.

[4]One step estimator.

[5]Two step estimator.

## 6 Findings and Discussion

The findings are reported in accordance with the splitting criteria (ownership group, size and debt capacity) used for the analysis. The model is reported significant and appropriate for all the groups on which analysis is performed. The results for group firms suggest sales and debt are positively significant while cash flow is negatively significant in first-order GMM analysis. In second-order analysis lagged investment is also found significant along with the above variables. The results from non-group firms found that cash flow is the only significant variable in both first order and second order analysis. This shows that firms without business group affiliation are more cash flow sensitive to investment in comparison to group affiliated firms. Further, a negative coefficient for cash flows for group firms suggests surplus cash flows that are much larger than investment opportunities available with these firms. Also, sales and capital structure are found to be key determinants that influence investment in group affiliated firms.

Further, robustness checks are performed using Arellano and Bond (1991) (also called AR (1) and AR (2) tests) and Sargan test (1958) for testing autocorrelation suggests that there is no autocorrelation in the model. AR (1) and AR (2) test represents the null hypotheses ($H_0$-zero autocorrelation) in first differenced errors for the first order and second order respectively. The *p* values reported for AR (1) and AR (2) are 0.1812 and 0.1630 which precludes us from rejecting the null hypothesis for group firms. Similarly, panel for standalone firms has reported no evidence for appropriateness of the model. Also, Sargan test fails to provide any evidence for autocorrelation with *p*-value 0.4215 and 0.1981 for a group affiliated and standalone firms respectively (Table 3).

The results according to size (market capitalization) report highest cash flow sensitivity to investment with coefficients[6] (1.5162) and (0.6363) for cash flows are reported for LMC firms. All other variables other than cash flow reported insignificant relationship for the same. Further, MMC firms report negative cash flow sensitivity to investment with a coefficient (−0.1258) in the first order and positive for second order (−0.1795). Sales, debt and lagged investment are also found significant to investment along with cash flows for the MMC firms. However, HMC firms report the insignificant relation between cash flows and investment. Debt is found as the most important determinant that positively influences investment along with marginal positive impact from sales in first order. While, Second order analysis denied the significant influence of sales but reported negative influence (−0.0037) of lagged investment on the HMC firms' investment. Tests for checking validity reject null hypotheses to provide evidence for no autocorrelation in the model.[7] Above findings suggest that cash flow sensitivity to investment is

[6]First order and second order respectively.

[7]LMC-MA1 (0.0087), MA2 (0.2990), Sargan (0.2495).
MMC-MA1 (0.0310), MA2 (0.1877), Sargan (0.9287).
HMC-MA1 (0.2157), MA2 (0.8173), Sargan (0.1763).

**Table 3** Results (ownership structure)

| $\left(\frac{I}{K}\right)_{i,t}$ (dependent variable) | Group firms | | Non-group firms | |
|---|---|---|---|---|
| | GMM 1 order (Coef.) | GMM 2 order (Coef.) | GMM 1 order (Coef.) | GMM 2 order (Coef.) |
| Lagged investment | −0.005 | −0.004*** | −0.046 | 0.026 |
| Change in sales | 0.288*** | 0.289*** | 0.001 | 0.001 |
| Cash flows | −0.472*** | −0.478*** | 0.211*** | 0.180** |
| Debt | 0.699*** | 0.687*** | 0.001 | 0.001 |
| Tangible net worth | −0.00688 | −0.01444** | 0.00476 | 0.006577 |
| Cash flows* Tangible net worth | 0.021803 | 0.04987*** | −0.00684 | −0.00999 |
| Constant | −0.524*** | −0.540*** | 0.118*** | 0.102*** |

*, **, *** Significant at 90, 95 and 99% confidence intervals respectively

**Table 4** Results size (market capitalization)

| $\left(\frac{I}{K}\right)_{i,t}$ (dependent variable) | Large firm size | | Medium firm size | | Small firm size | |
|---|---|---|---|---|---|---|
| | GMM 1 order (Coef.) | GMM 2 order (Coef.) | GMM 1 order (Coef.) | GMM 2 order (Coef.) | GMM 1 order (Coef.) | GMM 2 order (Coef.) |
| Lagged investment | −0.003 | −0.003*** | −0.148*** | −0.123** | −0.012 | −0.004 |
| Change in sales | 0.040*** | 0.009 | 0.072*** | 0.092*** | 0.001 | 0.001 |
| Cash flows | −0.067 | 0.106 | −0.111*** | −0.149*** | 0.818*** | 1.079*** |
| Debt | 1.428*** | 1.470*** | 0.231*** | 0.286*** | 0.004 | 0.002 |
| Tangible net worth | 0.018497 | 0.004607 | −0.00938 | −0.01699 | 0.010599 | 0.001224 |
| Cash flows* Tangible net worth | −0.01715 | −0.00083 | 0.021954 | 0.047649 | −0.326*** | −0.06371 |
| Constant | −1.171*** | −0.908*** | −0.110*** | −0.160*** | 0.044 | 0.009 |

*, **, *** Significant at 90, 95 and 99% confidence intervals respectively

inversely proportional to the size of the firm i.e. smaller the firm higher will be the cash flow sensitivity to investment for the firms (Table 4).

Similarly, results by splitting the firms by Debt capacity (tangible net worth) imitates the results from division according to size. LTNW firms report the significant positive influence of cash flows on investment while, all other variables reported insignificant relationship for the same. MTNW firms reported significant positive relationship for all the variables except cash flows which report negative influence on the investment. Further, HTNW firms report a significant relationship between cash flows and investment in first order but the results from second-order

**Table 5** Results tangible net worth (debt capacity)

| $\left(\frac{I}{K}\right)_{i,t}$ (dependent variable) | High debt capacity | | Medium debt capacity | | Low debt capacity | |
|---|---|---|---|---|---|---|
| | GMM 1 order (Coef.) | GMM 2 order (Coef.) | GMM 1 order (Coef.) | GMM 2 order (Coef.) | GMM 1 order (Coef.) | GMM 2 order (Coef.) |
| Lagged investment | −0.011 | 0.036 | −0.003 | −0.004*** | −0.008 | −0.001 |
| Change in sales | 0.007** | 0.001 | 0.270*** | 0.275*** | 0.002 | 0.001 |
| Cash flows | 0.143*** | 0.054 | −0.824*** | −0.652*** | 0.107*** | 0.120*** |
| Debt | 0.177*** | 0.049 | 0.736*** | 0.752*** | 0.004 | 0.003 |
| Tangible net worth | 0.000691 | 0.00037 | −0.02134 | 0.017962 | −0.01166 | −0.00304 |
| Cash flows* Tangible net worth | 0.029257 | 0.005811 | 0.036817* | −0.03022 | −0.01641 | −0.00105 |
| Constant | −0.140*** | 0.057 | −0.414*** | −0.399*** | 0.149*** | 0.136*** |

*, **, *** Significant at 90, 95 and 99% confidence intervals respectively

estimates denies any significant relationship for the same. Sales and debt are also found significant in first order but not in second-order analysis. The model reports no autocorrelation for robustness checks in the analysis.[8] Hence we can say that cash flow sensitivity to investment reduces with the increase in debt capacity of the firms (Table 5).

## 7 Conclusions

The study explores the investment behaviour pursuant to characteristics of the firms and to analyse the effect of tangibility of assets in alleviating financial constraints. The results report significant firm factors to investment by splitting the firms through a priori splitting criteria for the firms according to business group affiliation, market capitalization and tangible net worth. Standalone firms are found to be more cash flow sensitive to investment in comparison to group affiliated firms highlighting their strong dependence and scarcity of internal funds for investment decisions. Cash flow is found to be the only significant factor while taking investment decisions for the standalone firms whereas sales and capital structure are found crucial for investment decisions for group affiliated firms. The results from

[8]LTNW-AR 1 (0.0066), AR 2 (0.9225), Sargan (0.6458).
MTNW-AR 1 (0.2304), AR 2 (0.2902), Sargan (0.3126).
HTNW-AR 1 (0.2464), AR 2 (0.7519), Sargan (0.3353).

splitting the firms according to market capitalization and tangible net worth reveal a higher degree of cash flow sensitivity for firms with lower market capitalization and tangibility of assets. The results verify cash flow sensitivity as the proxy for financial constraints and are in line with the results of Fazzari et al. (1988). Findings of the study also suggest that medium market capitalization firms have mixed effects of all the variables for investment decisions as all the variables report significant relationship for the investment decisions. The results for effects of tangibility of assets on easing financial constraint are found significant only in low market capitalization firms. The results suggest that tangibility of assets does not play a significant role in accessing external finance for most of the firms. The study has a limitation of using only listed firms that restrict the scope of the study to the listed firms only. Future research can be conducted using a larger sample of non-listed firms and compare the discrepancies in the behaviour of listed and non-listed firms in terms of financial constraints.

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# Credit-Risk Decision Process Using Neural Networks in Industrial Sectors


**Aleksandra Wójcicka**

**Abstract** Due to increased bankruptcies noted among companies (debtors) banks pay more attention to credit risk management. One of the most valid tasks in credit risk evaluation is the proper classification of potential good and bad customers. Reduction of the number of loans granted to companies of questionable credibility can significantly influence banks' performance. An important element in credit risk assessment is a prior identification of factors which affect companies' standing. The research focuses on determining which of the factors have the biggest impact on company's solvency and which are redundant and therefore can be removed from future analysis. The other purpose of the research is to investigate and compare the results of two different structures of neural networks—the most common Multi-Layer Perceptron (MLP) and Radial Basis Function neural network (RBF). The conducted research bases on the financial reports of Polish companies in industrial sector and a credit risk analysis method applied in one of the banks operating on Polish market. The results of two different NN models are juxtaposed and compared with the real-world data. Moreover, the vulnerability analysis of entry data is carried out to find the most beneficial set of variables.

**Keywords** Credit risk · Neural networks · Financial ratios · Credit risk decision-making process

## 1 Introduction

Running a business is a constant process of decision making. Those decisions are always accompanied by risk which can be characterised by a different scale. Ultimately that risk takes a form of a financial dimension. One of the basic objectives of banks' activity (as a specific enterprise) is granting loans. The reduction of loans granted to companies of questionable creditability can significantly

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influence and improve banks' performance. The most important element in categorizing debtors as "good" or "bad" is a prior identification of factors that affect the condition of companies. For it is the condition that directly influences the creditability and solvency of the debtor and both of these factors result in low or high probability of default (PD).

Nowadays, risk analysis in financial markets is one of the most important factors and new methods must be very flexible and adaptive to changing realities of market economy. Therefore, a growing interest in solutions like artificial neural networks (ANN[1]) and their applications in credit risk assessment is noticeable and every improvement in accuracy, is a significant accomplishment.

The idea of neural networks as computing processors has its origin in the way a human brain computes and analyses obtained knowledge. A very important issue is the learning algorithm used in network design which influences the whole structure of NN. The different neural networks models used in the paper are Multi-Layer Perceptron (MLP) and Radial Basis Function (RBF).[2]

The main objective of the paper is to establish the optimum set of financial ratios which most efficiently describe companies' performance in industrial sector in a credit-risk evaluation process. This goal is also accompanied by another objective—the comparison of most commonly used neural networks. Both of these goals were combined to deliver not only a set of unique ratios, which most efficiently describe the industrial sector, but to provide it with a most convenient technical solution—chosen NN.

The findings of the research are significant for practice—especially in risk departments.

Scientific contribution of the paper is mostly connected to its business perspective and its novel findings are in the area of determinants of credit risk in industrial sector and its prediction.

## 2 Review of NN Implementation in Credit Risk Decision Process

Various steps are involved in credit risk assessment, as well as various techniques (models). Among the most popular methods are scoring models, discriminant analysis and neural networks, along with standard and internal ratings-based (IRB) credit risk models.

Neural networks in the scope of credit risk are broadly analysed and used world-wide. Atiya (2001) presents an empirical approach, basing on the

[1]In this paper, the acronym ANN and NN will be used alternatively to define artificial neural networks.

[2]More on architecture of MLP and RBF https://documents.software.dell.com/statistics/textbook/neural-networks#multilayera.

relationship of default and the characteristics of a firm learnt from the data. The conclusions indicate the superiority of neural networks over other techniques and the need for improvements in training methods, architecture selection, or input. The latter prompted the Author to search for better selection of independent input. Moreover, Baesens et al. (2003) investigated neural networks and their contribution in helping the credit-risk managers in explaining why a particular applicant is classified as either "bad" or "good". They conclude that neural network rule extraction and decision trees are effective and powerful management tools, allowing the construction of advanced and user-friendly decision-support systems for credit-risk evaluation.

Also in work of Pacelli and Azzollini (2011) it is stated that neural networks are particularly suited to analyse and interpret complex and often obscure phenomena and processes. However, it is also stressed that neural networks, similarly as other methods, have their strengths and weaknesses, which can be, for instance, the fact that it is unknown to the researcher what kind of links and interdependencies are included in the hidden layers.

Still, other research proves that despite the weaknesses neural networks show good performance when data are noisy or incorrect (see Angelini et al. 2008; Tollo 2006). In these studies, the most common NN were analysed. Other structures of neural networks, as well as their comparison with other techniques (Decision Trees, Discriminant Analysis, Regression Function etc.) can be found in works of e.g. Khemakhem and Boujelbènea (2015), Karaa and Krichene (2012), Huang et al. (2004), Oreski et al. (2012), Ogwueleka et al. (2015), Linder et al. (2004) and many others. As it is presented above, many studies are dedicated to neural network implementation, however, very little is said about the influence of an economic sector on companies' performance and, consequently, on bank loan-granting policy and potential losses due to the wrong classification of entities. It is visible in the financial statements of the entities that the line of business has an impact on statements' structure and figures included. All the above, gave the Author an incentive to investigate the topic further (see Wójcicka 2017a, b). Therefore, choosing the unique set of variables for particular sector (industrial) and implementing it in neural network is the key objective of the paper.

## 3 Methods

The study can be classified in applied studies group and the research strategy is descriptive. Neural network technique (NN)—also called artificial neural network (ANN)—is used. The collected data was obtained from a bank operating on Polish market, the Commercial Court in Poznań (Poland)[3] and from NOTORIA SERWIS. The data cover a period of six years (2009–2014). The sample contains financial

[3]The data is confidential therefore the names of the companies cannot be revealed.

statements of companies which include a balance sheet, an income statement, a cash flow statement and a statement of changes in equity. The obtained sample contained of 2901 objects, however, 323 units were incomplete regarding the financial statements, therefore, they were removed from further analysis.

The purpose of the research is to determine those endogenous factors which affect the level of company's credit risk. It is important to identify which of the factors have the biggest impact and which are redundant and therefore can be removed from future analysis. The research also focuses on investigating and comparing the results of two different structures of neural networks—the most common Multi-Layer Perceptron (MLP) and Radial Basis Function neural network (RBF).

The implemented tool is STATISTICA Neural Networks (SANN). Variables are divided into dependent and independent ones. Independent variables are the financial ratios which banks find the most significant in credit risk analysis and use them in their models. The dependent variables are identified as a "good" or "bad" company. A "good" company was the one which was granted financial resources and, consequently, the "bad" enterprise was the one whose application was rejected.

The data set was divided into three groups in a following manner:

1. learning group (80% of data set),
2. testing group (10% of data set),
3. validation/holdout group (10% of data set).

For building the models different variants of hidden layers were used.

## 4 Findings

The efficient classification of bank's customers to an appropriate risk group is a fundamental principle for banks' functioning. The goal of the research was to identify the optimum set of financial ratios from a global set of 25 most popular financial ratios (see more Wójciak and Wójcicka 2008, 2009; Wójcicka and Wójtowicz 2009) and to verify the hypothesis that a correct input of data can improve the performance of used method (neural networks). The whole set of ratios is presented in Table 1.

The initial set of 25 ratios was used as the entry data in NN learning process. 20 NN of two chosen artificial neural network models—MLP and RBF, were estimated to state whether the analysed company is "good" (healthy) or "bad" (unsound). Then the process of reducing the set of entry data began. It was conducted iteratively. The first step was to calculate the correlation between each pair of ratios. Next the pair of the strongest correlation was chosen. From that pair, this ratio was rejected which had the highest average level of absolute level of correlation with the remaining ratios. The obtained set of 24 ratios was then implemented as entry data into the NN learning system. Then another ratio was rejected and once

**Table 1** The set of ratios used in research

| No. | Ratio |
|---|---|
| 1 | Current ratio |
| 2 | Quick ratio |
| 3 | Receivables ratio |
| 4 | Stock turnover ratio |
| 5 | Receivables to liabilities ratio |
| 6 | Gross profit margin ratio |
| 7 | Net profit margin ratio |
| 8 | Sale profitability ratio |
| 9 | Costs level ratio |
| 10 | Total debt ratio |
| 11 | Equity debt ratio |
| 12 | Financial leverage |
| 13 | Debt/EBITDA |
| 14 | Financial surplus rate |
| 15 | Long-term debt ratio |
| 16 | Current assets turnover ratio |
| 17 | Short-term investments turnover ratio |
| 18 | Operating activity profitability ratio |
| 19 | Assets profitability ratio |
| 20 | Equity profitability ratio |
| 21 | Costs increase ratio |
| 22 | Sales dynamics |
| 23 | Operating ratio |
| 24 | Self-financing ratio |
| 25 | EBITDA/Financial expenses |

again, a new, limited set of entry data was applied to NN. This process was continued until the results of neural networks indicated the process of overfitting. Then, it was stopped. The process of ratios' selection might seem independent from neural networks, however, it is not entirely independent because the outcome of neural networks performance is the stopping point. In the process of ratios' selection, the rejected ratios were as follows (in order of rejection): Current ratio, Equity debt ratio, Stock turnover ratio, Short-term investments turnover ratio, Equity profitability ratio, Gross profit margin ratio, Costs increase ratio, Sales dynamics, Operating ratio, Self-financing ratio, Sale profitability ratio, Costs level ratio, Long-term debt ratio, Debt/EBITDA, EBITDA/Financial expenses, Financial leverage. Then, basing on the results of the individual (decreased) sets, the best set was chosen for each NN model.

It appears that the best set of ratios for MLP consists of 9 following ratios: Quick ratio, Net profit margin ratio, Total debt ratio, Receivables to liabilities ratio, Receivables ratio, Financial surplus rate, Current assets turnover ratio, Operating

**Table 2** MLP neural network—5 best results

| No. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Neural network | MLP 9-11-2 | MLP 9-10-2 | MLP 9-12-2 | MLP 11-13-2 | MLP 9-13-2 |
| Quality (learning) % | 85.00 | 83.33 | 81.67 | 80.00 | 80.00 |
| Quality (testing) % | 80.00 | 81.67 | 76.67 | 80.00 | 78.33 |
| Function of error | Entropy | SOS | SOS | Entropy | SOS |
| Activation (hidden layer) | Sinus | Tanh | Logistic | Sinus | Exponential |
| Activation (output) | Softmax | Exponential | Linear | Softmax | Sinus |

activity profitability ratio, Assets profitability ratio. Just in one case it was a set of 11 ratios (additional ratios—Financial leverage and EBITDA/Financial expenses).

However, RBF neural networks include a slightly wider set (10 ratios) adding to the above nine ratios also Financial leverage. In this case first 3 best NN include 10 ratios while the fourth and fifth position is taken respectively by NN of 11 and 12 ratios which are all presented in Table 3 (additional ratios EBITDA/Financial expenses and Debt/EBITDA). Rating of the results is presented in Table 2 for MLP and Table 3 for RBF. The neural networks are presented in a following manner: chosen architecture (MLP or RBF), X—number of inputs, Y—neurons in the hidden units, and Z—number of outputs (healthy, unsound[4]).

When concerning the results in a learning group it is certainly RBF 10-13-2 network which performs better then MLP, reaching 88.33% accuracy in comparison to 85.00%. However, level of accuracy in MLP 5 best networks is quite steady (the gap reaches just 5.00%) while in the same group of RBF 5 best networks this gap is almost twice as much (8.33%) which indicates a certain instability of possible results. Yet an opposite situation occurs when concerning testing group. A conclusion is justified that in case of testing group MLP neural networks do a little better than RBF. None of the RBF networks exceeded the level of 80.00% in testing group, while in case of MLP 9-10-2 exceeded that level (81.67%) along with two networks exactly at that level (9-11-2 80.00% and 11-13-2 80.00%). Also, the lowest level of testing quality was reached among MLP networks (76.67%, MLP 9-12-2) which proves the gap between the best and worst network to be relatively wide (5%) while in case of RBF it is merely 1.67%. Still, however, it did not exceed the gap in accuracy of RBF learning set (8.33%). The distance between the 1st and 5th best network is steady (5%) despite the group (learning or testing). It is worth stressing that both types of NN are in the range level above 80.00% when concerning the best networks in learning sets.

[4]In some neural network approaches, the final outcome would be denoted by "1" as expressions "healthy" and "unsound" would be treated as two options of one characteristic. In the approach used in the paper they are treated as two possible outcomes ("good" or "bad").

**Table 3** RBF neural network—5 best results

| No. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Neural network | RBF 10-13-2 | RBF 10-10-2 | RBF 10-12-2 | RBF 11-11-2 | RBF 12-14-2 |
| Quality (learning) % | 88.33 | 86.67 | 86.67 | 83.33 | 80.00 |
| Quality (testing) % | 80.00 | 80.00 | 78.33 | 80.00 | 78.33 |
| Function of error | Entropy | Entropy | Entropy | Entropy | Entropy |
| Activation (hidden layer) | Gauss | Gauss | Gauss | Gauss | Gauss |
| Activation (output) | Softmax | Softmax | Softmax | Softmax | Softmax |

**Table 4** Type II error for MLP and RBF networks

| Type of NN | Error type II (%) |
|---|---|
| MLP | 16.67 |
| RBF | 23.33 |

Summing up, in case of companies from industrial sector the recommendation for analysts, in a decision-making process, is to use the set of 9 ratios selected for MLP because results reached by this structure of neural networks (in testing group) were the most accurate. Testing the neural networks on a separate set of data (validation group) proved that both types of NN show good results, however, MLP performs slightly better than RBF. It was assumed on the basis of type II error. Type II error means that banks recognise a bad customer as a good customer and accept its application and grant financing which is very likely to lead to customer's insolvency and bankruptcy. Table 4 presents the results of type II error for both types of tested NN.

As type II error is considered to be more significant for the banks, it is justified to believe that MLP is more preferable to RBF, as the level of this type of error is lower in case of this NN type (16.67% compared to 23.33%). The performance of RBF is a bit alarming as the results of learning and testing sets did not indicate a possibility of deterioration and a decline in correct classification of companies (being at a steady level of 78.33–80.00%). This might indicate a problem of overfitting to initial data. Therefore, when given choice, the recommendation again is to stick to MLP, instead of RBF.

Comparison of MLP and RBF results with a banking credit scoring method (further referred to as BCSM) on the same set of data (validation group) is very encouraging. BCSM uses 6 ratios (respectively the best MLP and RBF architecture use 9 and 10 ratios) for making credit-granting decisions. These ratios are as follows: Current ratio, Quick ratio, Financial leverage, Total debt ratio, Debt/EBITDA, EBITDA/Financial expenses (see more Wójcicka 2012). Specified ranges for those ratios are set in advance by the bank. After calculating the required ratios and classifying them into particular range a decision, referring to debtor's internal

credit-rating, is made by an analyst according to the financial performance (ratios) and analyst's experience.

The fact that the set of ratios used by BCSM is invariable irrespective of the line of business is a vital drawback of this approach. This, in authors' opinion, can have an adverse impact on final outcome of the decisions made, as it is very often too static and does not follow the latest trends in rapidly changing economy and market conditions or it does not distinguish some subtle factors. However, it is also important to stress that BCSM is usually only a part of the whole process of granting or rejecting loans. Final decision is frequently based on BCSM findings and followed by the expert's or analyst's individual opinion. Both architectures of neural networks slightly exceed the performance of BCSM. Although, the differences between implemented methods can seem marginal, still they can be observed and eventually may decide not only about bank's performance but in extreme cases, about its survival. The results of MLP, RBF and BCSM are presented in Table 5.

As the results show the difference between MLP and BCSM is rather small, however, referring to a larger scale it still can influence bank's performance immensely. In author's opinion adjusting the set of variables (ratios) used in neural networks to a particular line of business can greatly contribute to better decisions concerning potential credit risk. This can suggest that even tailor-made, unique methods like BCSM can be insufficient. Therefore, the recommendation is to use approaches which can be instantly adapted to ongoing changes, such as neural networks which can be re-trained. Among various structures of neural networks, it is the Multi-Layer Perceptron which shows better results than other approaches and, therefore, is recommended. Comparison of current and previous research (ran for construction sector) (Wójcicka 2017a, b) proved that the line of business influences the optimum set of input data (financial ratios) as they vary depending on a particular branch. Ratios selected for analysed sectors are presented in Table 6.

Five ratios appear in case of both analysed sectors therefore they can be tentatively considered as universal. It means that they can be used regardless of the line of business of the assessed company. However, it is worth stressing that 12 out of 25 initial input ratios do not appear at all in any of neural networks cases. Moreover, BCSM shares four (in case of construction sector) and 5 (in case of industrial sector) of all 6 initial ratios it uses. However, its results are not better than tested neural networks. It proves that too narrow set of input data negatively influences the final outcome. It can be assumed that BCSM would benefit from

**Table 5** The quality of classification for all tested methods (MLP, RF, BCSM)

| Type of NN | Quality (%) |
|---|---|
| MLP 9-11-2 | 83.33 |
| MLP 9-10-2 | 83.33 |
| BCSM | 81.67 |
| RBF 10-13-2 | 76.67 |
| RBF 10-10-2 | 76.67 |

**Table 6** Ratios used as input in NN analysis in construction and industrial sector

| No. | Ratio | Construction sector | | Industrial sector | |
|---|---|---|---|---|---|
| | | MLP | RBF | MLP | RBF |
| 1 | Current ratio | x | x | | |
| 2 | **Receivables ratio** | x | x | x | x |
| 3 | **Net profit margin ratio** | x | x | x | x |
| 4 | **Financial surplus rate** | x | x | x | x |
| 5 | **Total debt ratio** | x | x | x | x |
| 6 | Costs level ratio | x | x | | |
| 7 | **Assets profitability ratio** | x | x | x | x |
| 8 | Financial leverage | x | x | | x |
| 9 | Operating activity profitability ratio | | x | x | x |
| 10 | Current assets turnover ratio | | x | x | x |
| 11 | Quick ratio | | | x | x |
| 12 | Stock turnover ratio | | | | |
| 13 | Receivables to liabilities ratio | | | x | x |

supplementing its basic set of 6 ratios by chosen ratios indicated as useful by neural networks in case of specific sector of business.

The comparison of research ran for construction sector with the current research of industrial sector also proved the tendency of MLP performing better than RBF (the gap is 11.67 pp in favour of MLP, and 6.67 pp in favour of RBF in case of construction sector). However, one fact remains disturbing. In case of construction sector, the results of accuracy that neural network achieved were generally a bit higher than in case of industrial sector. This can be due to the fact that construction sector is quite homogenous, while industrial sector covers a wide variety of activities. Therefore, it should be considered in future research whether it is justified to analyse the whole industry sector as a whole or whether it would be more beneficial to single out separate branches.

## 5 Conclusions

Making a wrong loan-granting decision can result in big financial losses. Therefore, credit risk estimation and correct classification of customers is a valid, up-to-day, significant issue. The objective of used methods is increased accuracy which means more creditworthy applicants are granted financing and thereby increasing bank's profits. Consequently, those accounts which are not creditworthy are denied the funding and thus avoiding unnecessary losses.

The two types of neural networks analysed in this paper are Multi-Layer Perceptron (MLP) and Radial Basis Function (RBF) which both proved to be highly

useful in credit risk decision-making process. The choice of those two types was dictated by the fact that they are the most commonly used architectures of NN. The obtained results show that irrespective of the model and data set the accuracy is not less than 80%.

The research decreasing the input data (set of financial ratios) showed that there is no need to excessively increase the number of ratios as the best results were obtained for subsets of approximately 9–10 ratios. It also showed that it is justified to use a small subset of universal ratios (regardless of the line of business) combined with another subset of ratios specific for particular sector.

Recommendation for banks and financial institutions:

the set of financial ratios for companies operating in industrial sector should include 9 ratios in case of MLP implementation: Quick ratio, Net profit margin ratio, Total debt ratio, Receivables to liabilities ratio, Receivables ratio, Financial surplus rate, Current assets turnover ratio, Operating activity profitability ratio, Assets profitability ratio,
the set of financial ratios for companies operating in industrial sector should include 10–11 ratios in case of RBF implementation: the above mentioned 9 ratios and Financial leverage and EBITDA/Financial expenses,
the results for tested NN structures show that better results are reached when using Multi-Layer Perceptron,
too narrow set of ratios deteriorates the final results of accuracy (see results of BCSM),
five ratios (Receivables ratio, Net profit margin ratio, Financial surplus rate, Total debt ratio, Assets profitability ratio) are used despite the line of business, therefore, they can be recognised as universal and may be used in case of companies from various sectors, preferably supplemented y sector-specific ratios.

In author's opinion, it would also be essential to implement other methods of including and excluding the variables—preferably independently for each method and line of business.

Moreover, one of the further directions of currently ongoing research may lead to broadening the set of exogenous factors which, in author's opinion, significantly influence credit risk.

The alternative direction of research, with respect to this analysis, bases on comparative analysis among neural networks and other approaches to classifying clients (popular credit-scoring methods, Z-score models, other classification methods—decision trees, regression etc.) and amid different types of neural networks as well.

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# Impact of Pay-for-Performance on Rating Accuracy


**Kittiphod Charoontham and Thunyarat Amornpetchkul**

**Abstract** This study analyses whether the pay-for-performance scheme can encourage Credit Rating Agencies (CRAs) to issue accurate ratings under an investor-pay model. In our model, a CRA individually sets disclosure rules between biased rating and the full disclosure regime; an investor who solicits ratings, decides to acquire information accuracy. The CRA's information production cost is compensated by a fixed fee, and incentive pay is tied to the portfolio outcome. Finding shows that the pay-for-performance scheme can efficiently motivate the CRA to adopt the full disclosure regime. Sufficiently high information acquisition level requested by the investor and relatively low incentive pay can induce the CRA to fully disclose rating information. The results reveal how the pay-for-performance scheme and the investor's decision effectively influence the CRA's behaviour of selecting rating policy.

**Keywords** Credit rating agencies · Investor-pay model · Pay-for-performance scheme · Rating accuracy

## 1 Introduction

To reduce asymmetric information between issuers and investors, CRAs verify the quality of financial assets when it cannot be credibly claimed by the seller (Partnoy 2009). Although credit ratings should ideally depend upon the creditworthiness of debt issuers, they have become an important indicator used by market participants to make informed decisions in practice (Katz et al. 2009). The ratings have become

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proxies to set optimal capital structure (Kemper and Rao 2013), buy securities (Chatterji and Toffel 2010), or determine the ability to raise debt (Faulkender and Petersen 2006). The ratings have been incorporated into international financial policies for banking industries (IOSCO 2008), and investment policies for institutional investors (e.g., mutual funds, and pension funds) (Löffler 2004). CRAs have unavoidably been blamed for their major contribution to the 2007–2009 crisis and the ongoing Eurozone crisis because the ratings do not reflect the credit risk of underlying assets. To prevent financial instability, the main concern about ratings is how their accuracy can be assured.

Probems from conflict of interest, inherited in an issuer-pay model of CRAs, causes inaccurate ratings since CRAs tends to offer overly high ratings to capture the issuers' interest (Bolton et al. 2012). In addition, the issuer-pay model encourages issuers to shop for ratings which directly deteriorate rating accuracy (Sangiorgi et al. 2009). Therefore, policymakers propose an investor-pay model to address the problem. Under the investor-pay model, institutional investors have incentives to occasionally shop for ratings, leading to inaccurate ratings (Nwogugu 2013). To ensure that ratings are accurate, the CRAs' compensation should be tied to their performance (Partnoy 2009).

To the best of my knowledge, existing studies regarding the investors' incentive to request rating information under the pay-for-performance system is relatively limited. Bongaerts (2013) consider a mandatory co-investment scheme which punishes or rewards a CRA based on outcomes of the rated securities. Kashyap and Kovrijnykh (2016) also consider a performance-based payment scheme when different agents (social planner, issuer, investor) order ratings. They find that the rating accuracy is higher when the investor orders the ratings than when the issuer does. However, both studies do not take the CRA's behaviour of issuing biased rating into account.

To fill the knowledge gap of examining the investor's incentive toward acquiring accurate rating when interacting with the investor-pay rating agency, this study has two main objectives (i) to investigate what the investor's incentives are towards acquiring accurate information, and (ii) to examine whether the pay-for-performance scheme can motivate the CRAs to issue accurate ratings. In contrast to existing literature, this study considers the CRA's behaviour of issuing biased rating and analyzes only a case of solicited credit ratings.

## 2 Literature Review

The role of CRAs has captured the attention of the media and governments after the financial crisis in 2008 and ongoing Eurozone crisis according to a massive default of high rated securities. Existing literature mostly points out that a conflict of interest inherent in the issuer-pay business model causes inaccurate ratings (Bonsall Iv 2014; Nwogugu 2013) because it supports issuing firms' rating shopping behaviour. Thus, policymakers and politicians propose the investor-pay model to

solve the conflict of interest (White 2013) argued by the findings of Calomiris (2009) because institutional investors also have incentive to shop for ratings in order to increase flexibility of investment alternatives. Partnoy (2009) recommends that compensation of CRAs should be tied to their performance to address inaccurate ratings being produced.

Alternatively, Bongaerts (2013) proposes a mandatory co-investment scheme to improve rating quality. The co-investment scheme requires the CRA to partially invest in securities receiving high ratings which can potentially curb financial market growth due to CRAs' capital constraint. Kashyap and Kovrijnykh (2016) consider if a commission scheme can keep rating quality in check while the rating is ordered by different agents (e.g., an investor, a social planner, and an issuer). Findings show that the issuer prefers a less informative rating than the investor does when a rating is solicited from the CRA. Accordingly, social welfare is higher when the investor orders the rating than when the issuer does. However, these two studies do not consider CRAs' behaviour of inflating ratings in their model settings, and the investors' incentive of acquiring informative rating is not considered.

Different from the existing literature, this study on the pay-for-performance scheme incorporates the CRA's behaviour of issuing inflated ratings and deflated ratings into the model, and what influences the investor's decision toward acquiring information level to improve rating accuracy is analysed. In addition, the dynamic interaction between the investor and the CRA operated under the investor-pay model is illustrated.

## 3 Models

A one-period model of the pay-for-performance scheme is considered. In the market, there are economic agents (e.g., an investor, and CRA) who are rational, and their risk-free rate is zero. For convenience of reference, an investor and CRA are referred to as "he" and "she" respectively. The investor has sufficient fund to invest in a loan portfolio and solicits a rating from the CRA. The CRA has knowledge about the information production technology. The loan portfolio requires an initial investment normalized to one and yields return at the end of the period. The net cash flow of the loan portfolio is $R > 1$ if the portfolio succeeds, and $R = 0$ if it fails. There are two types of portfolios $n \in \{good\,(g), bad\,(b)\}$. For simplicity, all portfolios are assumed to generate similar pattern of cash flows and the portfolio difference is the probability of success $p_n$ where $0 \leq p_b < p_g \leq 1$. The expected payoff of each type of portfolio is:

$$x_n(R) = p_n R - 1 \tag{1}$$

We assume that only a good portfolio can generate a positive payoff, $x_g(R) = p_g R - 1 > 0$; a bad one yields a negative payoff, $x_b(R) = p_b R - 1 < 0$. The investor is assumed to invest only in the assets obtaining investment-grade

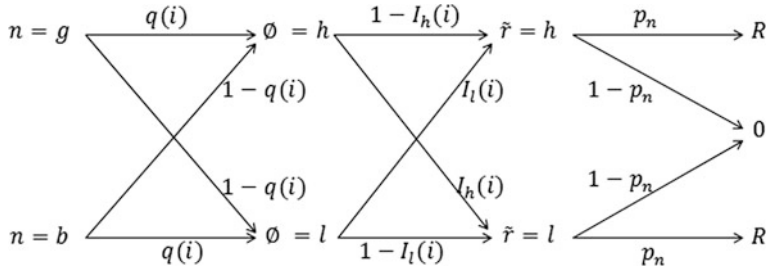


**Fig. 1** The rating process conditional on each type of portfolios

(high rating) from the CRA. The fraction of good portfolios, $\alpha_g$, and bad portfolios, $\alpha_b = (1 - \alpha_g)$, are commonly known in the market. A good market is designated by $\alpha_g x_g(R) + \alpha_b x_b(R) \geq 0$; a bad market is $\alpha_g x_g(R) + \alpha_b x_b(R) < 0$. The sequence of a rating process is: (i) the CRA sets rating-reported strategy $I_\emptyset \in \{I_h, I_l\}$ where $I_\emptyset$ is an indicator function, (ii) the investor acquires level of information accuracy $i$ and solicits a rating, (iii) the CRA observes a private signal $\emptyset$ and incurs information production cost $C(i)$, (iv) the CRA informs an indicative rating $\tilde{r} \in \{h, l\}$ where $h$ is high rating and $l$ is low rating, and (v) the investor can invest only in $h$-rated securities (see Fig. 1).

The cost function of information production when the CRA evaluates a rating is:

$$C(i) = ai^2 \quad \text{and} \quad a > 0 \tag{2}$$

where $a$ represents the CRA's cost for conducting due diligence and improving analytical models to evaluate the complexity of each asset class being rated. The quality of rating evaluation positively correlates with level of information production $i \geq 0$. The CRA observes a private signal $\emptyset \in \{high\,(h), low\,(l)\}$. The probability that CRA can evaluate the portfolio type correctly is greater as the level of information production rises.

$$\Pr\{\emptyset = h | n = g\} = \Pr\{\emptyset = l | n = b\} = q(i) = \alpha_m + i \tag{3}$$

where $\alpha_m = max\{\alpha_g, \alpha_b\}$ and $0 \leq i \leq 1 - \alpha_m$ implies historical success or failure of portfolios in the market. The signal accuracy of the CRA, $q(i) = \alpha_m + i$, is endogenous; the signal is uninformative if $i$ is zero. The CRA can privately select the rating policy $I_\emptyset$ between a full disclosure $(I_\emptyset = 1)$ and a bias rating regime $(I_\emptyset = 1)$. Since the signal and rating policy are privately known, the CRA may misreport the rating to collect fees (e.g., rating shopping).

# 4 Analysis

In period 0, when the investor purchases a rating, the CRA charges an upfront fee to cover the information production cost $C(i)$. In period 1, if the issued rating reflects the true quality of the portfolio, an investor keeps the retained share β and a CRA gains incentive pay, $1-\beta>0$. If the portfolio defaults, the CRA does not receive the incentive pay, $1-\beta=0$. The portfolio can obtain either a high or low rating after the CRA assesses the quality of the portfolio. The probability of the portfolio getting a high rating is:

$$\pi_{\mathrm{h}}(\mathrm{i})=\alpha_{\mathrm{g}}[\mathrm{q}(\mathrm{i})(1-\mathrm{I}_{\mathrm{h}}(\mathrm{i}))+(1-\mathrm{q}(\mathrm{i}))\mathrm{I}_{\mathrm{l}}(\mathrm{i})]+\alpha_{\mathrm{b}}[\mathrm{q}(\mathrm{i})\mathrm{I}_{\mathrm{l}}(\mathrm{i})+(1-\mathrm{q}(\mathrm{i}))(1-\mathrm{I}_{\mathrm{h}}(\mathrm{i}))]$$

The probability of the portfolio getting a low rating is:

$$\pi_{\mathrm{l}}(\mathrm{i})=\alpha_{\mathrm{g}}[\mathrm{q}(\mathrm{i})\mathrm{I}_{\mathrm{h}}(\mathrm{i})+(1-\mathrm{q}(\mathrm{i}))(1-\mathrm{I}_{\mathrm{l}}(\mathrm{i}))]+\alpha_{\mathrm{b}}[\mathrm{q}(\mathrm{i})(1-\mathrm{I}_{\mathrm{l}}(\mathrm{i}))+(1-\mathrm{q}(\mathrm{i}))\mathrm{I}_{\mathrm{h}}(\mathrm{i})]$$

The probability that the good portfolio gets a high rating is:

$$\pi_{\mathrm{gh}}(\mathrm{i})=\frac{\alpha_{\mathrm{g}}\mathrm{p}_{\mathrm{g}}[\mathrm{q}(\mathrm{i})(1-\mathrm{I}_{\mathrm{h}}(\mathrm{i}))+(1-\mathrm{q}(\mathrm{i}))\mathrm{I}_{\mathrm{l}}(\mathrm{i})]}{\pi_{\mathrm{h}}(\mathrm{i})}$$

The probability that the good portfolio gets a low rating is:

$$\pi_{\mathrm{gl}}(\mathrm{i})=\frac{\alpha_{\mathrm{b}}\mathrm{p}_{\mathrm{b}}[\mathrm{q}(\mathrm{i})(1-\mathrm{I}_{\mathrm{l}}(\mathrm{i}))+(1-\mathrm{q}(\mathrm{i}))\mathrm{I}_{\mathrm{h}}(\mathrm{i})]}{\pi_{\mathrm{l}}(\mathrm{i})}$$

## *4.1 Credit Rating Agency Analysis Problem*

The CRA can maximize her expected profit by setting the rating policy $I_{\emptyset}$ either full disclosure or bias rating regime. Under the full disclosure regime, the CRA truthfully reports a rating in accordance with the observed signal. If the CRA adopts the bias rating regime, the reported rating is contradicted to the observed signal. The investor funds the portfolio only if it gets a high rating (investment-grade). Therefore, the CRA's expected profit is:

$$\Pi_{CRA}=\max_{I_h(i),I_l(i)}\left[\pi_h(i)\pi_{gh}(i)x_g(R)+\pi_h(i)\left[1-\pi_{gh}(i)\right]x_b(R)\right](1-\beta) \qquad (4)$$

To clearly understand the CRA's behaviour, it is necessary to study the optimal choice of rating policy which directly affects the CRA's expected profit maximization.

**Proposition 1** *Given the requested information accuracy level i, the CRA's optimal response when observing a signal* $\emptyset \in \{l, h\}$ *is characterized by a threshold* $\bar{i}^{\emptyset}$*, such that*

- *If* $i < \bar{i}^{\emptyset}$*, it is optimal to misreport the portfolio type.*
- *If* $i \geq \bar{i}^{\emptyset}$*, it is optimal to truthfully report the portfolio type.*

See proof of Proposition 1 in Appendix.

The CRA implements the biased rating regime if the investor requests information accuracy level $i$ below the threshold of $\bar{i}^{\emptyset}$, endogenously set by the CRA. In this case, the reported rating does not reflect the true quality of the observed portfolio. The investor can in turn induce the CRA to adopt the full disclosure regime if he request higher accuracy level $i$ than the threshold of $\bar{i}^{\emptyset}$. Hence, the CRA reports the true quality of the observed portfolio.

## 4.2 Investor Problem

The investor's incentive toward acquiring information accuracy can be explained by the expected profit maximization. Accordingly, the expected profit of the investor is:

$$\Pi_{INV} = \max_{i} \left[ \left[ \pi_h(i)\pi_{gh}(i)x_g(R) + \pi_h(i)\left[1 - \pi_{gh}(i)\right]x_b(R) \right]\beta - C(i) \right] \tag{5}$$

**Proposition 2** *The optimal information accuracy level* $i^*$ *for the investor is characterized by two thresholds,* $\underline{\beta}$ *and* $\bar{\beta}$*, on the investor's retained share* $\beta$ *as follows.*

- *If* $\beta \leq \underline{\beta}$*, it is optimal to not request any accuracy* ($i^* = 0$).
- *If* $\underline{\beta} < \beta < \bar{\beta}$*, it is optimal to request* $i^* = \frac{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]\beta}{2a}$.
- *If* $\beta \geq \bar{\beta}$*, it is optimal to request the maximum accuracy* ($i^* = 1 - \alpha_m$).

See proof of Proposition 2 in Appendix.

It is intuitive that the investor does not need to acquire information accuracy to assure the true quality of the portfolio if a large portion of incentive pay is allocated to the CRA. In this case, the CRA can maximize her expected profit by minimizing the default rate of the portfolio since a one-time upfront fee is used up to cover information production cost. The investor acquires $i^* = \frac{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]\beta}{2a}$ if a middle portion of profits is shared with the CRA. The investor needs to acquire relatively high information accuracy to encourage the CRA to report true quality of the portfolio because the portion of incentive pay allocated to the CRA is smaller in this case. The investor needs to acquire maximum accuracy $i^* = 1 - \alpha_m$ if a little portion of incentive pay is given to the CRA. To induce the CRA to report accurate

rating, the investor must pay sufficiently high information production cost since the CRA gains relatively low incentive pay.

## 5 Conclusion

The managerial insight is that policymakers can enforce the pay-for-performance scheme to induce CRAs to improve the rating quality which in turn reduces asymmetric information between the issuing firm and the investor in financial markets. For academic insight, the dynamic interaction between the CRA and the investor is explored. The investors' decision to request information level and the impact of the investors' action on the CRAs' behaviour of issuing biased raitngs are illustrated under the pay-for-performance scheme. In the future, the study may consider other types of payment schemes which potentially increase the rating accuracy.

## Appendix

**Proof of Proposition 1** To maximize The CRA's expected profit from Eq. 4 knowing that the investor invests in the portfolio only if it gets a high rating, the CRA chooses to conduct full disclosure or a bias rating regime after observing the signal type of each loan portfolio:

**Case 1**: when the CRA observes $\emptyset = h$, the CRA decides whether to report a low rating (bias rating) or report a high rating (full disclosure). The CRA's expected profit when $\emptyset = h$ is:

$$\prod_{CRA}^{\emptyset=h} = \left[\alpha_g q(i)(1 - I_h(i))x_g(R) + \alpha_b(1 - q(i))(1 - I_h(i))x_b(R)\right](1 - \beta)$$

The CRA's expected profit when a high rating is reported (Full disclosure $(I_h(i) = 0)$):

$$\prod_{\mathrm{CRA}}^{\mathrm{h,FD}} = \left[\alpha_{\mathrm{g}}\mathrm{q(i)x_g(R)} + \alpha_{\mathrm{b}}(1 - \mathrm{q(i)})\mathrm{x_b(R)}\right](1 - \beta)$$

The expected profit of CRA when a low rating is reported (Bias rating $(I_h(i) = 1)$):

$$\prod_{CRA}^{h,BR} = C(i) - C(i) = 0$$

The CRA adopts the full disclosure regime when $\Pi_{CRA}^{h,FD} \geq \Pi_{CRA}^{h,BR}$ so that:

$$\left[\alpha_g q(i) x_g(R) + \alpha_b (1 - q(i)) x_b(R)\right](1 - \beta) \geq 0$$

Thus, $i \geq \bar{i}^h = -\left[\frac{\alpha_b x_b(R)}{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]} + \alpha_m\right]$

The CRA adopts the bias rating regime when $\Pi_{CRA}^{h,FD} < \Pi_{CRA}^{h,BR}$ so that:

Thus, $i < \bar{i}^h = \overbrace{\frac{-\alpha_b x_b(R)}{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]}}^{\leq 1} - \alpha_m$ while $\bar{i}^h \leq 1 - \alpha_m$

Thus, the CRA observes $\emptyset = h$ and reports a high rating (the full disclosure regime) only if $i \geq \bar{i}^h = -\left[\frac{\alpha_b x_b(R)}{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]} + \alpha_m\right]$. Otherwise, the CRA implements the bias rating regime.

**Case 2**: when the CRA observes $\emptyset = l$, the CRA decides whether to report a high rating (bias rating) or report a low rating (full disclosure). The CRA's expected profit when $\emptyset = l$ is:

$$\prod_{CRA}^{\emptyset = l} = \left[\alpha_g (1 - q(i)) I_l(i) x_g(R) + \alpha_b q(i) I_l(i) x_b(R)\right](1 - \beta)$$

The expected profit of CRA when a low rating is reported (Full disclosure $I_l(i) = 0$):

$$\prod_{CRA}^{l,FD} = C(i) - C(i) = 0$$

The expected profit of CRA when a high rating is reported (Bias rating $I_l(i) = 1$):

$$\prod_{CRA}^{l,BR} = \left[\alpha_g (1 - q(i)) x_g(R) + \alpha_b q(i) x_b(R)\right](1 - \beta)$$

The CRA adopts the full disclosure regime when $\Pi_{CRA}^{l,FD} \geq \Pi_{CRA}^{l,BR}$ so that:

$$0 \geq \left[\alpha_g (1 - q(i)) x_g(R) + \alpha_b q(i) x_b(R)\right](1 - \beta)$$

$$i \geq \bar{i}^l = \frac{\alpha_g x_g(R)}{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]} - \alpha_m$$

The CRA adopts the bias rating regime when $\Pi_{CRA}^{l,FD} < \Pi_{CRA}^{l,BR}$ so that:

$$i < \bar{i}^l = \overbrace{\frac{\alpha_g x_g(R)}{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]}}^{\leq 1} - \alpha_m \quad \text{while } \bar{i}^l \leq 1 - \alpha_m$$

Thus, the CRA observes $\emptyset = l$ and reports a low rating only if $i \geq \bar{i}^l = \underbrace{\frac{\alpha_g x_g(R)}{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]}}_{\leq 1} - \alpha_m$. Otherwise, the CRA adopts the bias rating regime.

**Proof of Proposition 2** We will show the results for two cases: (1) a bad market $(\alpha_g x_g(R) + \alpha_b x_b(R) < 0)$ and (2) a good market $(\alpha_g x_g(R) + \alpha_b x_b(R) \geq 0)$.

(1) Suppose $\alpha_g x_g(R) + \alpha_b x_b(R) < 0$. We learned from Proposition 1 that in this case, $\bar{i}^l < min\{0, \bar{i}^h\}$. We will first show the result assuming that $\bar{i}^h \geq 0$, and will later on discuss that the same result also holds when $\bar{i}^h < 0$. To characterize the optimal increase in accuracy, $i^*$, we will consider two intervals: (1.1) $0 \leq i \leq \bar{i}^h$ and (1.2) $\bar{i}^h < i \leq 1 - \alpha_m$.

(1.1) Consider $0 \leq i \leq \bar{i}^h$. In this case, the CRA adopts the full disclosure regime if observing a low signal since $i \geq 0 > \bar{i}^l$, and adopts the biased rating regime if observing a high signal since $i \leq \bar{i}^h$. Hence, the investor's expected profit from Eq. 5 is given by

$$\prod_{INV}^{\tilde{r}=h}(i) = -C(i)$$

where $\frac{d\Pi_{INV}^{\tilde{r}=h}}{di} = -C'(i) < 0$ since $C(i)$ is an increasing function of $i$.
Thus, the investor's profit is monotonically decreasing in $i$ for $0 \leq i \leq \bar{i}^h$.

(1.2) Consider $\bar{i}^h < i \leq 1 - \alpha_m$. In this case, the CRA adopts the full disclosure regime if observing a low signal since $i \geq \bar{i}^h > \bar{i}^l$, and also adopts the full disclosure regime if observing a high signal since $i > \bar{i}^h$. The investor's expected profit from Eq. 5 is given by

$$\prod_{INV}^{\tilde{r}=h}(i) = \max_i \left[\left[\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right][i + \alpha_m] + \alpha_b x_b(R)\right]\beta - C(i)\right]$$

where

$$\frac{d\Pi_{INV}^{\tilde{r}=h}}{di} = \left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]\beta - C'(i)$$

and

$$\frac{d^2\Pi_{INV}^{\tilde{r}=h}}{di^2} = -C''(i) < 0$$

This shows that the investor's profit is concave in $i$, with a unique solution to the first-order condition given by $i_0 := \frac{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]\beta}{2a}$.

Next, we will show that $\underline{\beta} = \frac{4a\bar{i}^h}{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]}$ and $\bar{\beta} = \frac{2a(1-\alpha_m)}{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]}$ characterize the investor's optimal $i$ as described in the proposition.

Suppose $\beta \leq \frac{2a\bar{i}^h}{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]}$. Notice that $\frac{2a\bar{i}^h}{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]} \leq \underline{\beta}$ since $\bar{i}^h \geq 0$. With some algebra, one can check that $i_0 \leq \bar{i}^h$. This implies that the investor's expected profit for $\bar{i}^h < i \leq 1 - \alpha_m$ is monotonically decreasing in $i$. It is also simple to check that the investor's profit function is continuous at $i = \bar{i}^h$. Together with what we learned from (1.1) that the investor's profit is monotonically decreasing in $i$ for $0 \leq i \leq \bar{i}^h$, we have that the optimal increase in accuracy, $i^*$, is 0. In other words, it is optimal to not acquire additional information accuracy in this case.

Suppose $\frac{2a\bar{i}^h}{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]} < \beta \leq \underline{\beta}$. It follows that $i_0 > \bar{i}^h$, hence $i_0$ is the interior maximizer of the investor's profit function for $\bar{i}^h < i \leq 1 - \alpha_m$. However, notice that $\Pi_{INV}^{\tilde{r}=h}(i=0) \geq \Pi_{INV}^{\tilde{r}=h}(i=i_0)$ since $\beta \leq \underline{\beta}$. Hence, it is optimal to not acquire additional information accuracy $(i^* = 0)$.

Suppose $\underline{\beta} < \beta < \bar{\beta}$. One can check that $\bar{i}^h < i_0 < 1 - \alpha_m$. This implies that $i_0$ is the interior maximizer of the investor's profit function for $\bar{i}^h < i \leq 1 - \alpha_m$. We obtain that $\Pi_{INV}^{\tilde{r}=h}(i=0) < \Pi_{INV}^{\tilde{r}=h}(i=i_0)$ since $\beta > \underline{\beta}$. Hence, it is optimal for the investor to choose $i^* = i_0$.

Lastly, suppose $\beta \geq \bar{\beta}$. It follows that $i_0 \geq 1 - \alpha_m$. This implies the investor's profit is monotonically increasing in $i$ for $\bar{i}^h < i \leq 1 - \alpha_m$, and is maximized at $i = 1 - \alpha_m$. Comparing the investor's profit at $i = 0$ and $i = 1 - \alpha_m$, we obtain that $\Pi_{INV}^{\tilde{r}=h}(i=0) < \Pi_{INV}^{\tilde{r}=h}(i=1-\alpha_m)$ since $\beta \geq \bar{\beta}$. Thus, it is optimal for the investor to choose $i^* = 1 - \alpha_m$.

It remains to show that the same result holds when $\bar{i}^h < 0$. Suppose $\bar{i}^h < 0$. Then, we only need to consider one interval of $0 \leq i \leq 1 - \alpha_m$, where the investor's profit is the same as that given in (1.2). Hence, the investor's profit is concave in $i$ with $i_0 = \frac{\left[\alpha_g x_g(R) - \alpha_b x_b(R)\right]\beta}{2a}$ as the solution to the first-order condition. Notice that $i_0 \geq 0$ since $\alpha_b x_b(R) < 0$. We have also seen earlier that $i_0 < 1 - \alpha_m$ if and only if $\beta < \bar{\beta}$. This implies, $i^* = i_0$ if $\beta < \bar{\beta}$, and $i^* = 1 - \alpha_m$ if $\beta \geq \bar{\beta}$. Note also that $\underline{\beta} < 0$ since $\bar{i}^h < 0$. Hence, the same result holds.

(2) Suppose $\alpha_g x_g(R) + \alpha_b x_b(R) \geq 0$. We learned from Proposition 1 that in this case, $\bar{i}^h < min\left\{0, \bar{i}^l\right\}$. We will first show the result assuming that $\bar{i}^l \geq 0$, and will later on discuss that the same result also holds when $\bar{i}^l < 0$. To characterize the optimal increase in accuracy, $i^*$, we will consider two intervals: (1.1) $0 \leq i \leq \bar{i}^l$ and (1.2) $\bar{i}^l < i \leq 1 - \alpha_m$.

(2.1) Consider $0 \leq i \leq \bar{i}^l$. In this case, the CRA adopts the full disclosure regime if observing a high signal since $i \geq 0 > \bar{i}^h$, and adopts the biased rating regime if observing a low signal since $i \leq \bar{i}^l$. Hence, the investor's expected profit from Eq. 5 is given by

$$\Pi_{INV}^{\tilde{r}=h} = \max_i \left[ \left[ \alpha_g x_g(R) + \alpha_b x_b(R) \right] \beta - C(i) \right]$$

where $\frac{d\Pi_{INV}^{\tilde{r}=h}}{di} = -C'(i) < 0$ since $C(i)$ is an increasing function of $i$.

Thus, the investor's profit is monotonically decreasing in $i$ for $0 \le i \le \bar{i}^l$.

(2.2) Consider $\bar{i}^l < i \le 1 - \alpha_m$. In this case, the CRA adopts the full disclosure regime if observing a low signal since $i \ge \bar{i}^l > \bar{i}^h$, and also adopts the full disclosure regime if observing a high signal since $i > \bar{i}^h$. The investor's expected profit from Eq. 5 is given by

$$\Pi_{INV}^{\tilde{r}=h}(i) = \max_i \left[ \left[ \left[ \alpha_g x_g(R) - \alpha_b x_b(R) \right] [i + \alpha_m] + \alpha_b x_b(R) \right] \beta - C(i) \right]$$

where

$$\frac{d\Pi_{INV}^{\tilde{r}=h}}{di} = \left[ \alpha_g x_g(R) - \alpha_b x_b(R) \right] \beta - C'(i)$$

and

$$\frac{d^2\Pi_{INV}^{\tilde{r}=h}}{di^2} = -C''(i) < 0$$

This shows that the investor's profit is concave in $i$, with a unique solution to the first-order condition given by $i_0 := \frac{\left[ \alpha_g x_g(R) - \alpha_b x_b(R) \right] \beta}{2a}$.

Next, we will show that $\underline{\beta} = \frac{4a\bar{i}^l}{\left[ \alpha_g x_g(R) - \alpha_b x_b(R) \right]}$ and $\bar{\beta} = \frac{2a(1-\alpha_m)}{\left[ \alpha_g x_g(R) - \alpha_b x_b(R) \right]}$ characterize the investor's optimal $i$ as described in the proposition.

Suppose $\beta \le \frac{2a\bar{i}^l}{\left[ \alpha_g x_g(R) - \alpha_b x_b(R) \right]}$. Notice that $\frac{2a\bar{i}^l}{\left[ \alpha_g x_g(R) - \alpha_b x_b(R) \right]} \le \underline{\beta}$ since $\bar{i}^l \ge 0$. With some algebra, one can check that $i_0 \le \bar{i}^l$. This implies that the investor's expected profit for $\bar{i}^l < i \le 1 - \alpha_m$ is monotonically decreasing in $i$. It is also simple to check that the investor's profit function is continuous at $i = \bar{i}^l$. Together with what we learned from (2.1) that the investor's profit is monotonically decreasing in $i$ for $0 \le i \le \bar{i}^l$, we have that the optimal increase in accuracy, $i^*$, is 0. In other words, it is optimal to not acquire additional information accuracy in this case.

Suppose $\frac{2a\bar{i}^l}{\left[ \alpha_g x_g(R) - \alpha_b x_b(R) \right]} < \beta \le \underline{\beta}$. It follows that $i_0 > \bar{i}^l$, hence $i_0$ is the interior maximizer of the investor's profit function for $\bar{i}^l < i \le 1 - \alpha_m$. However, notice that $\Pi_{INV}^{\tilde{r}=l}(i = 0) \ge \Pi_{INV}^{\tilde{r}=l}(i = i_0)$ since $\beta \le \underline{\beta}$. Hence, it is optimal to not acquire additional information accuracy ($i^* = 0$).

Suppose $\underline{\beta} < \beta < \bar{\beta}$. One can check that $\bar{i}^l < i_0 < 1 - \alpha_m$. This implies that $i_0$ is the interior maximizer of the investor's profit function for $\bar{i}^l < i \le 1 - \alpha_m$. We obtain that $\Pi_{INV}^{\tilde{r}=l}(i = 0) < \Pi_{INV}^{\tilde{r}=l}(i = i_0)$ since $\beta > \underline{\beta}$. Hence, it is optimal for the investor to choose $i^* = i_0$.

Lastly, suppose $\beta \geq \bar{\beta}$. It follows that $i_0 \geq 1 - \alpha_m$. This implies the investor's profit is monotonically increasing in $i$ for $\bar{i}^l < i \leq 1 - \alpha_m$, and is maximized at $i = 1 - \alpha_m$. Comparing the investor's profit at $i = 0$ and $i = 1 - \alpha_m$, we obtain that $\Pi_{INV}^{\tilde{r}=l}(i = 0) < \Pi_{INV}^{\tilde{r}=l}(i = 1 - \alpha_m)$ since $\beta \geq \bar{\beta}$. Thus, it is optimal for the investor to choose $i^* = 1 - \alpha_m$.

It remains to show that the same result holds when $\bar{i}^l < 0$. Suppose $\bar{i}^l < 0$. Then, we only need to consider one interval of $0 \leq i \leq 1 - \alpha_m$, where the investor's profit is the same as that given in (2.2). Hence, the investor's profit is concave in $i$ with $i_0 = \frac{[\alpha_g x_g(R) - \alpha_b x_b(R)]\beta}{2a}$ as the solution to the first-order condition. Notice that $i_0 \geq 0$ since $\alpha_b x_b(R) < 0$. We have also seen earlier that $i_0 < 1 - \alpha_m$ if and only if $\beta < \bar{\beta}$. This implies, $i^* = i_0$ if $\beta < \bar{\beta}$, and $i^* = 1 - \alpha_m$ if $\beta \geq \bar{\beta}$. Note also that $\underline{\beta} < 0$ since $\bar{i}^h < 0$. Hence, the same result holds.

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# Modelling of Currency Exchange Rates Using a Binary-Temporal Representation


**Michał Dominik Stasiak**

**Abstract** In the following article a new method for modelling exchange rates with a binary-temporal representation is proposed. The presented model allows for an approximation of change probabilities for course trajectory, depending on the direction and duration of previous change. Model parameters are appointed based on statistical analysis of a binary-temporal representation of 5-year historical tick data for AUD/NZD exchange rate. The main characteristics of the model are parameter's independence from any superior trends and a possibility of application in algorithms of automatic trade systems.

**Keywords** Foreign exchange market · High frequency econometric Technical analysis · Currency market investment decision support Modelling of currency exchange rates

## 1 Introduction

Due to a high variability in time, the methods of representing an exchange rate for currency pairs are dominated by the candlestick representation for a given time frame. This kind of representation is widely used by broker platforms, technical analysis methods, etc. (Schlossberg 2006; Murphy 1999). Using the candlestick representation, where the parameters are dependent on the appointed time interval, can lead to neglecting the information about the dynamic of changes within the considered time interval (Stasiak 2015). This kind of information could be, on the other hand, used in further prediction of the course trajectory.

In the following article we present a new approach of representing the tick data, based on the absolute value of the price change and the duration of the change. This king of approach simplifies the analysis of the course trajectory changes and is characterised by a higher accuracy compared to the candlestick representation.

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The course trajectory, given in the binary-temporal representation, was analysed by statistical methods on order to research the possible dependencies between the historical data and current changes.

The article presents a new method of modelling the exchange rate trajectory with use of binary-temporal representation. The proposed state model of the binary-temporal representation (SMBTR) allows for a highly accurate approximation of the probabilities of future course trajectory changes.

The research was performed on the 5-year tick data for the exchange rate AUD/NZD, taken from Ducascopy broker, in the time interval of 01.01.2010–01.01.2015.

The article is organized in the following way. The first section gives an introduction justifying the application of binary-temporal representation. In the second section a detailed description of constructing the binary-temporal representation is given, as well as a word about the obtained results of statistical analysis of this kind of representation. In the third section a new method of modelling the data is presented, which uses the binary-temporal representation. In the last section the main points and results of the research are summarised.

## 2 Binary-Temporal Representation

The value of the exchange rate changes with each tick, that is with every few seconds. Because of this kind of change dynamics, using the tick charts in the methods of technical analysis is practically impossible. Also, using the tick data in modelling the exchange rate course, because of the volume of the data, is not really effective. The exchange rate trajectories are usually represented in form of a candlestick charts for a given time interval (the most common intervals are those between 1 min and 1 month). Each candle is represented by four values: initial value, end value as well as minimal and maximal value reached during the given time interval. This way of representing the exchange rate course is used by broker platforms such as MetaTrader, JForex and others. Moreover, most of the technical analysis methods such as formations, Elliot's wave theory and other visual methods of assessing the course trajectory are based on the candlestick chart analysis. Also, the some indicators, for example averages, MACD, etc., (Murphy 1999; Schlossberg 2006; Yazdi and Lashkari 2013) take one of the four (or a combination) of the candlestick parameters as their input data. In case of most publications form the field of analysis and exchange rate course prediction, the candlestick representation is applied (Murphy 1999; Lee and Jo 1999; Valcu 2004).

The properties of course trajectory presented in a candlestick representation depend on the time interval and do not rely on the dynamics of trajectory changes. In the night periods and in periods of low volume we can register a few candles with the change amplitude of e.g. 20 pips. On the other hand, in times of presenting economic data, political problems etc., the amplitude of a single candle of the same

interval can be 10 or even 20 times higher. In this way the candlestick representation loses a lot of information about the character of changes 'inside' the candle. This kind of approach leads to omitting valuable information about the frequency and direction of small changes which can result in an less effective analysis process.

## 2.1 *Binary-Temporal Representation Versus Candle Stick Representation*

From the investor's point of view (or form the point of view of an automatic script, i.e. expert advisor), the change duration is not that important, while the most important aspect to consider is the direction and increase in changes by a value restricted by parameters TP (Take Profit) and SL (Stop Loss). Because of that, in the article (Stasiak 2015), a binary representation of the exchange rate was introduced. The main idea of this kind of representation was to discretize the exchange rate course based on the given discretisation unit.

In the Fig. 1a we can see an example of the discretisation algorithm performance. The algorithm assigns '0' if there occurs a decrease in the exchange rate course, the decrease having the value of the assumed discretization unit, or '1' in case of an increase. In effect of the algorithm performance we can represent the course trajectory as a binary string. This kind of approach eliminates from the analysis the periods of no variability, so for example nights, and in the same time retains the key information of the direction and volume of course changes.

Yet, the binary representation lacks the information about time. The moment in which the change occurred can in many cases be a valuable information from the point of view of future change prediction (Schlossberg 2006; Oberlechner 2005). For example, if the course trajectory change occurred very fast then the trend continuation can be more (or less) probable compared to a slower change. Therefore, an extension of the binary model by the parameter of change duration was proposed (binary-temporal representation). In case of the binary-temporal

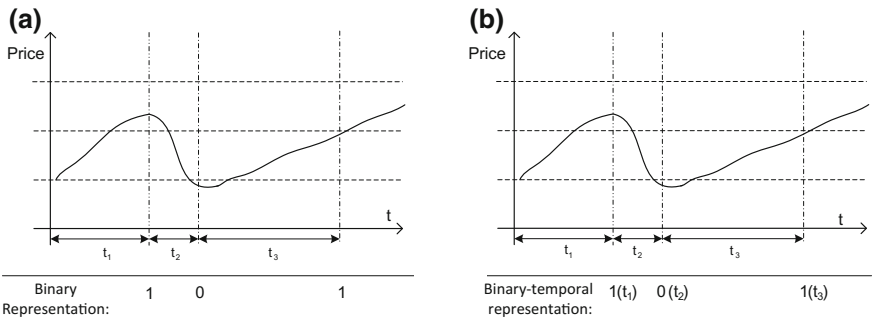


**Fig. 1** **a** Binary representation **b** binary-temporal representation

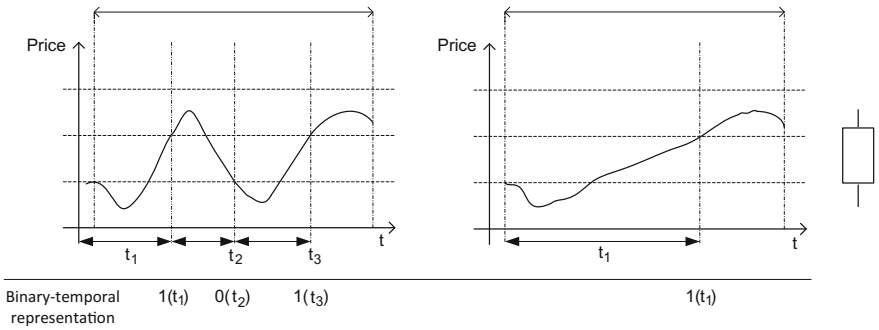


**Fig. 2** Two different trajectories of course changes given by the same candle stick and different binary-temporal representation

representation the exchange rate trajectory is represented by a two-element set consisting of the change direction ('1' or '0') and the time in which the change occurred, given in seconds. In the Fig. 1b we can see an example of a conversion between the tick data and the binary-temporal representation.

In the Fig. 2 we can see two tick plots given by the same candlestick. The example shows that, despite the candlestick parameters being the same, the process of changing the course trajectory can have a different dynamics and scenario. The advantage of a binary-temporal representation, in case of its application in predictive tools, is the concrete information about the direction of a future change and its range. For example, the information about a more probable occurrence of an increase ('1') can be a premise to make a transaction of buying with a TP of one discretisation unit. The binary-temporal representation also includes information about the duration of a change. The information can be treated as one of the indicators for predicting the exchange rate trajectory.

## 2.2 *Choice of Discretization Unit*

The properties of binary-temporal representation are dependent on the choice of discretisation unit (Stasiak 2015). While appointing a discretisation unit one has to consider the character and frequency of changes as well as some practical conditions. Deciding on overly big discretisation unit can lead to 'losing' some important data about the character of course trajectory changes. The smaller the discretisation unit, the more information presented in the binary representation. However, choosing too small discretisation unit can result in encompassing random fluctuations, that is a so called 'noise'. The problem of the noise and its possible filtration was researched numerous times in context of technical analysis (Lo et al. 2000; Logue and Sweeney 1977; Menkhoff and Taylor 2007). Still, the existing results cannot directly define the exact noise level.

While appointing the discretisation unit, one has also take into account the practical aspects such as possibility of making a transaction in which parameters TP and SL are one discretisation unit away of the current price. For this condition to be fulfilled, the discretisation unit has to be bigger than the spread offered for given currency pair. In this article we appointed the discretisation unit of 20 pips. Researching the influence of random fluctuations, the achieved binary string was statistically analysed in order to verify the random character of data, that is, if the ensuing changes in course trajectory are independent from the history of changes. If any of such kind of relations were found, the further analysis of the binary string would not have been reasonable.

In the performed research a set of four statistical tests from the SP800-22 packet was used (Rukhin et al. 2010) (recommended by NIST—National Institute of Standards and Technology used, among others, to verify the generators of pseudo-random numbers in cryptographic modules). The following tests were chosen: frequency test, runs test, non-overlapping template matching test and long run test. The simultaneous confirmation of the randomness hypothesis by all of the tests allows for qualifying the data as random. In all the tests, corresponding to recommendations given by NIST, a significance level of 0.05 was assumed.

For the binary string achieved from 5-year tick historical data for a discretisation unit of 20 pips, only the first test—the frequency test—confirmed the hypothesis of randomness. The result indicates the similar number of zeros and ones in the analysed string (Rukhin et al. 2010; Menezes et al. 1996). In the same time, the three remaining tests suggest a not random character of the data. This means that more frequent or sparse occurrences of particular patterns took place, as well as substrings of a particular structure (Godbole and Papastavridis 1994; Chung 2012; Rukhin et al. 2010; Menezes et al. 1996). This kind of results of statistical analysis indicates an existence of a relationship between historical structure of changes and the future direction of changes.

## *2.3 Distribution of Change Durations for Exchange Rates*

As statistical results presented in the previous section suggest, the history of changes can have an influence on the future direction of the course trajectory. In the mentioned analysis, the duration of changes was not taken into account. Generally, from the investor's (or expert adviser's) point of view, for small discretisation units reaching few or few dozen pips, the duration of a change is not significant. Still, the question arises if the duration of previous changes in course trajectory can be treated as an indicator of future change direction. If the increase in price, for a given discretization unit, takes place in less than one minute, is the probability of future increase different than if the increase took place during more than 30 min? In order to verify the possibility of applying duration time as a parameter in the predictive model a statistical analysis was performed for the change durations in

binary-temporal representation based on 5-year tick data for AUD/NZD exchange rate.

Since it is difficult to describe the character of a potential dependencies between the change duration times and the direction of future changes, an analysis of duration times distribution was performed. The registered duration distribution was compared to the exponential distribution. The exponential distribution is characterised by so called 'memorylossness', i.e. there is no influence of the previous events on the current one (Stasiak et al. 2010). If the time distribution had an exponential character, this fact would have excluded any possibility of using the duration times in creating prediction models.

In order to compare the distributions, the Kolmogorov-Smirnov test was applied. The test appoints an empirical distribution function from the analysed data and compares it with a theoretical distribution function assumed for a given distribution (Gibbons and Chakraborti 2011). In the performed research, a significance level of 0.05 was assumed. The Kolmogorov-Smirnov test disregarded the hypothesis of a compliance of the duration times distribution with the exponential distribution. This result confirms the possibility of a relationship between the duration of changes and the future direction of a trajectory change. Thus, using duration of changes in the prediction models seems to be sensible.

## 3 Exchange Rate Modelling with Binary-Temporal Representation

The exchange rate trajectory changes can be caused by many different factors. Among them we can find the macroeconomic parameters such as unemployment rate, interest rates, etc. (Murphy 1999; Cheung and Chinn 1999). In the same time, changes in macroeconomic parameters or in political situation in one country can affect the currency of other countries. Other factor with possible influence on the exchange rate trajectory is the investor's behaviour and its psychological basis (Oberlechner 2005), which, by its very definition, is extremely difficult to analyse and predict.

Quantitative inclusion of all of the factors influencing the current exchange rate trajectory is impossible in terms of practice. Therefore, the exchange rate model should rely on statistically most frequently occurring behavioural patterns of investors. Thus, parameters of proposed models will be appointed heuristically. What is important, the mentioned parameters should be stable and not dependent on the main trends occurring on the market. Because of that, the statistically appointed parameters should be characterised by a narrow confidence interval.

In following sections two models are presented: a simple model, based only on course changes (SMBR), and a model based on course changes and the duration of a change (SMBTR). Also, advantages and disadvantages of the models are given.

### 3.1 State Model of Binary Representation (SMBR)

The binary representation state model is the first (as well as the simplest) prediction model for an exchange rate, which uses a binary representation (proposed in Stasiak 2016). The model is based on describing possible states and appointing probabilities of transitions between states. The state is defined as $m$ previous course changes, thus the number of states can be described by the following formula:

$$S = 2^m. \tag{1}$$

For $m = 1$ the model consists of two states—one (1) and zero (0). State (1) was defined as the last increase in the course and state (0) as a previous decrease of one discretization unit.

In the Fig. 3a, a state diagram of this kind of model is presented. For $m = 2$, the state space is described by four combinations of previous and second previous change: {(00), (01), (10), (11)}, where, for example, the state (10) means that the price has increased at first (the second previous change) and then it decreased (previous change) by one discretization unit. The Fig. 3b depicts the state diagram in case of $m = 2$. The states change depending on registered ensuing changes in the course trajectory (0 or 1). If in the model with $m = 2$ we encounter a case when after an increase followed by a decrease (state (10)) there occurs another decrease in the course (by one discretization unit), that means that we have a transition into the state (00). But, on the other hand, if the course increases, we will find ourselves in the state (01). The transition probabilities are calculated empirically, based on historical data. In the model we assume, that the sum of all probabilities of a

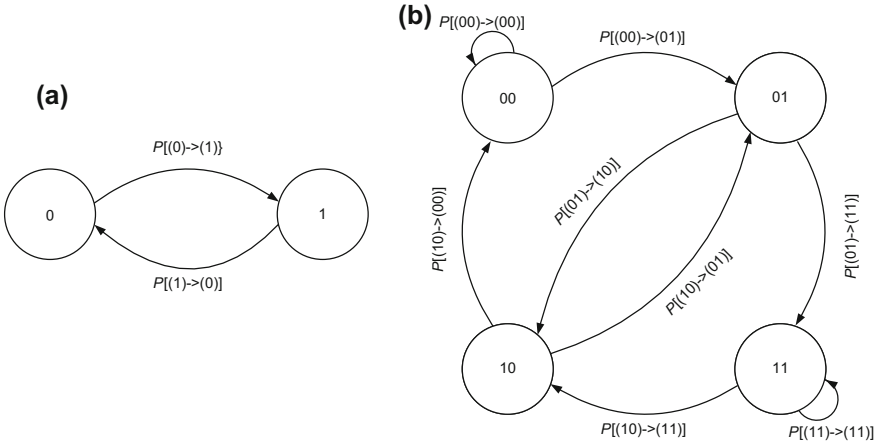


**Fig. 3** State diagram for models **a** SMBR ($m = 1$), **b** SMBTR ($m = 2$)

transition from a given state is equal to 1. Thus, the relationship between the probabilities of transition from states (00) and (01) can be calculated as:

$$P[(00) \rightarrow (01)] = 1 - P[(00) \rightarrow (00)], \tag{2}$$

where $P[(state1) \rightarrow (state2)]$ describes the probability of transition between appropriate states. In the Fig. 3b we can see a model diagram for $m = 2$, with transition probabilities included. The transition probabilities were appointed empirically based on the binary representation of trajectory changes for currency pair AUD/NZD in the 5-year scope and for discretization unit of 20 pips.

In the Table 1 exemplary detailed calculation results are shown, for the probabilities of transition from the state (10) into the state (00). The number of all observations was divided into 10 intervals (where one interval corresponds to the time of approximately half a year). In each interval, appropriate values of transition probabilities were calculated. Next, the average probability of transition $P[(00) \rightarrow (01)]$ was found, with a 95% confidence interval appointed according to t-Student distribution. The achieved result $0.6287 \pm 0.0362$. Results for other remaining transition probabilities are characterized by a similar accuracy. All the results suggest, that the obtained probabilities can be considered as constant in time and not dependent on superior trends observed on the market. Same conclusion can be achieved by interpreting the Fig. 4, which depicts a time chart of analysed period, with highlighted different superior trends.

The binary representation state model can be described by the following parameters:

- currency pair,
- discretization unit appointed for binary representation,
- number of analysed changes ($m$),
- probabilities of transitions between states ($P$).

The performer analysis suggests that the SMBR model can be used in constructing prediction algorithms for the exchange rate course changes.

**Table 1** Probabilities of transitions P(00, 01) in MSRB ($m = 2$)

| Range | Number of transitions | $P[(00) \rightarrow (01)]$ |
|---|---|---|
| 1 | 323 | 0.6380 |
| 2 | 323 | 0.6469 |
| 3 | 323 | 0.6795 |
| 4 | 323 | 0.5905 |
| 5 | 323 | 0.5994 |
| 6 | 323 | 0.6202 |
| 7 | 323 | 0.6083 |
| 8 | 323 | 0.7092 |
| 9 | 323 | 0.6231 |
| 10 | 323 | 0.5727 |
| | 3230 | 0.6287 |

**Fig. 4** Different trends in analysed time frame—candlestick representation

## 3.2 State Model of Binary-Temporal Representation (SMBTR)

SMBR model presented in the previous section gives a base for a binary-temporal representation state model (SMBTR) which will be described in this section. The modelling of an exchange rate trajectory with a binary-temporal representation is possible only by appropriately defining possible states and appointing probabilities of transitions between them. We define a state as a pair, where the first element is a pattern described by $m$ previous course changes (similarly to the SMBR model) and the second element corresponds to the criterion of assumed change duration threshold ($t_p$ given in minutes) in $n$ previous transitions ($n \leq m$). This condition is described by a binary variable $w$ which can be calculated by the following formula:

$$w_i = \begin{cases} 0 & if \quad t_i > t_p, \\ 1 & if \quad t_i \leq t_p, \end{cases} \tag{3}$$

where $t_i$ describes the duration of $i$-th change, $i \in \{1, n\}$.

In the Fig. 5 we can see a state diagram for the simplest model with parameters ($m$ = 1, $n$ = 1, $t_p$ = 10 min). For example, the state (0, 0) defines a decrease in course (first 0) in time longer than 600 s (second 0). In order to increase the readability of the figure, only probabilities of transitions from the state (0, 0) are included. The transition probabilities between states (0, 0) and (0, 1) are written, according to the notation used in the article, as $P[(0,0) \rightarrow (0,1)]$.

The number of state in model SMBTR can be described by the formula:

$$S = 2^{(m+n)}. \tag{4}$$

The most important parameter characterising the model for a particular currency pair are the appropriate values of transition probabilities between any states $P[(state1) \rightarrow (state2)]$. Transition probabilities can be appointed heuristically, based on the historical data for a particular currency pair. Sum of transition probabilities form a given state must be equal to one.

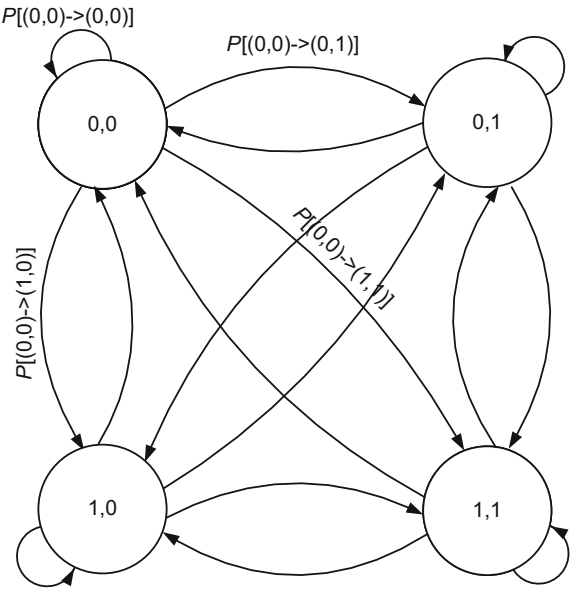


**Fig. 5** State model SMBTR ($m$ = 1, $n$ = 1, $t_p$ = 10 min)

In the Fig. 6 a state diagram for a model described by parameters ($m$ = 2, $n$ = 1, $t_p$ = 10 min) is presented. Therefore, the model takes into consideration two last changes in trajectory, as well as the duration of the last course change. The diagram shows all existing states and possible transitions between them. In order to make the diagram more readable, the calculated transition probabilities are not included. In the considered model, the state (01, 1) describes ensuing decrease and an increase in the course trajectory, with the increase taking place in time shorter than 10 min. The state (01, 0), on the other hand, describes ensuing decrease and an increase in the course trajectory, with the increase taking place in time longer than 10 min.

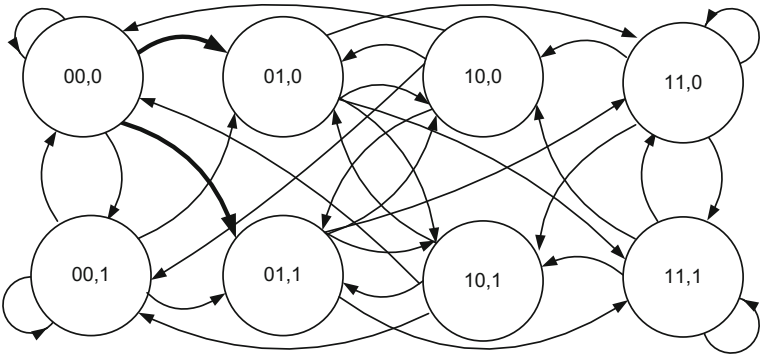


**Fig. 6** State model SMBTR ($m$ = 1, $n$ = 1, $t_p$ = 10 min)

From the practical view, the most important aspect for an expert advisor is the assessment of probabilities describing the direction of future trajectory changes. The time plays only the role of an indicator used in appointing the probabilities of future change direction. The course can increase or decrease both while satisfying or not satisfying the condition of threshold time. Because of this, based on the appropriate diagram, we can define the probability of increase/decrease of the price. In model ($m$ = 2, $n$ = 1, $t_p$ = 10 min) it is represented by transitions to appropriate states. In the Fig. 6, the transitions representing a course increase to state (00, 0) are indicated by the bold line. Therefore, the probability of this increase $P_{increase}(00,0)$ can be written as follows:

$$P_{increase}(00,0) = P[(00,0) \rightarrow (01,0)] + P[(00,0) \rightarrow (01,1)], \tag{4}$$

Analogously, the probability of a decrease in state (00,0) is equal to:

$$P_{decrease}(00,0) = P[(00,0) \rightarrow (00,0)] + P[(00,0) \rightarrow (00,1)]. \tag{5}$$

Probabilities $P[(00,0) \rightarrow (00,0)]$, $P[(00,0) \rightarrow (00,1)]$, $P[(00,0) \rightarrow (01,0)]$, $P[(00,0) \rightarrow (01,1)]$ in formulas (4) and (5) describe the probabilities of leaving the state (00,0). Because the sum of all probabilities must be equal to one, thus:

$$P_{increase}(00,0) + P_{decrease}(00,0) = 1. \tag{6}$$

Analogous dependencies can be found for every state of the model.

The state model of binary-temporal representation (SMBTR) can be thus described by the following parameters:

- currency pair,
- discretization unit appointed for the binary-temporal representation,
- number of analysed changes ($m$),
- number of analysed duration thresholds for historical changes ($n$),
- conditions imposed on the change duration ($t_p$),
- probabilities of transitions between states ($P$).

Let us now consider a state model of the binary-temporal representation (SMBTR) with parameters ($m$ = 2, $n$ = 1, $t_p$). The probabilities were appointed empirically based on 5-year historical data for a currency pair AUD/NZD, in binary-temporal representation, for a 20-pips discretization unit. Similarly as for the SMBR model, the probabilities were calculated based on 10 intervals, considering the 95% confidence interval. The results accuracy fits into 3–5% confidence interval and is not dependent on the time conditions ($t_p$). This fact confirms the lack of dependency between the trends observable on the market and the model accuracy.

In the Fig. 7 we present a relationship between the probability of a course increase (from the state (00, 1)) for different threshold values $t_p$. By analysing the chart one can see that the probability of an increase in course is higher if the duration of the last change is shorter. In the figure we can also see the probability of

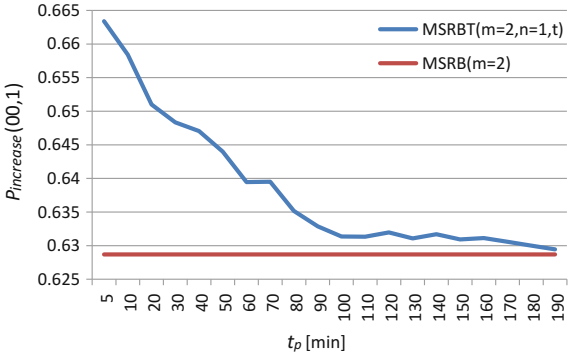


**Fig. 7** Probability of price increase from the state 00, 1 in model SMBTR ($m = 2$, $n = 1$, $t_p$), depending on the parameter $t_p$ [min]

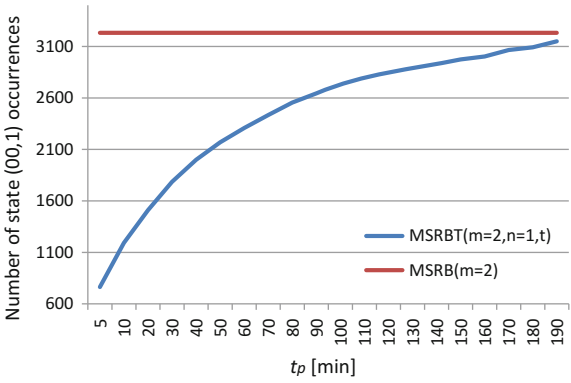


**Fig. 8** Number of state 00, 1 occurrences in model SMBTR ($m = 2$, $n = 1$, $t_p$), depending on the parameter $t_p$ [min]

an increase from the state (00) in the MSRB ($m = 2$) model. By using the parameter of transaction duration in the prediction model its accuracy rose to 4.5% (for $t_p = 2$ min).

In the presented model, in contrary to the reference SMBR model, each of the states is represented by two separate sub-states. For example, the state (00) of SMBR model is represented by states (00, 0) and (00, 1) in SMBTR. In case of parameter $t_p$ values which are considerably different form the median, the number of occurrences for a given state can sharply decrease. In the Fig. 8, the dependencies between the $t_p$ parameter and number of state (00, 1) occurrences are presented. The figure also presents the number of state (00) occurrences in model SMBR. Based on the results we can assume, that the approximated probabilities of future changes in trajectory are higher in case of more sparse occurrences of a given state. This kind of effect is not beneficial from the investor's point of view (smaller number of signals to make a transaction), but its utility depends mostly on the applied investment strategy. Generally, in most of the strategies the increase in probability of success compensates the lesser number of transaction signals.

## 4 Summary

In the article a new state model for binary-temporal representation (SMBTR) was proposed, modelling the exchange rate trajectory for currency pair AUD/NZD. The model was introduced as a generalization of a previously proposed binary representation state model (SMBTR). The universal character of the model allows for its application in modelling any currency pair. Probabilities of transitions between states are appointed empirically, based on the historical data. The achieved results are characterized by high accuracy and stability (that is, a lack of dependencies between the trends observable on the market and probabilities of transitions between states).

In the SMBTR model, the time conditions are defined by the investor depending on strategy, money management etc. The investor can, based on the model, achieve sparser signals which are compensated by a higher probability or, on the contrary, more frequent ones with a lower probability. The proposed model offers therefore a higher effectivity of modelling the market in comparison to the binary representation state model (SMBR).

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# The Role of Tax Havens in Tax Avoidance by Multinationals


**Małgorzata Kutera**

**Abstract** Today, multinationals play a leading role in shaping the economic relations in the world. Their investment decisions lead to huge capital flows which have a direct impact on the budgets of many states. A key role in this process is played by the differences in tax systems, which allow the profits generated to be taxed at the minimum percentage rate (or none at all) depending on the location in which the business is actually run. This leads to intentional tax avoidance, which has now become one of major economic problems and significantly contributes to the increasing socio-economic inequality. The main purpose of this publication is to present the scale of tax avoidance by multinationals and how this impacts the capital flows in the global economy. This article is mainly based on an analysis of financial figures of the largest supranational enterprises and selected macroeconomic ratios.

**Keywords** Tax havens · Tax avoidance · Multinationals · Tax abuses

## 1 Introduction

The problem of tax avoidance has been the subject of heated debate among both scientists and practitioners for many years, which is constantly stirred up by the publication of new data about the scale and the scope of entities hiding their profits in tax havens. It is enough to mention the scandals unearthed in just the last years: Panama Papers (2016), Swiss Leaks (2015) and Lux Leaks (2014). Each of them shocked the public opinion, but for the specialists they only confirmed something the latter have known for years: the rich pay no taxes.

This has been particularly exacerbated by globalisation, which has removed practically all barriers to expanding business and capital flows. It has been used to

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the utmost by supranational corporations which established extensive structures of affiliated entities located in practically every region of the world. The differences in tax systems, which allow the profits generated to be taxed at the minimum percentage rate (or none at all) regardless of where the business is actually run, became a key factor in these decisions.

The purpose of this article is to present the scale of tax avoidance by taking advantage of tax havens, and their impact on the capital flows in the global economy. The considerations start with the presentation of current controversies about this problem, mainly related to financial scandals that are uncovered. This is followed by the presentation of the number of offshore companies established by multinationals in tax havens and the amount of capital placed there. The last part describes the scale of losses to the budgets of selected states and the impact of this phenomenon on the financial situation of countries that practice unfair tax competition.

This article forms a part of a difficult school of research on the problems of tax avoidance by multinational corporations. The precise estimation of the scale of this abuse is, of course, impossible because the empirical data is highly confidential. This is also the greatest limitation of the research on this subject. On the other hand, every publication revealing this problem helps to gradually fill this gap and effectively supports changes of laws and regulations preventing this practice.

The main part of the article is founded on analyses of financial figures of the largest multinationals with regards to the income they report as generated in their country of domicile and in tax havens, the amount of taxes paid and the number of affiliated companies registered in tax havens. This analysis covers the 50 largest multinationals from the Fortune and Forbes rankings. The direct and original source of data is provided by the annual 10-K returns filed by these companies with the SEC, and then disclosed in various reports published by international organizations dealing with this problem (including the OECD, World Bank, Oxfam, Citizens for Tax Justice). Basic macroeconomic data which shows the level of investment flows and tax receipts in selected countries was also analyzed based on World Bank and Eurostat databases.

## 2 Controversies Related to Tax Avoidance

Tax avoidance with the use of tax havens gives rise to many controversies. Many economists believe that this phenomenon is absolutely negative and impermissible, mainly because of the ethical dimension of this problem and its macroeconomic consequences. On the other hand, it can be said prove the in-depth knowledge of international tax regulations and their skillful use according to the rule that "everything which is not forbidden (by law) is allowed".

The size of the problem is indirectly illustrated by reports on scandals related to tax havens that are brought to light. It is worth revisiting at least the most recent of

them. However, it should be borne in mind that this is just the proverbial tip of the iceberg.

The year 2014 saw the publication of the results of an investigation in which the main culprit was Luxembourg (hence the popular name of the case: Lux Leaks). It was announced that in the last decade, over 300 multinationals signed secret, very favourable tax agreements with this state. Under the Luxembourg law, such agreements were legal, but they significantly reduced tax receipts in other countries in which the companies actually ran their business. In addition, this scandal had a political dimension. It was disclosed after that post of the head of the European Commission was filled by Jean-Claude Juncker, after he served as the Prime Minister and Minister of Finance of Luxembourg and frequently encouraged multinationals to invest in his country. The accused companies included Pepsi, IKEA, AIG, Deutsche Bank, Google, Amazon, Starbucks and Walt Disney. An important role in these transactions was played by the international consulting giant, PWC, which helped multinationals obtain about 550 very favourable tax decisions in 2002–2010 (ICIJ 2014).

Another case related to the leak of confidential bank information from the Swiss branch of HSBC (Swiss Leaks). This data concerned 100,000 individual clients from over 200 countries, 20,000 companies and a huge amount of €180 billion. The list, apart from many show business artists, also included the relatives and members of the ruling elites of Syria, Egypt and China as well as terrorists, drug dealers and individuals associated with organized crime. Most clients of this branch —over 11,000—were Swiss and altogether stashed away $31.2 billion in their accounts, followed by 9000 French, over 8000 Britons and 7000 Italians. Altogether, $21.7 billion came from the UK, $14.8 billion from Venezuela, 13.4 billion dollars from the US and $12.5 billion from France. The bank had an entire branch of employees whose only job was to help clients hide their identity and execute transactions (ICIJ 2015).

The last famous scandal called the Panama Papers showed the gigantic scale of this practice. Over 11.5 million of confidential documents related to tax havens and executed by the legal and tax firm of Mossack Fonseca were disclosed. This data related to about 214,000 offshore companies. It identified the owners and boards of these entities as well as their detailed transactions since the 1970s. Assets of political elites and prominent officials were disclosed, leading to universal public outrage. The scale of this leak is illustrated even just by the fact that the documents were analyzed by about 400 journalists from 80 countries. The disclosure included over 4.8 million emails, 3 million files of various databases, and over 2 million PDF documents. Mossak Fonseca was considered to be the leader of the offshore finance sector. It employed over 500 employees at 400 offices all over the world and worked with the largest financial institutions, such as Deutsche Bank, HSBC, Société Générale, Credit Suisse or Commerzbank. The firm represented over 300,000 entities based in about 100 countries. Its business was focused on establishing shell companies with fictitious boards in tax havens for its clients and thus hiding the information about the real owner of the funds. Mossak Fonseca is estimated to have established about 15,600 such companies (The Guardian 2016).

## 3 Scale of Tax Haven Use by Multinationals

The most reliable information comes from analyzing financial data disclosed by multinationals. Research has demonstrated that the overwhelming majority of multinationals use tools for tax avoidance offered by tax havens, and the scale of these deals is growing (Eurostat 2015; HM Revenue & Customs 2016; Zucman 2014, 2015).

One of the most popular mechanisms used in this regard is to establish offshore companies in tax havens and shift profits to them (European Commission 2016). The most popular method of estimating the scale of this practice is the direct comparison of the amount of pre-tax profits reported by companies located in countries with high income tax rates and by their subsidiaries located in tax havens. Many studies of US corporations have shown the extraordinary profitability of offshore companies they have established (Sullivan 2004; Clausing 2011). Huizinga and Laeven (2008), in turn, confirmed that the level of profits reported by European corporations is strictly correlated with the structure of their groups and their ability to transfer capital. Similar research for Europe was carried out by Egger et al. (2010). They checked the amounts of taxes paid by multinationals and smaller companies domiciled in the EU and demonstrated that the effective taxation of the former is much lower. The analyses cited above clearly demonstrate the widespread use of tax avoidance mechanisms utilising offshore structures.

Interesting results also came from a detailed analysis of the 2014 figures of the largest Fortune 500 companies, partially presented in Table 1.

**Table 1** Total amount of equity invested in offshore companies ($m)

| Company | Number of companies registered in tax havens | Amount placed in offshore companies ($m) |
|---|---|---|
| Apple | 3 | 181,100 |
| General Electric | 18 | 119,000 |
| Microsoft | 5 | 108,300 |
| Pfizer | 151 | 74,000 |
| International Business Machines | 15 | 61,400 |
| Merck | 121 | 60,000 |
| Johnson & Johnson | 58 | 53,400 |
| Cisco Systems | 59 | 52,700 |
| Exxon Mobil | 37 | 51,000 |
| Google | 2 | 47,400 |
| Procter & Gamble | 38 | 45,000 |
| Citigroup | 41 | 43,800 |
| Hewlett-Packard | 25 | 42,900 |
| Oracle | 5 | 38,000 |
| PepsiCo | 132 | 37,800 |

*Source* Author's development based on http://ctj.org/ctjreports/2015/10/offshore_shell_games_2015.php [30.07.2016]

The results show that at least 358 of them had one subsidiary registered in a tax haven as a minimum. In some cases, these entities did not have many offshore companies, but the total income located in them was huge. Together, the 50 corporations had stashed over $1.5 billion away in tax havens! The first place is taken by Apple, which, in 2014, reported a gigantic amount transferred to offshore companies: over $180 billion. It was followed by other well-known multinationals: General Electric, Microsoft, Pfizer. This leads to a complete disconnect between the place where the real business is run, and the place where the income generated from it is reported and taxed.

Other companies, in turn, established gigantic numbers of offshore companies in tax havens, though the total amount of income they hid in them was not so significant (Table 2). Companies such as Kohlberg Kravis Roberts & Co., Morgan Stanley and AES disclosed over 200 such units! Altogether, 50 entities established

**Table 2** Number of offshore companies registered in tax havens

| Company | Number of companies registered in tax havens | The most important location of companies registered in tax havens |
|---|---|---|
| Kohlberg Kravis Roberts & Co. | 258 | Cayman Islands 217, Ireland 12 |
| Morgan Stanley | 210 | Cayman Islands 100, Channel Islands 10, Hong Kong 12, Luxembourg 36 |
| AES | 206 | Cayman Islands 83, Netherlands 78 |
| Blackstone Group | 161 | Cayman Islands 128, Netherlands 12 |
| Thermo Fisher Scientific | 155 | Cayman Islands 12, Hong Kong 12, Luxembourg 24, Netherlands 53, Singapore 10, Switzerland 18 |
| Pfizer | 151 | Ireland 27, Luxembourg 38, Netherlands 52 |
| PepsiCo | 132 | Bermuda 15, Cyprus 13, Ireland 12 |
| Merck | 121 | Bermuda 10, Ireland 25, Netherlands 42, Switzerland 19 |
| Marsh & McLennan | 117 | Bermuda 23, Hong Kong 10, Ireland 17, Netherlands 14, |
| Stanley Black & Decker | 110 | Hong Kong 16, Ireland 23, Luxembourg 17, Netherlands 20 |
| Wells Fargo | 98 | Cayman Islands 36, Luxembourg 23 |
| Dow Chemical | 92 | Netherlands 41, Singapore 15, Switzerland 10 |
| Abbott Laboratories | 91 | Ireland 13, Netherlands 23 |
| Emerson Electric | 86 | Hong Kong 14, Netherlands 25, Singapore 14, Switzerland 13 |
| Mondelēz International | 82 | Ireland 15, Netherlands 27, Singapore 10, Switzerland 15 |

*Source* Author's own development based on https://ctj.org/ctjreports/2015/10/offshore_shell_games_2015.php [30.07.2016]

4038 offshore companies in tax havens. It should be mentioned that in the majority of cases this did not consist in building actual factories and conducting real business, but only in registering sham companies. This is best illustrated by a modern, tiny office block in the Cayman Islands called the Ugland House, in which 18,857 companies are registered.

By comparing data from both tables, entities can be identified which have disclosed a relatively large number of offshore companies and at the same time, a high amount of income placed in them. The most significant ones include:

- PepsiCo—132 companies and $37.8 billion;
- Pfizer—151 companies and $74 billion.

An analysis of changes in the number of offshore companies and the level of income placed in them in recent years has also brought to light interesting trends. Some companies are apparently reducing the number of entities registered in tax havens, but are increasing the level of financial flows through them. The most notable cases (CTJ 2015):

- Citigroup—in 2008, it reported 427 units registered in tax havens, but in 2014, only 41. However, during this time, the bank almost doubled the amount of income placed in tax havens;
- Bank of America—in 2013 disclosed 264 offshore companies, but a year later, only 22. Regardless of such a dramatic drop in the number of units, the amount of flows grew to $17.2 billion;
- Google—in 2009, it reported 25 units registered in tax havens, but in 2010, only 2. However, over those two years, the amount of income placed in tax havens grew from $7.7 billion to 47.4 billion;
- Microsoft—disclosed 10 offshore companies in 2007, but in 2014 there were only five. Within the same time, the amount of income placed in tax havens increased almost 14 times.

In the entire group of the 500 largest corporations, the most popular tax havens were: the Netherlands, Singapore, Hong Kong, Luxembourg, Switzerland, Ireland, the Cayman Islands and Bermuda. The popularity of these tax havens is also confirmed by Fig. 1, which shows the largest amounts of income channelled by all US enterprises out of this country in 2012.

An analysis of this data shows that the greatest amounts of income were located in the Netherlands—$154,706 million, Ireland—$128,586 million and Bermuda—$102,734 million. The remaining tax havens are less significant.

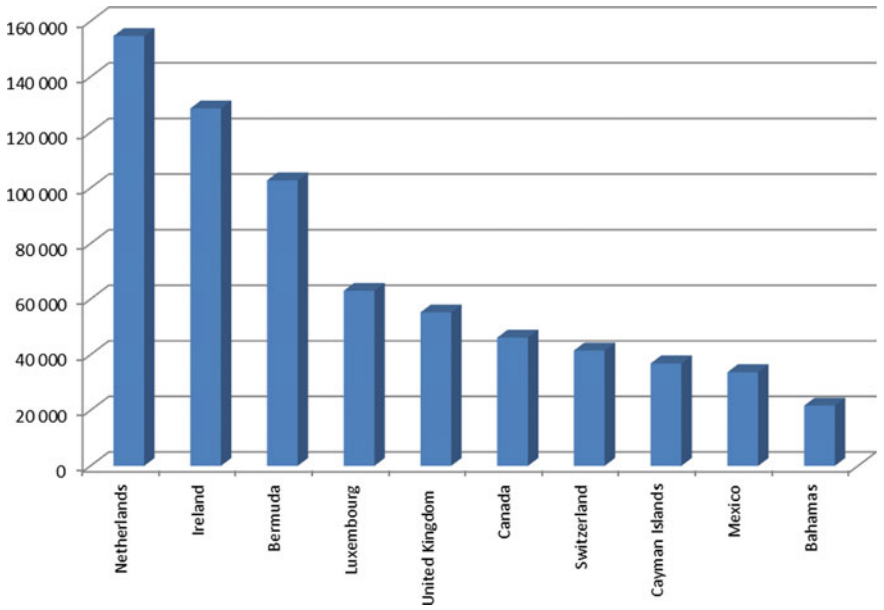


**Fig. 1** Income of US corporations placed out of the US in 2012 [$million]. *Source* Author's own development based on https://www.irs.gov/uac/soi-tax-stats-controlled-foreign-corporations [30.07.2016]

## 4 Tax Avoidance Versus Capital Flows in the Global Economy

From the point of view of the macro-economy and the development of global economic relations, tax avoidance and moving income to tax havens has many negative consequences. The most important of them is directly driving the rising inequality between the rich and the poor: the rich increase their fortunes faster. Research shows that 1% of the richest people in the world now hold more assets than all the rest. Just 62 individuals together hold assets worth the same as 3.6 billion, i.e. half of all humanity. Their total wealth has increased by 45% over the last five years (Oxfam 2016). Tax avoidance also curtails stable economic growth in certain regions of the world. It is well known that tax receipts are the primary source financing the activities of the state as the institution providing protection to its citizens and satisfying their other needs.

However, tax avoidance makes the real revenue of the budgets of individual states much lower than it should be. This is suggested by many studies of the effective tax rate. An analysis of the cumulative financial figures of the 50 largest US corporations for 2008–2014 has demonstrated that the effective income tax rate for at least 40 of them was way lower than the nominal tax rate of 35%. Table 3 shows that the lowest tax rates were recorded by General Electric (6.7%), Morgan

**Table 3** Effective tax rate (amounts in $m)

| Company | Profit | Income tax paid | Effective tax rate (%) | Tax at the nominal US rate of 35% |
|---|---|---|---|---|
| General Electric | 144,272 | 9718 | 6.7 | 40,777 |
| Morgan Stanley | 20,050 | 1586 | 7.9 | 5432 |
| Bank of America | 33,361 | 3346 | 10.0 | 8330 |
| Amgen | 35,545 | 3994 | 11.2 | 8447 |
| Verizon Communications | 98,938 | 15,677 | 15.8 | 18,951 |
| Twenty-First Century Fox | 27,945 | 4489 | 16.1 | 5292 |
| Prudential Financial | 10,677 | 1857 | 17.4 | 1880 |
| Cisco Systems | 67,235 | 11,986 | 17.8 | 11,546 |
| Qualcomm | 39,943 | 7254 | 18.2 | 6726 |
| Pfizer | 99,903 | 18,977 | 19.0 | 15,989 |

*Source* Author's development based on https://action.oxfamamerica.org/stoptaxdodging/data-table [30.07.2016]

Stanley (7.9%) and the Bank of America (10.0%). The total losses of the federal budget on account of the difference between the tax rates were estimated at about $330 billion.

Media reports show that the losses for the budgets of individual states are huge. The OECD estimates (2015) that the total losses amounted to between $100 and $240 billion per annum, which represents 4–10% of global corporate income tax receipts. The US budget is losing 90–110 billion dollars a year (Clausing 2011; Gravelle 2009). Analyses of European countries demonstrate, in turn, that the highest losses are incurred by Italy—$295.9 billion, Germany—$244.4 billion and France—$186.5 billion (Raczkowski 2015). However, it is worth mentioning the many problems of estimating them reliably. This is best illustrated by the UK. According to the official statistics of HM Revenue and Customs (HMRC), the tax gap in this country amounted to 36 billion pounds in 2014, while other serious studies give the figure of 122 billion pounds for the same period (Murphy 2014). This confirms the extreme complexity of this subject.

The losses to the budgets of states with high tax rates have a positive impact on the finances of tax havens, because the main flows of capital are channeled there. What is the most impressive, however, is the comparison of the total amount of income of the largest corporations located in tax havens to the GDP of these countries. The Table 4 presents the data for 2010. It shows the huge scale of the 'artificial' financial flows.

This table clearly shows that even a modest amount of income of offshore companies placed in a given tax haven represents a significant source of revenue for the state. In three cases, this amount exceeded 1000% of the country's GDP—Bermuda, Cayman Islands and British Virgin Islands.

**Table 4** The income of offshore companies in selected tax havens

| Tax haven | Amount of income of companies placed in the haven ($bn) | GDP ($bn) | Offshore company income as a % of the country's GDP |
|---|---|---|---|
| Bermuda | 94 | 6 | 1567 |
| Cayman Islands | 51 | 3 | 1700 |
| British Virgin Islands | 10 | 1 | 1000 |
| Bahamas | 10 | 8 | 125 |
| Luxembourg | 55 | 52 | 106 |
| Ireland | 87 | 208 | 42 |
| Netherlands Antilles | 1 | 4 | 25 |
| Netherlands | 127 | 772 | 16 |
| Cyprus | 3 | 23 | 13 |
| Singapore | 20 | 217 | 9 |
| Switzerland | 47 | 551 | 9 |

*Source* Author's development based on https://www.irs.gov/uac/soi-tax-stats-international-business-tax-statistics, http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?view=chart [15.08.2016]

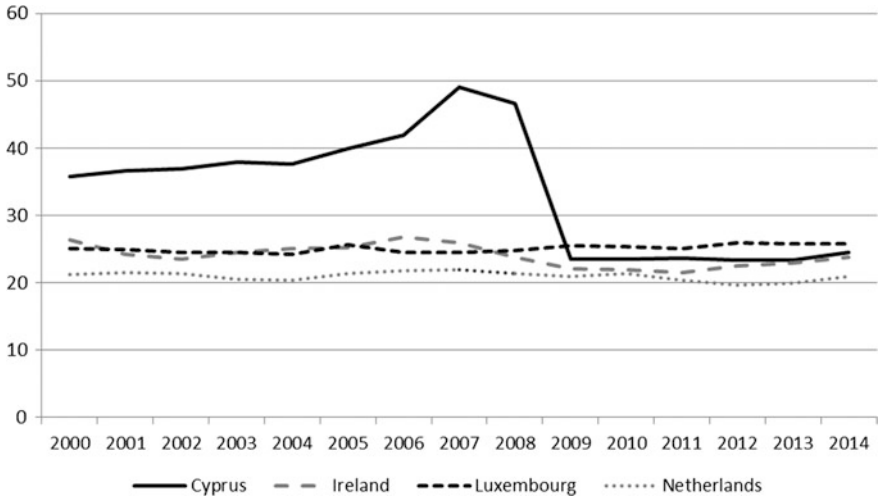


**Fig. 2** Tax receipts into the state budget as a % of GDP. *Source* Author's own development based on https://data.worldbank.org/indicator/GC.TAX.TOTL.GD.ZS [15.08.2016]

Similar conclusions are also drawn from an analysis of the macroeconomic data of selected tax havens concerning the level of tax receipts into their budgets relative to the GDP (Fig. 2). The graph justifies the statement that the tax revenue recorded

in these countries has stayed at a stable level of 20–30% of the GDP for at least 10 years. Compared to other European states, this level is rather high. In the last few years, Central European countries averaged 15–16%, OECD countries 14–15% and Europe as a whole 19–20%. What can also be seen is the unstable situation of Cyprus, where the level of this revenue accounted for almost 50% of its GDP in 2007–2008, but later fell significantly.

The negative impact of tax avoidance also applies to poorer developing countries. The United Nations Conference on Trade and Development UNCTAD (2015) identified that just one method of escaping taxes cost these countries between $70 billion and $120 billion a year. Altogether, they lose between $660 billion and $870 billion every year, which is six times more than the amount of aid received from developed countries.

Another important consequence is the constant strengthening of the position of huge multinationals which already have a leading influence on the development of global economic, social and even political relations. Consequently, tax avoidance should be assessed as negative in this context as well.

## 5 Conclusion

A complete and reliable estimation of the scale of tax avoidance with the use of tax havens seems impossible. This is also confirmed by significant differences in the estimated amount of losses revealed by research (like in the above example of the UK). However, the estimates presented in this article show that the losses for the budgets of individual states are huge and measured in billions of dollars. The largest US multinationals set up hundreds of offshore companies in tax havens and shift significant capital to them. In some cases, the ratio of the profits of these companies to the overall GDP of selected tax havens even exceeded 1000%.

This is why we are now witnessing intense legislative work, both at the international and national levels, aimed at tightening tax systems in this area. It is mainly about improving the transparency of corporations' reporting of the size of their operations in different countries and eliminating the discretion of tax havens, jointly finding legal loopholes at the international level and an efficient system of exchanging information about tax settlements. However, it must be clearly stated that its effect is greatly dependent on the mutual agreement and broader cooperation between states.

The greater the knowledge of the magnitude and the consequences of tax avoidance by multinationals, the more effective can the fight against this practice be. This article deals exactly with this subject. However, the greatest limitation of studies in this field is the confidentiality of data, which has a negative impact on the possible scope of analyses and leads to differences in their results. The direction of future research will concern the financial effects of other tax optimization tools used by multinationals.

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# Number of Automated Teller Machines in Selected European Countries: Exploration of Trends and Development Indicators Impacts


**Anita Pavković, Ksenija Dumičić and Berislav Žmuk**

**Abstract** The main aim of the paper is to discover and compare variability and trends in the number of Automated Teller Machines (ATMs) over time in the recent history in the European Union member states, as well as to enlighten the influence of selected development indicators, which could explain the change in the No. of ATMs as the dependent variable in the regression model. The main variable under study is defined as the "No. of Automated Teller Machines—ATMs per 100,000 adults" (No. of ATMs). Using the regression modelling in analysing the impact of selected development indicators on the dependent variable No. of ATMs for the 28 EU countries in 2014, two OLS estimated multiple liner regression models, each with three independent variables, were built. Firstly, the economic development level indicator "GDP per capita, given as the PPP in current international $", secondly, the ICT development level indicator the "No. of Internet users per 100 people"; and, finally, selected "digital banking development indicators", are used as the regressors. The multiple regression models are analysed, showing that most of the independent variables are positively correlated with the "No. of ATMs", with the exception of the "No. of Internet users per 100 people". The conducted panel analysis revealed that the impact of selected independent variables on the No. of ATMs is quite similar to the impact observed in previously developed regression models.

**Keywords** Automated teller machines (ATM) · Payment and terminal transactions · GDP per capita · Internet penetration rate · Multiple linear regression modelling

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## 1 Introduction

Automated teller machines (ATMs) can be observed as computerized telecommunications devices that can be used for different financial transactions in a public place. According to Investopedia (2016): "An automated teller machine (ATM) is an electronic banking outlet, which allows customers to complete basic transactions without the aid of a branch representative or teller". Anyone with a credit card or debit card can access most ATMs. "The first ATM appeared in London in 1967, and in less than 50 years, ATMs spread around the globe, securing a presence in every country". The increase of GDP per capita, as well as the increase in ICT development influence the changes in No. of ATMs needed. According to Youngo (2013) top 10 trends in the digital banking industry analysis, which is based on data and trends obtained by studying financial institutions, in 2013 the majority of mobile users become involved in mobile banking very early in their digital banking lifecycle. Among new consumers who implement mobile phones, within 90 days of registering for Internet Banking 62% of them adopt mobile banking. Mobile banking leads to higher engagement of financial institutions' clients. On the monthly basis, an average offline bank client visits the bank branch two times and an ATM three times. When compared to a busy online bank user, the financial institution has three times the opportunity to cross trade to this client.

According to Koch and MacDonald (2014), traditional services imply physical visits of bank customers to bank tellers, customer service representatives and loan officers in a bank's home office or its branches. Alternatively, many of those services can be offered via ATMs, the Internet, call centres, and the mobile (call phone) banking. Also, many companies or stores offer systems that directly challenge traditional banking payment systems or use mobile phones and other smart devices for direct point of sale transactions. Each of these transfer channels requires a different investment and ongoing costs of operations for the system operator but also provide different opportunities for reaching out to new customers, reducing delivery costs, speeding up processing times, and proposing new products and services. Despite the abovementioned, banks have continued investing into both channels, the traditional physical and as well as the digital one.

The World Bank defines ATMs in the following way "Automated teller machines are computerized telecommunications devices that provide clients of a financial institution with access to financial transactions in a public place". Also, Koch and MacDonald (2014) define ATMs as the computerized telecommunications systems that offer limited bank services to customers directly. Customers usually have a plastic card encoded with an identifier that allows an individual to insert the card in an ATM to withdraw cash, make deposits, take advances on credit cards, and check account balances. Typically, the bank that owns or hosts the ATM will charge a fee to the user for the access. Many banks will waive fees imposed by other banks to allow their customers the same access as the customers of the host bank.

Most banks allow customers to access their account information and conduct routine banking business via secured World Wide Web sites. Typical services include account reviews, bill payments, wire transfer of funds, and applications from loans and new accounts. Customers can conduct their banking business virtually at any time and at any place that has an Internet access. The primary disadvantage of Internet banking is that thieves have had success in stealing account information from individuals and quickly depleting account balances. The use of cell phones and tablets to conduct banking business will speed up transactions processing and increase customer convenience because you can review your deposit account activity, make loan payments, stop checks, and make small-denomination purchases with your cell phone instead of using a computer or having to go to an ATM. Usually, younger customers prefer channels that offer the greatest convenience such that they never have to enter a bank building, but older customers, often prefer branch visits.

The appearance of new technologies and changed customers' habits could have an impact on the No. of ATMs. Consequently, the aim of the paper is to discover and compare variability of the No. of ATMs over time in the European Union member states. The research hypothesis is that the No. of ATMs has negative trends in the EU-28. In addition, the influence of different variables that could explain the change in the No. of ATMs as the dependent variable is also observed.

The organisation of the paper is the following one. After the brief introduction, in the second section the literature review is provided. In the third section data sources and the used analysis methods are introduced. In the fourth section No. of ATMs trend analysis is conducted. In addition to the trend analysis, regression and panel analyses were conducted also. In the final, fifth, section conclusions are made.

## 2 Literature Review

Bilginol et al. (2015) examined the location distribution of Automated Teller Machines (ATMs) in Turkey. In order to find optimum locations for ATMs they used the Ordinary Least Squares (OLS) linear regression method. Their findings have shown that the impact on ATM location efficiency has a negative impact, whereas social media and the rival distribution have a positive impact on ATM usage by clients. Worthington (2007) conducted a national telephone survey of 3548 respondents in Australia. It has been shown that about 73% of respondents knew how to use or already used ATMs. The ability and willingness to use ATMs was examined by using the logit regression analysis approach.

In order to investigate the contribution of Automated Teller Machines (ATMs) to changing a bank branch's local deposit market share, Banker and Kauffman (1988) applied multivariate regression modelling. In the regression models, the dependent variable was the variable branch's percent of the total amount of collected deposits by banks at a certain area. On the other side, the independent variables have been divided into four groups and they describe the organization type of the observed

banks, the physical design of branches, ATM status and other variables. The research has shown that ATMs have a significant impact on a certain part of the bank business but no confirmation has been found that a higher ATM density leads to a better deposit collection.

Mwatsika (2016) conducted a survey on a sample of 353 respondents to research the impact of ATM use on customer satisfaction with banks. The results of the multiple regression analysis have shown that a customer's satisfaction level with ATM use accounts for about 40% of a customer's overall satisfaction level with a bank. Similarly to Mwatsika (2016), Phan and Nham (2015) investigated customer satisfaction with the automated teller machine service. They have applied the exploratory factor and the regression analysis. Finally, they have concluded that the assurance component and the tangibles component have a significant impact on customer satisfaction with the ATM service. Abdul Mumin et al. (2014) surveyed 160 bank customers by using the multi-stage stratified sampling approach to determine factors which have an impact on the level of ATMs use. In the analysis the probit regression model was applied and it has been discovered that the education level, No. of ATMs, convenience of use, security characteristics of ATMs, efficiency of ATMs use and transaction costs have a statistically significant impact on the level of ATMs use.

Ali and Kalu (2016) have explored the correlation between customer deposit series and the value of the ATM transactions in the period of five years. The regression analyses have shown that there is a statistically significant positive correlation between the value of the ATM transactions and the private sector demand deposits. On the other hand, there is no statistically significant correlation of the value of the ATM transactions neither with the private sector savings deposits nor with the private sector time deposits. Wijesekara and Kandambi (2015) investigated the customer attitudes towards ATM usage, also. The research has shown that demographic characteristics have a statistically significant impact on the level of ATM use. The formed regression model revealed that the variables usefulness, perceived risk, ease of use, trust and security all have a positive and statistically significant impact on the ATM usage attitudes. Furthermore, the regression analysis has shown that there is a positive linear correlation between the actual ATM use and attitudes towards ATM usage.

Onywoki and Opiyo (2016) made a step further in the analysis of the technology level and examined what influences the customers' decisions to accept biometric ATMs. According to conducted factor and multiple regression analyses it has been concluded that variables such as performance expectancy, effort expectancy, social influence and user privacy have the highest impact on biometric ATM adoption. Županović et al. (2015) conducted the cost-benefit analysis of the ATM automatic deposit service. Among other things, they have evaluated ATM automatic deposit services by using the correlation and the regression analysis approach. Olusanya and Fadiya (2015) have shown that security and privacy have an impact on the ATM level of use. Furthermore, the regression analysis pointed out that there is a statistically significant correlation between convenience and approachability of ATMs use. Al-Zahrani and Almazari (2015) have been interested in the impact of

e-banking on ATMs. The correlation and the regression analysis have shown that there is a statistically significant negative relationship between these two variables.

## 3 Data and Methods

The main variable under the study is the number of Automated Teller Machines (ATMs) per 100,000 adults. This variable is going to be observed for the 28 European Union member states in the period from 2004 to 2014. The data are collected from the World Bank. Unfortunately, there are no available data for each EU member state in the each observed year.

After conducting basic descriptive statistics exploration, which was used to determine the differences among the EU member states in the No. of ATMs, a trend analysis was conducted. In the trend analysis three trend models were used: the linear trend polynomial model of the first and the second degree and the exponential trend polynomial model of the first degree. The best model was chosen according to the best fit criteria measured by a coefficient of determination ($R^2$).

In the further analysis, variables that affect the No. of ATMs were inspected. In the preliminary analysis, a selection of variables was conducted. More than 25 digital banking development level and economic indicators were initially considered to be used in the analysis. However, various linear and logarithmic regression models have shown that many of the observed variables do not have a statistically significant impact on the No. of ATMs, neither individually, nor together with some other variables. Finally, only four variables, which are going to have a role of independent variables in multiple regression models, are chosen. In Table 1, the list of all the observed variables included in the regression analyses is provided, according to the European Central Bank (2013).

Firstly, multiple regression models based on 2014 data are formed. Afterwards, the regression models with the same independent variables are made for the other years too. The differences in the estimated parameters values among different years were commented. Finally, a panel analysis based on all available data is conducted.

## 4 Research Findings

### *4.1 Exploratory Data Analysis*

In order to obtain an insight into the difference in the No. of ATMs among the EU-28 member states, a descriptive statistics analysis is conducted. It has been decided that only two years are going to be observed that way. Consequently, the No. of ATMs was observed in 2008, the last year before the great economic and financial crisis, and in 2014, which is the most recent year for which the No. of

**Table 1** Variables and data sources

| Symbol | Variable code and name | Source |
|---|---|---|
| $Y_{ATMs}$ | Number of Automated Teller Machines (ATMs) (per 100,000 adults) | World Bank (2016c) |
| $X_{IntUsers}$ | Internet users (per 100 people) Penetration rate | World Bank (2016b) |
| $X_{NoTranCards}$ | Payment and terminal transactions involving non-monetary financial institutions (non-MFIs), No. of transactions for cards issued by resident payment service providers (PSPs), cards with a debit function, in millions of Euro | Statistical Data Warehouse (2016a) |
| $X_{ValueTranCards}$ | Payment and terminal transactions involving non-monetary financial institutions (non-MFIs), Value of transactions per type of payment service, For cards issued by resident payment service providers (PSPs), cards with a debit function, in millions of Euro | Statistical Data Warehouse (2016b) |
| $X_{GDPpc}$ | GDP per capita, PPP (current international $) | World Bank (2016a) |

ATMs is known. In Table 2 the No. of ATMs for each EU-28 member state is given.

According to Table 2, the lowest No. of ATMs in both observed years was in Finland. On the other hand, convincingly the highest No. of ATMs in 2008 and in 2014 was achieved in Portugal.

The box-pot diagram, provided in Fig. 1, confirms that Portugal had considerably higher No. of ATMs in 2008 than the other EU-28 member states. The difference in the No. of ATMs in 2008 is so large that Portugal can be considered as a possible outlier. However, the difference between Portugal and other EU-28 member states decreased in the period from 2008 to 2014. Accordingly, Fig. 2 shows that there are no outliers, according to the No. of ATMs variable value, in 2014.

According to Table 3, the descriptive statistics indicators for the No. of ATMs in the EU-28 member states in 2014 compared to 2008 mostly remained unchanged. Both, the averages (36 in 2008, and 34 in 2014) and the coefficients of variation (44% in 2008, and 41% in 2014) remained mostly unchanged.

## *4.2 Trend Analysis*

The trend analysis of the No. of ATMs developed using the OLS regression models resulted in the estimated models that differ from country to country. Figure 3 shows an example of a trend in the EU-28 member states.

**Table 2** The No. of ATMs in the EU-28 member states in 2008 and 2014

| Country | Codes | $Y_{ATMs2008}$ | $Y_{ATMs2014}$ |
|---|---|---|---|
| Austria | AT | 110.16 | 119.44 |
| Belgium | BE | 87.45 | 93.91 |
| Bulgaria | BG | 79.88 | 90.72 |
| Croatia | HR | 89.25 | 116.82 |
| Cyprus | CY | 66.35 | 53.13 |
| Czech R. | CZ | 38.23 | 49.80 |
| Denmark | DK | 68.71 | 54.29 |
| Estonia | EE | 89.71 | 76.82 |
| Finland | FI | 37.36 | 35.87 |
| France | FR | 101.53 | 108.05 |
| Germany | DE | 109.73 | 118.19 |
| Greece | EL | 79.14 | 59.09 |
| Hungary | HU | 54.10 | 58.04 |
| Ireland | IE | 95.95 | 84.77 |
| Italy | IT | 99.13 | 91.85 |
| Latvia | LV | 68.10 | 63.20 |
| Lithuania | LT | 54.49 | 51.69 |
| Luxembourg | LU | 107.32 | 106.29 |
| Malta | MT | 47.49 | 56.28 |
| Netherlands | NL | 64.10 | 50.58 |
| Poland | PL | 43.01 | 63.58 |
| Portugal | PT | 187.21 | 177.69 |
| Romania | RO | 52.95 | 64.78 |
| Slovakia | SK | 49.54 | 58.85 |
| Slovenia | SI | 99.51 | 95.8 |
| Spain | ES | 156.76 | 119.63 |
| Sweden | SE | 42.14 | 40.24 |
| UK | UK | 125.55 | 129.76 |
| European Union | EU-28 | 79.51 | 64.78 |

*Source* World Bank (2016c)

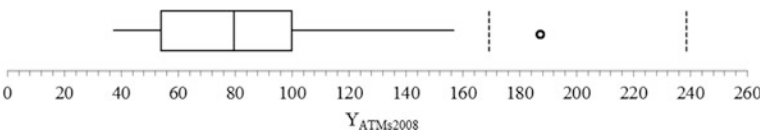


**Fig. 1** Box-plot for the No. of ATMs in the EU-28 member states in 2008

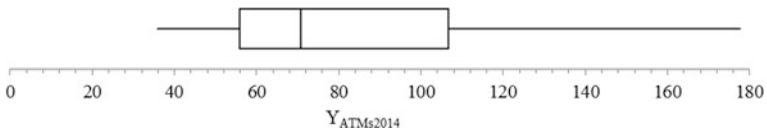


**Fig. 2** Box-plot for the No. of ATMs in the EU-28 member states in 2014

**Table 3** Descriptive statistics for the No. of ATMs in the EU-28 member states in 2008 and 2014

| Indicator | $Y_{ATMs2008}$ | $Y_{ATMs2014}$ |
|---|---|---|
| Count | 28 | 28 |
| Mean | 82.32 | 81.76 |
| Sample standard deviation | 35.83 | 33.49 |
| Minimum | 37.36 | 35.87 |
| Maximum | 187.21 | 177.69 |
| Range | 149.85 | 141.82 |
| Skewness | 1.09 | 0.91 |
| Kurtosis | 1.55 | 0.73 |
| Coefficient of variation (CV) | 0.44 | 0.41 |
| 1st quartile | 53.82 | 55.78 |
| Median | 79.51 | 70.80 |
| 3rd quartile | 100.02 | 106.73 |
| Interquartile range | 46.20 | 50.95 |

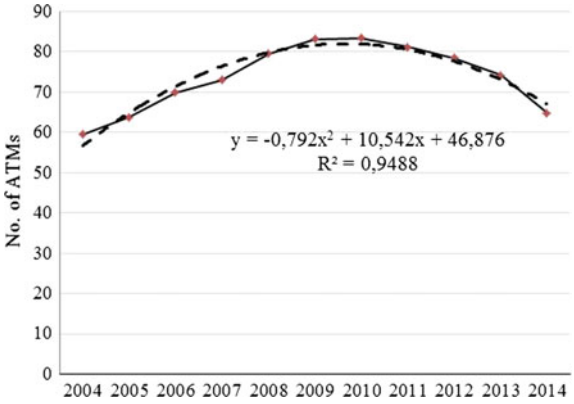


**Fig. 3** Linear trend polynomial model of the second degree for the No. of ATMs in the EU-28 member states

Figure 3 shows that the second order polynomial is the most suitable trend model for the description of the dynamics of the No. of ATMs in the EU-28 member states for the period from 2004 to 2014. The coefficient of determination shows that nearly 95% of the total sum of squares is explained by this model. In Table 4, the trend analysis results for each EU-28 member state are provided.

**Table 4** Dynamics of the best fitted trend models for the No. of ATMs in the EU-28 member states, period 2004–2014, linear trend polynomials of the second degree

| Country | Time series length | Coefficient of determination | Type of dynamics |
|---|---|---|---|
| Austria | 11 | 0.73 | Degressive-progressive |
| Belgium | 11 | 0.92 | Progressive-degressive |
| Bulgaria | 11 | 0.99 | Progressive-degressive |
| Croatia | 10 | 0.99 | Progressive-degressive |
| Cyprus | 11 | 0.83 | Progressive-degressive |
| Czech R. | 11 | 0.98 | Progressive-progressive |
| Denmark | 11 | 0.95 | Progressive-degressive |
| Estonia | 11 | 0.96 | Progressive-degressive |
| Finland | 9 | 0.93 | Degressive-progressive |
| France | 11 | 0.97 | Progressive-degressive |
| Germany | 7 | 0.97 | Progressive-degressive |
| Greece | 10 | 0.96 | Progressive-degressive |
| Hungary | 11 | 0.98 | Progressive-degressive |
| Ireland | 11 | 0.72 | Progressive-degressive |
| Italy | 11 | 0.87 | Progressive-degressive |
| Latvia | 11 | 0.90 | Progressive-degressive |
| Lithuania | 11 | 0.84 | Progressive-degressive |
| Luxembourg | 11 | 0.32 | Progressive-degressive |
| Malta | 11 | 0.83 | Progressive-progressive |
| Netherlands | 11 | 0.80 | Progressive-degressive |
| Poland | 11 | 0.99 | Progressive-degressive |
| Portugal | 11 | 0.98 | Progressive-degressive |
| Romania | 11 | 0.99 | Progressive-degressive |
| Slovakia | 11 | 0.98 | Progressive-degressive |
| Slovenia | 11 | 0.96 | Progressive-degressive |
| Spain | 11 | 0.98 | Progressive-degressive |
| Sweden | 11 | 0.83 | Progressive-degressive |
| UK | 10 | 0.61 | Progressive-progressive |

According to Table 4, for the EU-28 member states the linear trend polynomial of the second degree turned out to be the best trend model according to the coefficient of determination criteria. Coefficients of determination have rather high values for all the EU-28 member states except for Luxembourg (0.32) and for the United Kingdom (0.61). Table 4 also reveals that for some EU-28 member states not all data from the period from 2004 to 2014 were available.

If the trends are observed, it can be concluded that for almost all the EU-28 member states, except for Austria and Finland, the No. of ATMs has an increasing trend. However, the trend models points out that the increase seems to be smaller and smaller every year. At some point in the future it is expected that this increase

will become a decrease. Such a situation is present for 23 of the EU-28 member states. On the other side, it can be concluded that 5 (Austria, the Czech Republic, Finland, Malta, the United Kingdom) of the EU-28 member states have an increasing trend of the No. of ATMs. If all EU-28 member states are observed together it can be concluded that the No. of ATMs will decrease in the future. Taking all results into account, the research hypothesis of the paper can be accepted.

## 4.3 Correlation and Regression Analysis

In the following analysis, correlation between the above named selected variables is going to be observed. The correlation matrix based on 2014 data is given in Table 5.

The correlation analysis discovered mostly positive correlations between pairs of variables in 2014, as given in Table 5. There is only one pair of variables with a very weak negative correlation between variables $X_{IntUsers}$ and $Y_{ATMs}$. The strongest positive correlation appeared for the variables $X_{ValueTranCards}$ and $X_{NoTranCards}$ with r = 0.984 in 2014.

Using all possible regression techniques, several multiple regression models have proved to be statistically significant. However, in this paper, two of them are found to be both meaningful and statistically significant, and these two models were tested for regression model diagnostics.

In analysing the impact of selected development indicators on the variable No. of ATMs, two OLS estimated multiple liner regression models, each with three independent variables, were developed, as given in (1) and (2), and both were tested for diagnostics.

The estimated Model 1 is given by the equation for the EU-28 countries in 2014:

$$\begin{aligned} &Y_{ATMs} = 174.349 - 1.8205 \cdot X_{IntUsers} + 0.00016 \cdot X_{ValueTranCards} + 0.0011 \cdot X_{GDPpc} \\ &n = 28,\ R^2 = 0.3513,\ \text{Adj.}R^2 = 0.2270,\ \text{S.E.Reg.} = 28.612, \\ &F = 4.33\ (p\text{-value} = 0.01416). \end{aligned} \quad (1)$$

**Table 5** Correlation matrix, EU-28 member states, data from 2014

| Variables | $Y_{ATMs}$ | $X_{IntUsers}$ | $X_{NoTranCards}$ | $X_{ValueTranCards}$ | $X_{GDPpc}$ |
|---|---|---|---|---|---|
| $Y_{ATMs}$ | 1.000 | | | | |
| $X_{IntUsers}$ | −0.113 | 1.000 | | | |
| $X_{NoTranCards}$ | 0.325 | 0.403 | 1.000 | | |
| $X_{ValueTranCards}$ | 0.381 | 0.359 | 0.984 | 1.000 | |
| $X_{GDPpc}$ | 0.150 | 0.674 | 0.155 | 0.153 | 1.000 |

The overall Model 1 was tested to be statistically significant at the 5% significance level (F = 4.33, *p*-values = 0.014). The Variance inflation factor (VIF) being smaller than 5 for all cases indicated that there is no problem of multicollinearity of the model. The Jarque-Bera normality test, with J-B statistic = 6.76, and *p*-value = 0.034, showed that residuals might be considered to be normal at the 1% significance level. The White Heteroskedasticity Test, with Obs*R-squared = 8.207 and *p*-value = 0.514 confirmed that the heteroskedasticity problem does not exist.

Based on the estimated multiple regression Model 1, the following conclusions have been made. If $X_{IntUsers}$ increased by one, fixing other independent variables $X_{ValueTranCards}$ and $X_{GDPpc}$ to stay unchanged, the regression value of $Y_{No.ATM\_2014}$ would decrease by 1.8 ATMs per 100,000 adults. Further, if $X_{ValueTranCards}$ increased by one million EUR, with unchanged values of other independent variables $X_{IntUsers}$ and $X_{GDPpc}$, the regression value of $Y_{No.ATM\_2014}$ would increase by a very small amount of 0.0002 ATMs per 100,000 adults. If $X_{GDPpc}$ increased by one $, with the remaining regressors $X_{IntUsers}$ and $X_{ValueTranCards}$ unchanged, the regression value of $Y_{No.ATM\_2014}$ would increase by 0.0011.

The estimated Model 2 for the EU-28 in 2014 is given by the equation as follows:

$$\begin{aligned} &Y_{ATMs} = 178.2169 - 1.9091 \cdot X_{IntUsers} + 0.0082 \cdot X_{NoTranCards} + 0.0011 \cdot X_{GDPpc} \\ &n = 28,\ R2 = 0.3222,\ Adj.R2 = 0.2375,\ S.E.Reg. = 29.246, \\ &F = 3.80\ (p\text{-value} = 0.02313). \end{aligned} \tag{2}$$

The overall Model 2 was proved to be statistically significant at the 5% significance level (F = 3.80, *p*-values = 0.023). The Variance inflation factor (VIF) being smaller than 5 for all cases indicated that there is no problem of multicollinearity of the model. The Jarque-Bera normality test, with J-B statistic = 4.57, and *p*-value = 0.11, showed that residuals might be considered to be normal at the 1% significance level. The White Heteroskedasticity Test, with Obs*R-squared = 0.627 and *p*-value = 6.686 shown that the heteroskedasticity problem does not exist.

Based on the multiple regression Model 2, the following conclusions have been made. If $X_{IntUsers}$ increased by one, fixing other independent variables $X_{NoTranCards}$, and $X_{GDPpc}$ to stay unchanged, the regression value of $Y_{No.ATM\_2014}$ would decrease by 1.9 ATMs per 100,000 adults. If $X_{NoTranCards}$ increased by one mil EUR, with unchanged values of other independent variables $X_{IntUsers}$ and $X_{GDPpc}$, the regression value of $Y_{No.ATM\_2014}$ would increase by 0.008 ATMs per 100,000 adults. If $X_{GDPpc}$ increased by one $, with the remaining regressors $X_{IntUsers}$ and $X_{NoTranCards}$ unchanged, the regression value of $Y_{No.ATM\_2014}$ would increase by only 0.0011.

### 4.4 Panel Analysis

Due to missing data, regression models, where all the EU-28 member states are included, could be estimated only for 2014. Because of that, an unbalanced panel analysis was conducted. Two panel models were estimated with the same variables included as at the above developed regression models (see Eqs. 1 and 2). Conducted tests, Breusch-Pagan LM tests for random effects and the F-test for fixed effects, have shown that at both panel models the fixed effects model should be used. Consequently, the estimated panel models are the following:

$$Y_{ATMs} = 76.62 - 0.6516 \cdot X_{IntUsers} + 0.00015 \cdot X_{ValueTranCards} + 0.0011 \cdot X_{GDPpc} \quad (3)$$

$$Y_{ATMs} = 77.62 - 0.6835 \cdot X_{IntUsers} + 0.0073 \cdot X_{NoTranCards} + 0.0011 \cdot X_{GDPpc} \quad (4)$$

In both panel models all independent variables are highly significant. Furthermore, both panel models used 267 data. The coefficient of determination at the first panel model (Eq. 3) is 0.3525, whereas at the second panel model (Eq. 4) is 0.3239.

## 5 Conclusions

In the EU-28 in 2008, there were 80 ATMs per 100.000 adults, and in 2014 there were 65. Since we focused on Croatia and Poland, it could be concluded that these countries are between the maximum no. of ATMs, as given in Portugal (187 in 2008 and 178 in 2014), and the minimum no. of ATMs, given in Finland (37 in 2008, and 36 in 2014. In Croatia there were 89 ATMs per 100.000 adults in 2008, and that number increased to 117 in 2014. In Poland in 2008 there were 43 ATMs per 100.000 adults, and in 2014 the no. of ATMs increased to 64.

Descriptive statistics of the "No. of ATMs" in 2008 and 2014 show that in 2008 there was an outlier for the maximum number of 187 of ATMs per 100,000 adults appearing in Portugal, but in 2014 there were no outliers in the EU-28 countries. There were no big changes in 2014 compared to 2008. Both, the averages (82.32 in 2008, and 81.76 in 2014) and the coefficients of variation (44% in 2008, and 41% in 2014) remained mostly unchanged. The same is true for the range, which is between 37 and 187 in 2008, and between 36 and 178 in 2014. The range of the "No. of ATMs" in 2008 is 150, and in 2014 it is a bit smaller, being 142. In 2008 the median was 80, and in 2014, it decreased to 70 ATMs per 100,000 adults. It might be concluded that in the EU-28 countries the variability of the "No. of ATMs" remains more or less equal in 2014 in comparison to 2008. In 2008, the skewness equals 1.09, and for 2014 it is equal to 0.91, meaning that in both years the distributions are moderately positively skewed.

The trend analysis conducted for data from 2004 to 2014 shows that the second order OLS polynomial models, showing a decrease of the "No. of ATMs", are best fitted for the trends in the EU-28 and Slovenia, with very high coefficients of determination of 95% for the EU-28, and 96% for Slovenia. For Croatia and Poland, the linear models, showing an increase of the "No. of ATMs", are best fitted, with coefficients of determination of 95% for Croatia and 96% for Poland.

Based on the correlation analysis for the variables included in two regression models, Model 1 and Model 2, it was shown that there are two variables: the economic development level indicator "GDP per capita in PPP in current international $", and digital banking development indicator, "Payment and terminal transactions involving non-MFIs", both positively impacting the regression value of the "No. of ATMs". In the same time, the ICT development level indicator variable, called the "No. of Internet users per 100 people", influences the regression value of the "No. of ATMs" negatively.

In the further regression analysis, the digital banking development indicator "Payment and terminal transactions involving non-MFIs" was used in two versions: for Model 1, "Value of transactions per type of payment service, for cards issued by resident PSPs, cards with a debit function, in millions of Euro"; and, for Model 2, "Number of transactions for cards issued by resident PSPs, cards with a debit function, in millions of Euro", and both versions of this variable impact the "No. of ATMs" with a positive pre-sign. In both regression models, built for the 28 EU countries in 2014, the impact of change of the variables $X_{IntUsers}$ and $X_{GDPpc}$ is mostly the same, showing the same amount and the same direction of moving regression value for the No. of ATM's for a unit increase of each of these independent variables, having the remaining independent variables fixed. No. of Internet users is slightly negatively correlated with the No. of ATMs (correlation = −0.11). On the other hand, the variable GDP per capita is slightly positively correlated with the No. of ATMs per 100,000 adults (correlation = 0.15) in the EU-28 member states.

And finally, the conducted panel analysis for 2014 revealed that the impact of the independent variables $X_{NoTranCards}$, $X_{ValueTranCards}$ and $X_{GDPpc}$ on the No. of ATMs is quite similar to the impact observed in previously developed regression models.

The authors suggest that the future research should take into consideration some other development level indicators that probably influence the number of ATMs in the EU countries in a statistically significant way. Especially, the new ICT development challenges might be important influencing the payment methods.

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# ‘Repolonization’ Process of Domestic Banks. Analysis of Conditions and Opportunities


**Irena Pyka and Aleksandra Nocoń**

**Abstract** The study analyzes the repolonization process, directed at domestic banks, which becomes increasingly important in the state economic policy and the strategy of the National Bank of Poland. The main premise of the undertaken problem is a rapidly changing environment of banking sector in Poland and the world economy, especially in the Member States of the European Union. The main aim of the study is identification of the process, indication of its basic features, and finally determination of main motives of repolonization process of domestic banks.

**Keywords** Repolonization process · Banks’ consolidation
Re-nationalization of a banking sector · Bank capital · Bank capital structure

## 1 Introduction

The global financial crisis has not only caused an ‘earthquake’ in the global economy, but has also revealed its various irregularities and institutional weaknesses. A reaction on it clearly indicates that banking sector needs a special reactivation, mainly large corporations operating internationally, exposed to systemic risk and transforming it into national financial systems.

Polish economy due to its not-so-distant market transformation and membership in the European Union (since 2004) is like many countries of the world economy, exposed to the migration of financial capital, which makes once again revives the idea of restoring in Polish banks domination of Polish owner. It turned out that, as a result of the global financial crisis, foreign financial groups, which in the vast majority were owned banks, operating in Poland, suffered significant losses, often

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so high that their recapitalization by governments was required and their different current financial condition favors repurchase of shareholdings of Polish subsidiaries.

First offers of sell Polish subsidiaries of banks contributed to the return of the concept of repolonization of Polish banking sector. This concept, which has its political source in the program of current ruling political party, earlier was also present in the views of representatives of bankers and theorists of the past period of socialist-minded. In fact, it always means abrasion of economic and financial visions of two economic trends—neo-liberal and keynesian, which attracted and still attract their new supporters and/or opponents.

The main aim of the study, focused on the problems of repolonization of Polish banking sector, is to identify basic conditions for its implementation. In the view of previously very one-sided approach to repolonization, firstly its concept and forms were identified. The second part of the study was directed to recognition of trends and characteristics of ownership structure in selected countries of the world economy. Assuming that repolonization is a long-term process of ownership changes in domestic banks, in the third part of the study are analyzed positive and negative determinants of its implementation.

## 2 Identification and Forms of Banking Sector Repolonization

The concept of banks' repolonization was renewed in pre-election program debate of currently ruling Polish political party,[1] resulting from view that the level of dependence of domestic banks on foreign capital is too high and foreign parent companies often treat their Polish subsidiaries harshly, focusing on its own financial, economic and social interests, allowing dispel the myth that in the global economy capital does not have homeland. Therefore, it is assumed that it should be considered the repurchase a part of banking sector by Poland and to domesticate national banks.

However, so far such actions were not taken. While arguments for or against domestication of capital of Polish banking sector, mainly on political plane, are seeking. But the consensus on this issue was not found. Thus, we can observe stiffening positions of supporters and opponents of nationalization of domestic banks.

A major argument against repolonization is estimated its high financial cost, which requires greater involvement of state capital in operating activities of commercial banks in Poland. For the time being re-nationalization of Polish banking sector does not have political as well as social support. Moreover, it was confirmed

[1]In 2015, the government was formed by "Law and Justice" party. The party gained a majority electoral mandate.

lower efficiency of state capital. Re-nationalization of banking sector may also result in larger sovereign debt in Poland.

It is difficult to refute these arguments. Therefore, nationalization of domestic banks should be regarded as an important form of repolonization. However, nationalization of banking sector in Poland is not devoid of positive features. They can be seen in an increase of its financial security and improvement of lending conditions of economic entities. There can also be expected an increase of possibility of influence of government on dynamic of economic growth of a state or finally seen as an important source of budget revenues and financing of public debt.

However, liberal orientation of Polish economy, related to its growing expansion on an international scale, requires repolonization associated mainly with an increase in the share of Polish private capital in domestic banks. Therefore, privatization of domestic banks with the share of Polish financial capital should be considered as its basic form. It should ensure high efficiency standards in domestic banks decreasing the risk of profit escape of Polish banking sector abroad, at the same time increasing the possibility of reinvesting bank's income in Polish economy.

Repolonization, as a concept of domestication of bank capital and, therefore, its nationalization—in essence—will be the next stage of changes in the ownership structure of domestic banks. In the assumptions, it should settle on the scale of re-nationalization, determine balance between the share of foreign and Polish financial capital in a banking sector, specify proportions and ways of participation by private and state capital. Consequently, repolonization is a serious political strategy, concerning expected changes in Polish banking sector, infringing their previous course, conditioned by marketization of Polish economy in nineties of the twentieth century.

Based on political debate, it can conclude that repolonization would change the proportion of foreign to domestic bank capital from 60%:40% into 40%:60%. However, it is not known what arguments confirm such a proportion. Or maybe it should be 55%:45% or even 70%:30%. Without rationale, any expected change in the share of national capital in Polish banking sector above 50% would meet the criterion of repolonization. While, in Germany in some periods domestic investors had less than 50% shares in Deutsche Bank. The question is whether such a situation meant the need for its re-nationalization.

It should also be noted that if at the end of 2014 total assets of Polish banking sector amounted to 1529.6 bln PLN, 20% of the value—necessary to achieve the assumed proportions in repolonization process—requires the purchase of shares from foreign owners in the amount of 305.92 bln PLN. It arises not only the question of how gain such a sum, but also in which banks this sum should be invested, whether it would be optimal investment and highly efficient and finally—what would be the market price of banks' shares, given various foreign investors.

In the analyzed context, repolonization has to be associated with a long-term process of reducing foreign capital in Polish banking sector, without the need for an unambiguous determination of the boundaries of changes in ownership structure of domestic banks. It requires not only resolve of signaled issues, but also unambiguous and clear identification of a center of strategic decision making and to

determine the scope of its competence. It also requires to specify investment abilities of Polish financial capital, including instruments to implement this process. Repolonization does not ensure the only predominance of Polish bank capital.

## 3 Comparative Analysis of Ownership Structure of Bank Capital in the Global Economy

It is extremely difficult to assess changes in the ownership structure of banking sectors in countries of the global world economy, due to their considerable economic and social diversity. For this reason, there is no appropriate measures enabling to formulate of conclusions based on conducted comparative analysis.

Free movement of money and capital on an international scale, resulting directly from the dynamic development of globalization of the world economy at the turn of XX and XXI centuries, has contributed significantly to the increase in the share of foreign capital in domestic banking sectors, at the same time stimulating scientific research in this area (Węcławski 2015, pp. 189–199; Czepirska 2016, pp. 38–52; National Bank of Poland 2001; Baszyński 2011; Davydoff et al. 2013; Košak and Čok 2008, pp. 93–122; European Central Bank 2015, pp. 18–25). They usually indicate that banks with headquarters in the country dominate in highly developed countries. While, foreign banks dominate in countries with a lower level of development. Given the direction of migration of financial capital on an international scale, it is difficult to question such a relation.

Figure 1 indicates share of foreign capital in developed and ex-communist countries and confirms the existence of such a relation.

The share of foreign capital in banking sectors of developed countries fluctuates around 20%, while in ex-communist countries exceeds 70%.

Assessing correlating of share of banks controlled by foreign banking groups (so called banks controlled abroad) with size of the economy measured by the value of GDP (see Fig. 2) (Capital Strategy 2012, p. 5), it is also noted that in the major EU economies (Spain, Germany, France, Sweden, Italy) dominate banks which have their decision-making centers in a given country, while in small economies dominate banks controlled abroad.

The case study (see Fig. 2) also indicates that Polish economy, being large in a European scale in terms of GDP, has a banking sector structure characteristic for small European economies. Almost 70% of total assets of the 10 largest banks in Poland is represented by banks controlled abroad.

The analysis of ownership structure of banking sectors of countries with lower level of development, points to its significant differentiation. It concerns both the size of foreign capital invested in national banking sectors, as well as proportion between national, public and foreign capital. Asian countries are characterized by quite balanced capital structure (see Fig. 3). A significant part, except foreign capital (27% of share) and national capital being held by private investors (38% of

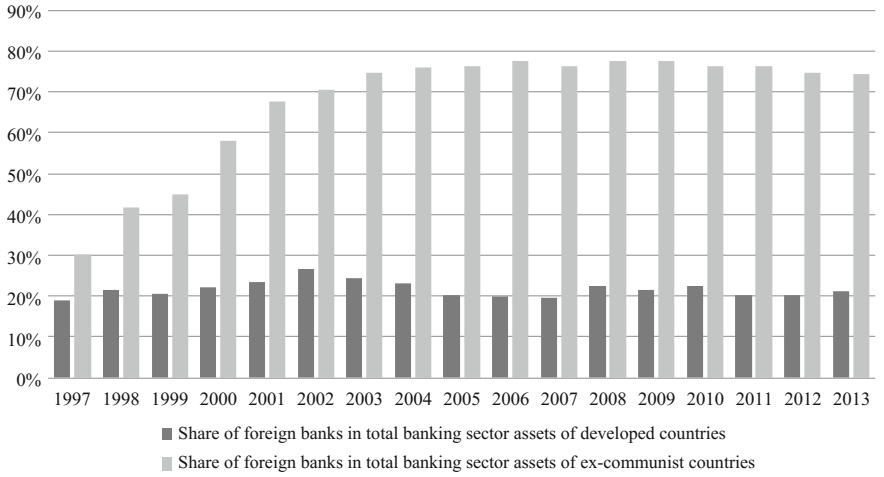


**Fig. 1** Share of foreign banks in total banking sector assets of developed and ex-communist countries in the years of 1997–2013. *Source* Own work based on ECB data

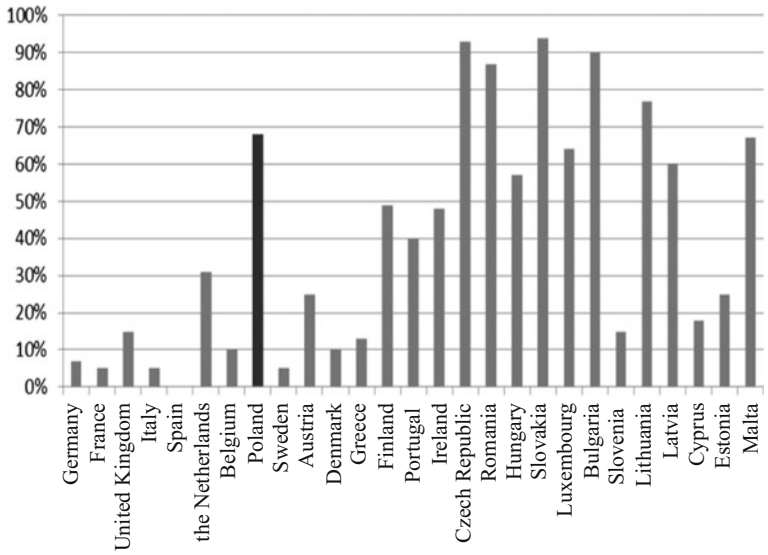


**Fig. 2** Share of banks controlled abroad in total assets of 10 largest banks (in 2008) according to country's GDP (data available in 2010). *Source* Kamerling and Makipaa (2008)

share), is also state capital (24% of share) as well as capital of other financial institutions—cooperative banks and credit unions (11% of share). This is mainly due to significant geographical territory and territorial unit of Asian countries, particularly China and India (Mihaljek 2010, pp. 34–35).

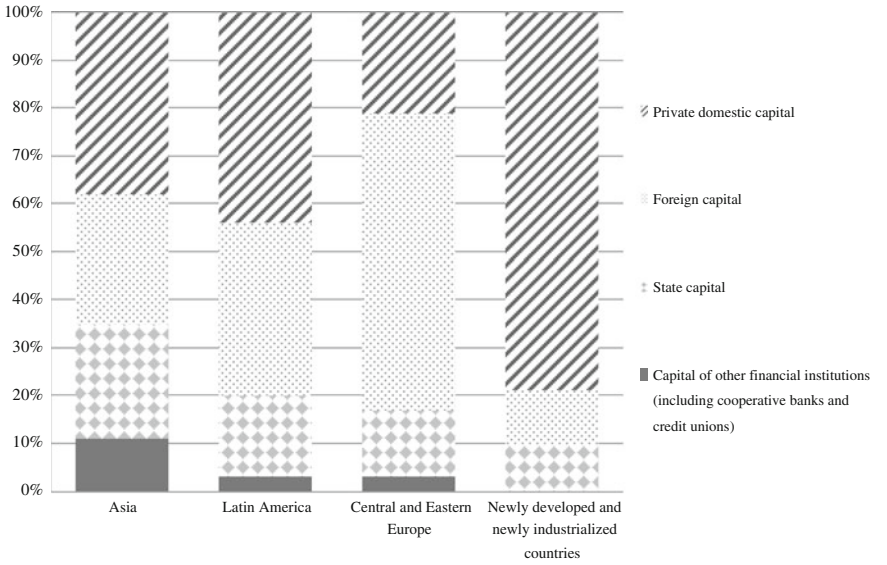


**Fig. 3** Ownership structure of banking sectors of developing countries (as a percent of total assets of the whole banking sector). *Source* Own work based on central banks data

In Latin America, domestic and foreign banks represent about 80% of total banking sector assets, while state-owned banks—only 17%. It means that 36% is held by foreign capital, and 44% by domestic capital. In other newly developed countries—such as Israel and Saudi Arabia, and newly industrialized countries—Republic of South Africa,[2] dominate domestic capital, which represents 79% of total banking sector assets. Foreign capital has a negligible share in these countries—only 11% of share.

In Central and Eastern Europe (CEE)—as shown in Fig. 4, foreign capital on average represents 62% of total banking sector assets. Domestic capital private oscillates at an average level of 21%, while state capital is equal to 14%. Against this background, it is noted significant difference in ownership structure of CEE countries[3] in relation to other developing countries of the global economy, with dominant role of foreign capital in total banking sectors assets (Mihaljek 2010, pp. 34–35).

A characteristic feature of Central and Eastern Europe countries is high share of foreign capital in total assets of national banking sector. Hungary has the largest share—approximately 92% of the total banking sector assets is foreign capital.

[2]Since 2011 Republic of South Africa has joined to the group of countries known as BRICS, which includes Brazil, Russia, India and China.

[3]These countries are often referred as CEC5—*Central and Eastern Countries 5*, which means that this is five countries of Central and Eastern Europe, namely Poland, Czech Republic, Slovenia, Slovakia and Hungary.

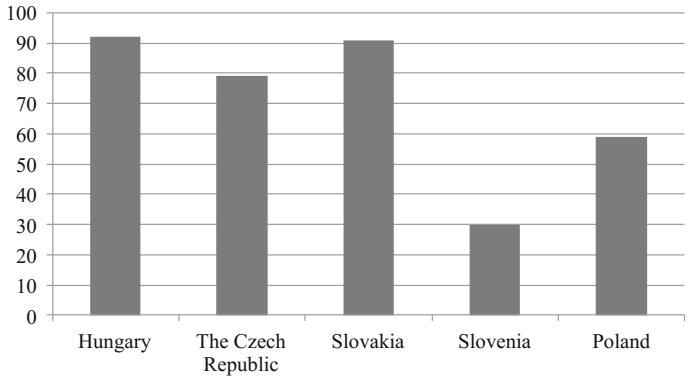


**Fig. 4** Share of foreign capital in domestic banking sectors of Central and Eastern Europe countries (in percent). *Source* Own worked based on central banks data

In Hungary the largest shareholder is Austria (24% of foreign capital invested in domestic banks), on next position are capital from the Netherlands (14%), Germany (13%), Belgium (12%), USA (12%), Luxembourg (9%) and France (4%).

In the Czech Republic strongly dominates—like in Hungary—Austrian capital (33.2%). In Slovakia, the largest share is represented by capital of Luxembourg—30% and Austria—29%. Slovakia is the only country among five analyzed of Central and Eastern Europe, where the ownership shares have also financial institutions from that region—Czech and Hungarian banks. In Slovenia, all foreign investment in the banking sector are limited to a narrow range of EU Member States (Austria, Italy, France and Belgium). Moreover, Slovenia has the lowest share of foreign capital in domestic banking sector among five CEE countries. It represents only 30% of share. Thus, 70% of total banking sector assets is held by domestic investors (Rusnok 2014, p. 5). In Polish banking sector, controlling stakes have investors from 18 countries, while dominant is Italian (10.7%), German (10.5%) and Spanish capital (9%)—see Fig. 5. Foreign capital from France (7.2%), the Netherlands (6.7%), USA (5.1%) and Portugal (4.1%) are less import ant (Polish Financial Supervision Authority 2016, p. 20).

Therefore, it should be noted that in Central and Eastern Europe countries dominate foreign capital, from countries which are members of the European Union. It is mainly German, French, Italian and Austrian capital. The exception is American capital, which however has a small share in total assets of banking sectors in Central and Eastern Europe. Analysis also indicates that the largest share in total assets of banking sectors of these countries has capital from neighboring countries. Like Scandinavian countries are the largest investors on banking market of Baltic countries, so in the case of the Czech Republic, Slovakia or Hungary, one of the main investors is Austria (Mérő, Endrész and Valentinyi 2003, p. 19).

Besides substantial domination of foreign capital in these countries, the attention should be paid to ownership structure of the largest banking institutions. The three

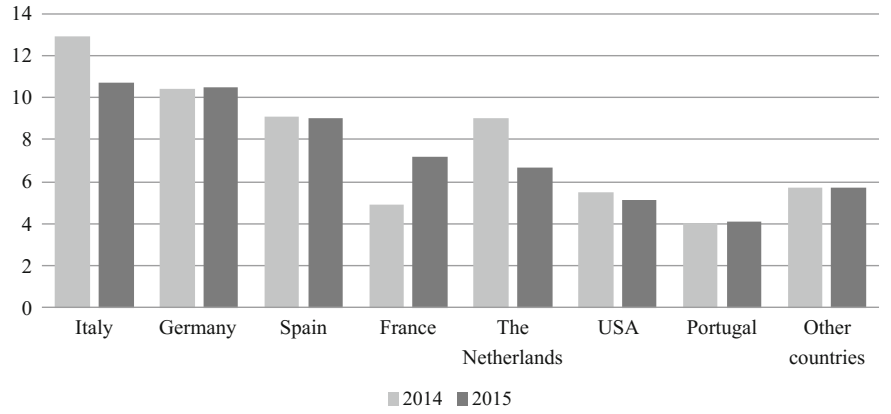


**Fig. 5** Share of foreign capital by countries in total assets of Polish banking sector in 2014 and 2015 (in percent). *Source* Own work based on Polish Financial Supervision Authority data

largest banks in the Czech Republic, Hungary and Slovakia are owned by foreign companies. Foreign investors have bought controlling stakes during the banks' privatization process at an earlier or a later stage of their development. In turn, in Slovenia the largest bank is state-owned, while the second and third in terms of total assets are managed by private domestic investors. Also in Poland, the largest bank is still in majority state-owned, while the second and third are controlled by international financial institutions.

## 4 Determinants of Repolonization of Domestic Banks

Repolonization strategy undoubtedly requires the analysis of its determinants. They mainly indicate what is the probability of its implementation, what kinds of positive and negative consequences can be expected in a banking sector, which is undergoing major changes in ownership structure.

A major factor that hinders repolonization process is also the ownership structure of Polish banking sector, which has formed so far. Foreign capital, dominant in domestic banks, regardless of the assessment of financial benefits their major shareholders (owners) or negative effects of such domination, undoubtedly shaped modern framework of commercial banking in Poland at the beginning of the twenty-first century. It is expressed not only in nature and methods of provided financial services by domestic banks, but also in market value of bank capital. Therefore, the costs of repolonization of Polish banking sector might be much higher than expected, or realistically predicted. In this situation, social barrier of this process should be seriously take into account. Past privatization irregularities, mainly in sole-shareholder banking companies of the State Treasury, unresolved

politically accused of embezzlement of bank capital, disputes about high costs of banking service (for example mortgage in CHF) are main—but not the only—factors of social resistance to subsequent changes in Polish banking sector.

Past experience in ownership transformation process of domestic banks are also in most negative. This process began in Poland along with the political transformation, which allowed to identify three, diverse in terms of their specific features, stages (Pyka and Cichorska 2013, pp. 146–147; Cichy 2010, pp. 126–127):

1. privatization and remedial commercialization in the years of 1990–1996,
2. administrative consolidation in the years of 1997–2000,
3. changes in shareholding structure of bank capital, mostly foreign origin, after 2000.

The first stage of ownership changes was closely associated with reform of the political system of Polish economy. In 1991, the Council of Ministers of the first government of the "the new Republic of Poland" has decided to transfer responsibility for banks management from the Minister of Finance representing the State Treasury, to its authorities and owners, at the same time starting period of their commercialization, while creating the conditions for privatization of nine independent commercial banks, which so far had status of state-owned banks, established by their separation from assets of the National Bank of Poland (NBP). During this period, significant number of licenses has been granted for establishment of private commercial banks and many new banks started operating as joint stock companies. This process was directly subordinated to the increase of share of foreign capital in ownership structure, due to the lack of private domestic capital and liberal policy of ownership changes, carried out by the National Bank of Poland. Moreover, there was expected a rapid increase of capital concentration of banks, mainly with bad financial condition, but also those required liquidation or major restructuring processes, due to the lack of business management skills (Pyka and Cichorska 2013, pp. 146–147; Cichy 2010, pp. 126–127).

The concept of administrative consolidation has become a form of response to the serious, not only ownership, problems in Polish banking sector, resulting from the first stage of ownership changes (Pyka 2009, pp. 672–673). It was prepared by the government with the assumption of establishment in Polish banking sector two large capital groups—Bank Pekao S.A. (successful) and Bank Handlowy w Warszawie S.A. However, this attempt was unsuccessful and the experience of this period showed that administrative coercion in carrying out banks' consolidation is not sufficiently effective. The concept of administrative consolidation also had not strong political support. An important objective of Polish banking sector restructuring, since the market reform of Polish economy (often incorrectly referred as Balcerowicz reform) was privatization of Polish state-owned banks, subordinated to the rapid increase of private capital share, regardless of source of its origin. This goal was quickly achieved. In 1996, total of core and supplementary funds of commercial banks with majority of state capital was 55.9%, and in 2000—it was only 14.2%. It has also changed the structure of private bank capital. In 1996, share

of private foreign capital in Polish banking sector was 20.7% and in 2000—it was already 77.6% (Pyka 2009, pp. 672–673).

However, ownership changes in Polish banking sector constantly occur. After 2000, and especially at the beginning of the first decade of the twenty-first century, they were influenced by escalating of globalization process of the world economy. As a result of the reform of the political system, Polish banking sector has become open to the international money and capital flows. Thus, significant barrier of progressive capital consolidation has disappeared. However, the ownership structure of bank capital in Poland at that time did not change much. While transformations concerned shareholding of banks with majority of foreign capital. On an international scale, new banking groups and financial holding companies were established under the influence of escalating of globalization process. Mergers of foreign banks beyond Polish borders, which in the privatization process have become shareholders, having a majority shareholding of Polish commercial banks, caused essentially changes in their ownership structure. They were taking place through (Cichy 2010, pp. 133–135):

1. acquisition of subsidiaries by parent company—e.g. ING Bank and Bank Śląski S.A.,
2. ownership consolidation—e.g. merger of Bank PKO S.A. and BPH S.A., as a result of a merger of two foreign banks which were shareholders of Polish banks, or acquisition of mini-BPH S.A. by GE Money Bank S.A.

However, the process of these changes was slow. It was accompanied constantly by the idea of privatization of Polish banking sector. In 2004, PKO BP S.A. was privatized, as a result of which share of the Treasury in the share capital of PKO BP S.A. decreased from 62.30 to 51.96%. Moreover, in 2004 Treasury lowered its capital share in Bank Gospodarki Żywnościowej S.A. from 49.48 to 43.5%, contributing to its join among a group of private banks with majority of foreign capital.

Favorable conditions of changes in shareholding of Polish banking sector were intensified during the global financial crisis, when investment banks have disappeared from map of the world economy, which operated internationally, and when many commercial banks had to perform restructuring process, including re-nationalization.

Table 1 presents the intensity of changes in capital structure of Polish banking sector after the global financial crisis. There can be observed dominance of tendency to decrease of national capital in the structure of Polish banking sector. In these circumstances, it should explain the lack of interest in taking over domestic banks by Polish private capital and intensification of the process of their capital consolidation in Poland.

Undoubtedly, an important reason for lack of expected progress of repolonization of domestic banks is the lack of its strategy and a constant battle against political opponents. Moreover, in Poland there is a deficiency of financial capital, because of its strong dispersion. Therefore, repolonization of domestic banks requires liquidation of an institution of strategic investor. Bank management should

**Table 1** Mergers and acquisitions in Poland in 2007–2016

| Acquired institution | Acquirer institution | Year | Increase/decrease of national capital value in structure of Polish banking sector | Effects of acquisition/merger |
|---|---|---|---|---|
| Bank BPH | Bank Pekao | 2007 | Decrease | In November 2007 Bank BPH has been divided, and the greater part (over 80% of total assets) has been incorporated into Bank Pekao S.A. The acquisition of Bank BPH by Bank Pekao, which is owned by the Italian group UniCredit, has reduced the share of national capital in structure of Polish banking sector |
| Bank BPH —so called mini-BPH | Bank Pekao | 2008 | Decrease | In June 2008 majority shareholding of divided Bank BPH (so called mini-BPH) was purchased by General Electric Company with headquarter in the US. Repurchase of Mini-BPH shares has reduced the share of national capital in structure of Polish banking sector |
| Dominet Bank | Fortis Bank Polska | 2008 | Decrease | In October 2006 51% of shares of Dominet Bank—entirely funded by domestic capital, were bought by Fortis Bank Polska, owned by Belgian Fortis group |
| Fortis Bank Poska | BNP Paribas | 2009 | No change | 75% of shares of Fortis Bank Polska was taken over by BNP Paribas, which initially operated under BNP Paribas Fortis brand name |
| Getin Bank | Noble Bank | 2010 | No change | In January 2010 after a merger of Getin Bank and Noble Bank was established Getin Noble Bank S.A. However, it did not result in changes in ownership structure of Polish banking sector, because both companies were fully financed from national capital |

(continued)

**Table 1** (continued)

| Acquired institution | Acquirer institution | Year | Increase/decrease of national capital value in structure of Polish banking sector | Effects of acquisition/merger |
|---|---|---|---|---|
| Allianz Bank Polska | Getin Holding S. A. | 2010 | Increase | 18 November 2010 Getin Holding S.A. acquired 100% of shares of Allianz Bank Polska. Since June 2011 Allianz Bank Polska S.A. offered its products and services as Get Bank. This acquisition increased a share of national capital in ownership structure of Polish banking sector |
| AIG Bank Polska | Santander Consumer Bank | 2010/ 2011 | No change | Santander Consumer Bank acquired majority shareholding of AIG Bank Polska, operating in Poland since 1998. There has been an increase of share of Spanish capital in ownership structure of Polish banking sector. However, the share of Polish capital has not changed |
| BZ WBK | Santander | 2011 | No change | BZ WBK since 1995 was owned by an Irish group—Allied Irish Bank. After bank's acquisition in 30 March 2011, Santander took over 95% of shares. Thus, there has been an increase of share of Spanish capital in ownership structure of Polish banking sector. However, the share of Polish capital has not changed |
| Get Bank S.A. | Getin Noble Bank S.A. | 2012 | No change | The brand name of Getin Noble Bank S.A. was adopted after a merger of Get Bank S.A. with Getin Noble Bank S.A. Both companies were fully financed from national capital |
| Polbank EFG S.A. | Raiffeisen Bank | 2012 | No change | 4 December 2012 Polish Financial Supervision Authority approved a merger |

(continued)

**Table 1** (continued)

| Acquired institution | Acquirer institution | Year | Increase/decrease of national capital value in structure of Polish banking sector | Effects of acquisition/merger |
|---|---|---|---|---|
| | Polska S. A. | | | of Polbank EFG S.A. with Raiffeisen Bank Polska, which was completed in 31 December 2012. The new bank operates under the name of Raiffeisen Polbank. Polbank capital originated from Greece, while Raiffeisen capital from Austria. Thus, a merger of these banks did not cause any changes in ownership structure of Polish part of the banking sector |
| DnB Nord | Getin Bank | 2013 | Increase | In May 2013 DnB Nord bank has undergone a reorganization, as a result of which provided individuals clients, economic communities and SMEs to Getin Noble Bank. This resulted in an increase of share of domestic capital in ownership structure of Polish banking sector |
| Kredyt Bank | Santander | 2013 | No change | Kredyt Bank assets were fully acquired by the bank of Santander group. As a result BZ WBK bank merged with Kredyt Bank, and the new institution became the third largest bank in Poland |
| BGŻ | BNP Paribas | 2014 | No change | A merger of BGŻ bank, which was owned by the Dutch Rabobank, with BNP Paribas Bank Polska, was a consequence of take control over the bank by BNP Paribas Group in mid-2014 |
| Nordea Bank | PKO BP | 2014 | Increase | Bank PKO BP acquired a Polish subsidiary of the Swedish Nordea group. This resulted in an increase of share of domestic capital in ownership structure of |

(continued)

**Table 1** (continued)

| Acquired institution | Acquirer institution | Year | Increase/decrease of national capital value in structure of Polish banking sector | Effects of acquisition/merger |
|---|---|---|---|---|
| | | | | Polish banking sector to 38.5% of total assets |
| Meritum Bank | Alior Bank | 2015 | Increase | In February 2015 Meritum Bank became a majority shareholder of Alior Bank. This resulted in an increase of share of domestic capital in ownership structure of Polish banking sector |
| Sygma Bank | BGŻ BNP Paribas S. A. | 2015/ 2016 | No change | In December 2015 BGŻ BNP Paribas bank acquired all block of shares of Sygma Bank Polska from BNP Paribas Personel Finance, and announced liquidation of Sygma Bank brand. In May 31, 2016 there was a legal merger, under which Sygma Bank was taken over by BGŻ BNP Paribas S.A. bank |

*Source* Own work

receive more permissions in the context of ownership changes, and repurchase of dispersed shares by Polish capital, would increase chances of repolonization. Despite this, it seems that there is a lack of interest of Polish investors in such investments. They constantly have better opportunities of allocation their financial resources. The more that banking sector, not only in Poland, needs to improve security and stability. Furthermore, strong regulatory discipline, executed often beyond borders of the country, is a determinant lowering motives of repolonization of domestic banks. Statutory provisions of domestic banks also need changes, so as to repolonization process increases their competitiveness, blocking capital concentration. These determinants do not form a complete framework of necessary changes in acceleration of repolonization process. They only indicate the main directions increasing chances of repolonization of Polish banking sector.

## 5 Summary

The carried out comparative analysis of ownership structure in the various countries of modern world economy seems to confirm that due to observed trends repolonization will be a long-term process, breaking down expansion of the European capital of developed countries. Repolonization process, in its nature, accumulates high risk arising from a breach of existing interests of banking business in Europe.

Observing situation in the international banking market it can be noticed permanent trend to changes in ownership structure in capital not only parent companies of Polish banking subsidiaries. The main stage of this process is acquisition of companies by private capital and ownership consolidation, aimed at building strong banking groups. None of them has yet been used to intensify repolonization process of domestic banks. The concept of building banking group was created in PZU. There has not also been used chances to take over companies of domestic banks by Polish private capital after the global financial crisis.

However, in the years of 2000–2015 it can be noted an increase of share of national capital in Polish banking sector (see Fig. 6).

It shows the growing opportunities for repolonization, especially that in the global economy appeared favorable circumstances to carry out ownership changes in banks. However, the success of repolonization process depends on many factors. Among them, formed structure of bank capital is a serious impediment of its implementation, which impacted and constantly impact on transformations in Polish commercial banking. Domestic banks, financed from foreign capital, currently will have to be bought expensive despite their earlier sales to foreign investors at a low market price. However, market indoctrination of the previous period in Polish society, including scientific and political societies, was so strong, that larger national threats has not been seen in the process of marketization of Polish banks. Currently, it still remains a serious barrier of the repolonization process.

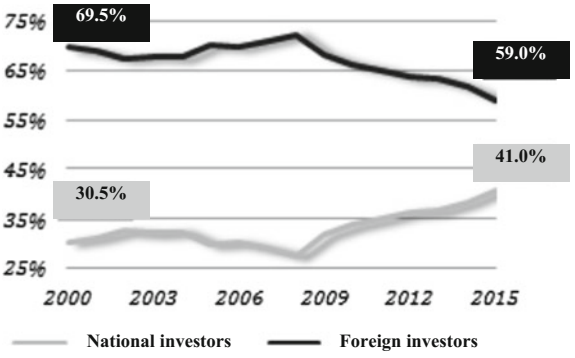


**Fig. 6** Ownership structure of Polish banking sector (share in total assets of whole sector) between 2000 and 2015. *Source* Polish Financial Supervision Authority (2016, p. 20)

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